LEAD POISONING

WITH SPECIAL REFERENCE TO

RENAL AND VASCULAR SYMPTOMS.

by

GEORGE F. B. PAGE, M.B., Ch.B.

Surgeon Lieutenant Commander, Royal Navy.

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NOTE.

This Thesis is presented by permission of the Medical Director General of the Navy subject to the conditions that initials only of patients are given and that no names or localities of Naval Establishments appear.

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INTRODUCTION.

With the exception of iron, lead plays a more important part in the lives of the civilised nations of to-day than any other metal. Among metallic poisons lead is facile princeps. These two facts raise the subject of lead poisoning to a position of the first importance, not only from the point of view of preventive medicine, but from the point of view of the general practitioner and the community at large whom he serves.

Lead enters very intimately into industrial and domestic life. Apart from the smelting of the metal itself, and from the preparation of its compounds, lead is found in so many trades that an exhaustive list would reach a very considerable length.

Among everyday occupations one might mention plumbing, painting and lithographing; the manufacture of china-ware, pottery and glass; the huge tin plate trade which in turn supports the canned food industry; and even the polishing of precious stones.

Lead/

Lead may enter our houses in drinking water, which is commonly conveyed in lead pipes and stored in lead lined cisterns. Conditions may occur which render a safe and potable water plumbo-solvent, and serious harm may be done before the danger is realised.

The use of tinned foods is increasing and they are a necessity in our naval and military services. Cheap tin plate, cheap enamelled ware and cheap pottery may yield lead to acid contents.

Despite opposition and the advertisement of substitutes lead paints continue to be used very largely for every sort of purpose.

Lead and its compounds are omni-present, and wherever they are found in absorbable form they remain a danger. Nor are the symptoms of early plumbism of such a kind as to constitute any kind of safeguard or warning. Absorption may be slow, the attack insidious and recognition too late.

The toxic qualities of lead have been known for a very long time, but to Tanquerel des Planches[1] belongs the credit of the classical description of the signs and symptoms. Sir Thomas Oliver of Newcastle-on-Tyne has done much to increase our knowledge in recent years, and to bring industrial lead poisoning into prominence. Among other writers in the English language/

language may be mentioned Goadby and Legge in this country, and Alice Hamilton in America.

The legislature of almost all civilised countries has recognised the impairment of health and high mortality suffered by workers in trades wherein lead may be absorbed, and such trades are described as "dangerous and unhealthy industries"[2]. The Factory and Workshops Act of 1895 made cases of lead poisoning occurring in factories and workshops notifiable, and it is at this point that our statistical knowledge of industrial plumbism commences. The order was repeated in the Act of 1901, but it is noteworthy that plumbism among house-painters and ship-painters is not included. As notification in this class of worker is voluntary, our returns are necessarily incomplete, and this is the more regrettable as it is believed that the incidence of plumbism is high among them.

The beneficial results of legislation are shown in the White Lead Trade. In the ten years 1900 to 1909 the cases notified had fallen from 358 to 32, and the deaths from 6 to 2. "In[3] 1912 the manufacture of white lead no longer occupies the unenviable position of first place in the list of trades in which plumbism occurs. The position is taken by the earthenware/

earthenware and pottery industry ..... and close upon it comes coach-building".

Such a chapter compares favourably with any in the annals of preventive medicine, but the matter has not been allowed to rest there. The Earthenware and China Industry has been attacked by a [4] Parliamentary Departmental Committee, and under the powers of the existing Act comprehensive regulations were gazetted on 7th January 1913. To these and previous orders must be attributed the improved health of the workers.

The latest [5] information calls attention to the diminishing number of cases and deaths in most of the trades concerned, and to the reduction in the severity of the symptoms and in the number of chronic cases. It is, however, admitted that during the War many industries were adversely affected, and that the improvement for this period is more apparent than real.

The especially baneful effect of lead upon women and young people was made the subject of certain recommendations by the General Conference of the International Labour Organisation held at Washington in 1919, and the points raised have been embodied in the "Women and Young Persons (Employment in Lead Processes) Act of 1920."

Still the incidence of lead poisoning remains too high.

The/

The following table gives the Registrar General's returns for England and Wales for recent years:-

TABLE I.[6]

Year.	Total deaths from lead poisoning.	Deaths from occupational lead poisoning.	Remarks.
1910	93[x]	86	x including 1 suicide.
1911	121	110	
1912	117	106	
1913	93	81	
1914	90	79	
1915	73	68	
1916	62	55	
1917	59	51	
1918	36	36	
1919	50	48	
1920	-	61	return incomplete

In the Registration Area of the United States there were in 1917[7] one hundred and forty-seven deaths from plumbism, and this return is incomplete.

The Factory Department of the Home Office records

267 reported cases in the ten principal lead-contact trades during 1914.

The leading symptoms of established lead poisoning are pretty generally recognised, even if they are not altogether satisfactorily explained. They occur most frequently in those occupations where the worker is brought constantly and intimately into contact with lead and its compounds in absorbable form, particularly in the form of dust: but where the amounts absorbed have been exceedingly small and over comparatively long periods, somewhat different results may be looked for. It is my opinion, and also that of others of much greater experience, that many minor ills among the workpeople may be due to plumbism, although, in the absence of definite evidence, one does not wish to put this idea into the heads of individuals who are often only too ready to attribute to lead their every-day ailments.

While, then, it is important to recognise incipient cases and unusual signs, it is equally important to avoid fanaticism which may seek to draw within the circle of things saturnine conditions which are really due to other, though possibly concurrent, causes.

During the fifteen months which terminated on 31st Dec. 1920, I had charge of some forty painters, plumbers and tinsmiths at a Naval Establishment; and I have recently had opportunities of examining the same classes of workmen at two of the Royal Dockyards. During this time I have attempted to estimate the effect on health of the long continued absorption of very small quantities of lead among men who do not, as a rule, present any of the more obvious and certifiable forms of plumbism.

In the present thesis I propose to consider industrial lead poisoning in general first of all, and then to pass on to the more remote and chronic effects, especially the effects on the arteries and kidneys.

It is my intention to consider painters in particular, and it will be necessary to discuss rather fully the allied subject of "paint sickness". Large quantities of lead, especially paint, are used daily both in the Dockyard (civilian) part of the Royal Navy and in the Service Afloat.

References.

1. L.Tanquerel des Planches. Traite des Maladies de Plomb ou Saturnines. Paris 1839.

2. Factory and Workshops Act. 1901, Part IV.

3. Oliver, Sir Thomas. "Lead Poisoning" 1914, p.37.

4. Departmental Committee appointed by Parliament in 1908 to enquire into The Danger or Injury to Health arising from Dust and Other Causes in the Manufacture of Earthenware and China and in the processes incidental thereto, including the making of Lithographic Transfers.

5. Memorandum on Industrial Lead Poisoning published by the Factory Department of the Home Office, January 1921.

6. Compiled from figures supplied by the courtesy of The Registrar General, Somerset House, London.

7. Osler & McCrae, "Principles & Practice of Medicine", 9th ed, 1920, p.393.

HISTORICAL NOTE.

The use of lead and of lead compounds is of great antiquity. Lead was mined in the Sinai Peninsular before the time of Moses[1] and was one of the wares brought to the Tyrian markets. It is mentioned in the Book of Exodus (ch.XV.10), the Hebrew word being "bêdil". Lying as it frequently does near the Earth's surface, galena, the metallic looking native sulphide, was bound to attract attention. It is probable, too, that the natural carbonate was known to the ancients and that it is identical with the cosmetic called "psimuthion" by Xenophon[2] (circa 400 B.C.), and the substance referred to by Ovid, Pliny the Elder and other classical writers as "cerussa".[3]

The ores are easily smelted, and the weight, malleability and general usefulness of the metal must have appealed strongly to the artisans of other days.

Blocks of lead bearing the Roman Arms have been found in the Midlands, and something of its poisonous nature must have been realised, for historians tell us that its use was forbidden in the construction of Rome's aqueducts in the time of Caesar Augustus. At an early period in the development of the British Nation lead came into use for roofing important buildings - /

buildings - churches and castles -, for the conveyance of water and the manufacture of pewter; spheres of usefulness which it maintains to the present day. The alchemists of the Middle Ages were much impressed by the property which lead possesses of swallowing up the "noble metals" (gold and silver) in the molten state. They called lead "saturn" and gave it the sign "♄".

Pliny described a method of making white lead by corroding the metal with vinegar in earthenware pots sunk in dung. In those times the white lead of Rhodes enjoyed a considerable reputation. Sir Thomas Oliver states[4] that the residuum of pressed grapes is still used for the purpose at Klagenfurth in Carinthia. In 1622 the Dutch improved the process by adding wine-lees and chalk to the vinegar, and so gave their name to a method which is still much used in a modified form, the introduction of spent tan being made later by English manufacturers.

Poisonous properties and symptoms attributable to lead, particularly colic, were known to many early writers - Pliny, Hippocrates and Nicander. Celsus recognised the dangers associated with the administration of lead preparations; he recommended that persons who had swallowed white lead should be made to vomit.

In/

In 1656 Stockhusen[5] stated definitely that colic in lead miners and smelters was due to fumes from the molten metal. Tronchin in 1757[6] discovered that certain wines were able to dissolve out lead from the glazed earthenware vessels in which they were stored, and ten years later an English observer, Sir George Baker,[7] traced "Devonshire colic" to the similar action of cider.

In the seventeenth and eighteenth centuries, and even in the early part of the nineteenth, lead (acetate) was used extensively in medicine for internal administration, especially on account of its supposed favourable action upon the blood in fevers, malaria and phthisis. Text books of medicine record that singularly small doses have been known to produce symptoms, so that cases of poisoning must have been fairly frequent.

So far as the internal administration of lead is concerned, its glory has departed; but its value in medicine survives in the external preparations. The use of diachylon as an abortifacient has been common knowledge for years.

The/

The epidemic of lead poisoning from the water* supply at Sheffield in 1887 is historical, and it has served to focus attention on this source of danger.

It is impossible to estimate the ill-effects upon industrial life which lead may have had in the past, but probably they were small compared with those brought about by the growth of chemical and manufacturing activity in the nineteenth and twentieth centuries.

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* The falling off of fish life in Lake Ulswater during the last half century has been attributed to the washings from the lead mines. An improvement has occurred of late years, the mines having been inactive. One of the lakes near Snowden is said to suffer in a similar way from copper.

References.

1. The Oxford Bible, Clarendon Press.

2. Xenophon, Oec 10,2. " ἐντε-τριμμένην ψιμυθίῳ "

3. Ovid, Medic:Fac:73 "nec cerussa tibi, nec nitri spuma rubentis desit".
Pliny the Elder, Naturalis Historia, 34,18,54.
Cicero, Oratio in Pisonem.11,25. "cerussatus" = painted with white lead. Also Martial 7, 25, 2.

4. Oliver, Sir T. "Lead Poisoning" p.31.

5. Stockhusen, "De Litharg. Fumo", 1656.

6. Tronchin, "De Colica Pictonum", 1758.

7. Baker, "De Colica Pictonum", 1767.

THE INDUSTRIES IN WHICH LEAD POISONING OCCURS.

Lead is used in over one hundred industries and trade processes, but for the last twenty years the principal branches of manufacture which have been observed to be connected with lead poisoning have been classified as follows:-

TABLE II.

The table shows the average number of cases reported to the Home Office, with the deaths in brackets, during the four five-year periods between 1900 and 1919.

Industry.	average 1900-04	average 1905-09	average 1910-14	average 1915-19.
Lead smelting, spelter & desilvering etc	37(2)	45(2)	40(4)	34(2)
Brass work	8	7	7	1
Sheet lead & piping	13	9	7	2
Plumbing	20(1)	23(2)	32(2)	19(1)
Printing	18(1)	22(2)	29(2)	13(2)
File cutting	32(3)	11	13(1)	3(1)
Tinning hollow-ware etc.	10	18	13	3
White lead	183(4)	76(3)	31(1)	17
Red lead	13	9	8	11
Pottery	119(5)	94(7)	67(10)	19(6)
Litho-/				

Litho-transfer making.	5	5	1	-
Glass cutting & polishing	6(1)	3(1)	2(1)	-
Enamelling	6	4	12	2
Electric accumulators	32	25(1)	36	40(1)
Paints & colours	46(1)	39(1)	20	12
Coach building, railways, tramways, motor cars etc.	64(4)	75(4)	77(5)	23(3)
Shipbuilding, including government dockyards	29(1)	24(1)	31(3)	16(2)
Paint used in other industries	46(2)	45(2)	49(2)	16(1)
Other industries:- Shot-making, metal sorting, glass making, tempering springs, coopering, india-rubber, dyeing yarn, etc., etc.	66(2)	65(2)	73(3)	48(2)
Total	753(27)	599(28)	548(34)	279(21)

It will be seen that there has been a general decrease in the number of cases, although it must be conceded that the figure for the War years is partly due to a falling off in trade. It will also be noted that deaths remain at much the same figure, a point which will be alluded to again.

Before proceeding to the consideration of these trades individually, one or two other points call for comment.

The most marked decrease in plumbism has occurred in trades long known to be dangerous and where much has been done in the way of legislation and technical improvement, e.g. the manufacture of white lead and pottery.

There has been a decrease of cases in the manufacture of paints and colours. But in trades where paint is used there has been an increase; e.g. enamelling, coach building, shipbuilding and painting.

At the present time, therefore, painting assumes a position of considerable importance among lead-contact occupations.

It is now necessary to describe each industry and to discuss how lead may be absorbed.

Lead Mining. This is an ancient and essentially British industry now confined to Derbyshire, the North of England and the Lowlands of Scotland. Lead occurs in other parts of the country, for example Cornwall and South Devon, but not in quantities of commercial value. Formerly a valuable national asset, the trade has declined owing to the importation of foreign ore, but from time/

time to time revivals have occurred as prices have become favourable. Lead mining is not an important source of plumbism owing to the fact that the native sulphide (galena) is insoluble.

This is not the case with cerussite or native crystallized lead carbonate, which powders readily into a fine dust and has all the power for evil possessed by white lead. Cerussite was mined largely at Broken Hill, Australia, twenty-five years ago, but the deposit is practically exhausted.

Lead Smelting, Desilvering and the manufacture of Spelter.

The risk of plumbism begins with the smelting and purification of lead ores. Various processes are used, but they consist essentially of roasting the ore with coke in a blast furnace fed from above, or upon an open hearth whereon a charge is built up and ignited. The molten metal and slag are run off in front as they collect, and the fumes, rich in lead, arsenic and other harmful substances, are led into the main flue and thence to the chimney which is often as much as a mile away.

Lead melts at 617°F. and fumes are given off at the temperature of the furnace. Workmen engaged in feeding/

feeding the furnace and in collecting the molten lead and slag are exposed to these fumes, and the danger is increased should the flue be faulty. In the open hearth or Scotch method the slag is usually broken up and re-melted, and clouds of plumbiferous dust arise during the process. The dust of metallic lead and of lead oxides will also be found round about the furnace.

Flue dust may contain a high percentage of lead, and the cleaning of the flues to recover this is dangerous work which has frequently caused severe poisoning. The flues are most safely cleansed by water, the resulting sludge being practically innocuous.

Lead smelting may not only be dangerous to the workmen but also to those in the surrounding district if the flues are not long enough to condense the bulk of the fume, and the chimneys not high enough to disperse the remainder over a wide area. Human beings, cattle and horses, dogs, cats, poultry and even wild birds have been known to suffer. Oliver[1] speaking of the Broken Hill mines says "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".

Zinc ores may contain lead, so that zinc smelters/

smelters are exposed to plumbism.

Spelter[2] is a mixture of zinc, copper, tin and various amounts (2-3%) of lead, used for brazing. Its manufacture and use are attended by danger from lead fumes. Spelter workers returned 64 cases of plumbism in the five years 1910-14.

The desilvering of lead is carried out by the Pattinson or the Parkes process. The former depends upon the fact that lead crystallizes out at a higher temperature than a mixture of lead and silver. It is an application of the well known principle of fractional crystallization. The forming lead crystals have to be ladled out of a series of pots, until in the last pot almost pure lead is left. The first pot contains lead rich in silver.

In the Parkes process zinc is added, and an alloy of zinc, silver and lead is formed which rises to the surface of the melting pot as the mixture cools, and is skimmed off as a crust. This crust is subjected to a de-zincking process, when the zinc is driven off as vapour. The remainder is now cupelled at a high temperature, when the lead is converted into oxide and driven into a receiver by the air blast, leaving the unoxydisable metallic silver behind. Not only are the workmen exposed to the fumes of the molten lead, but also to those of the zinc which cause nausea.

Brass/

Brass contains about 1.5% of lead added to soften the metal. Those employed in (1) casting may suffer from the fume; (2) polishing, from the lead in the abraded dust; (3) chandelier fitting, from testing joints with the mouth, the joints being made with white lead paste. The last cause has become uncommon (only 7 cases from 1910-14).

Sheet Lead and Lead Piping. The manufacture of sheet lead and piping is not responsible for many cases of plumbism, since the handling of clean metal would seem to have but little deleterious effect. Fume from improperly hooded melting pots (the preliminary stage of pipe making), dust from skimming the dross from the molten mass, and handling old, dusty and oxydised piping are the chief causes. In the period 1910-14 - 33 cases are returned, 17 classified as arising from the melting pot and 16 as "elsewhere".

Plumbing and Soldering. Plumbers are poisoned by handling old lead pipes, by contact with red and white lead in making joints, and from handling putty which usually contains a high percentage of lead. They also suffer/

suffer from the fume when soldering or making wiped joints, and from lead burning with the oxy-hydrogen or oxy-acetylene blow pipe flame.

House plumbers are not included under this heading in the official returns. Precise figures are difficult to obtain, but the incidence of plumbism does not seem unduly high, considering the nature of the work and the number of persons employed. In the period 1910-14 - 158 cases are returned. In the same period the "Health[3] of the Navy" only records four cases, one of whom, however, "developed double wrist-drop after many previous attacks of colic".

Printing and Type Founding. Type metal is an alloy of lead and antimony, and poisoning arises from dust in the type cases and from drossing the molten metal. The dust arising from general wear and tear may contain as much as 14% of lead in this country, and three times as much in continental printing shops[4].

Chronic lead poisoning lowers the general resistance, and this combined with the bad hygienic conditions found in printing shops predisposes the employees to pulmonary tuberculosis and favours infection. In them phthisis is apt to run a rapid course.

Mechanical/

Mechanical type setting, realisation of the dangers run, and better sanitary conditions have done much to improve the health of this class of worker in recent years.

File Cutting. Two steps in the manufacture of files bring about exposure to plumbism.

The marks upon the file are cut with a hammer and chisel, the file being strapped to a cushion of lead. When one side is done, the file is reversed and the operation repeated. While at work the man or woman sits astride a "stock" which becomes covered with fine lead dust. This dust, metallic at first, becomes transformed into the more soluble oxide which is readily inhaled and swallowed.

Sheffield is the centre of the industry, the work being carried out in small and dirty workshops or in the homes of the workpeople. In the second step the files are hardened or tempered by being plunged into a bath of molten lead, and from this symptoms may occur.

In the five years before the War 53 cases were caused by cutting and only 12 by hardening.

Lead poisoning among file cutters is rapidly diminishing, because machine cut files tempered between hot iron bars are coming more into use. Moreover the file/

file makers themselves are better educated, less dirty and work under better conditions than formerly. Old trade customs die hard and as Oliver[5] remarks "File Cutters are extremely conservative in their work, and are averse to innovations. So, too, are the men who use the files". This sentence may well be remembered by the medical man who seeks to improve industrial conditions.

Like printers, and for similar reasons, file cutters suffered formerly a good deal ~~of~~ from pulmonary tuberculosis.

Tinning. In the tinning of hollow-ware the vessels are first cleaned with hydrochloric acid in the case of iron goods, or with chloride of zinc (killed spirits) in the case of copper and brass. The interior is swilled with a molten mixture of lead and tin. Interaction between the metal and the acid evolves soluble lead chloride vapour. Food cooked in cheap tinned ware is liable to contamination, so that the purchaser may suffer as well as the producer. The metal used for cheap goods sometimes contains as much as 70% of lead.

White/

White Lead. The manufacture of white lead is of the first importance from the point of view of industrial lead poisoning. It illustrates well the baneful effects of lead dust in absorbable form and the brilliant results of legislation.

Whichever of several processes is used, the underlying principle is to expose metallic lead to the action of acetic acid. The lead acetate so formed is then acted upon by carbonic acid gas, whereby it is converted eventually into a basic compound, hydroxy-carbonate of lead or "white lead". This has the formula $2PbCO_3,Pb(OH)_2$. and whether it is a chemical compound or a mechanical mixture matters not: it is sufficient to know that pure lead carbonate is useless as a pigment, and that the production of this amorphous basic compound is the aim and object of the manufacturer. The best white lead and more than half that produced in the world is made by the modified Dutch Process, the Chamber Process being the next most important.

(1) The Dutch Process. A series of wide-mouthed pots is arranged in a three walled room, the floor of which has been strewn with tan. The pots contain 3% acetic acid and upon them strips or girds of pure lead/

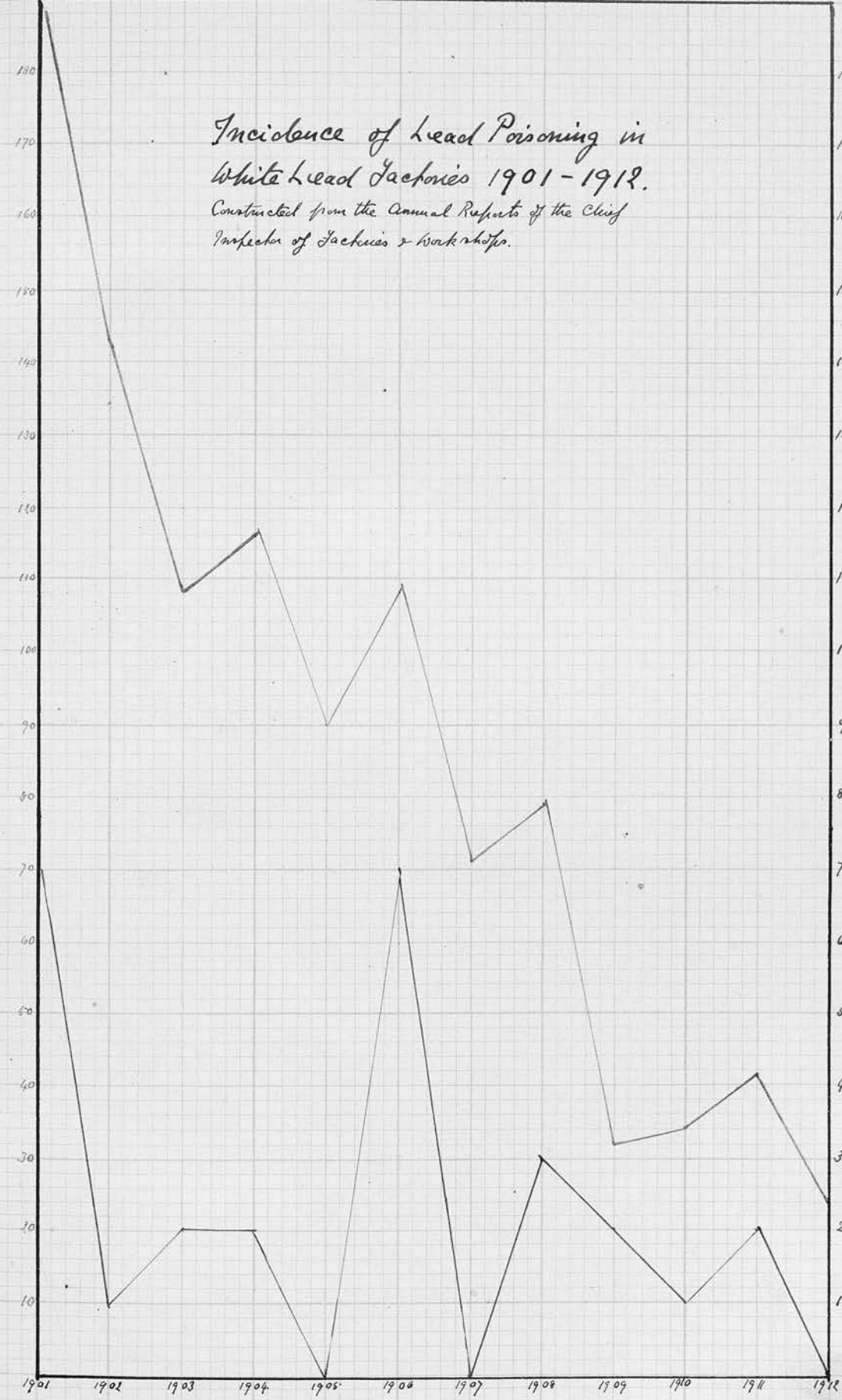
lead are placed, and finally planks of wood. Tiers or "heats" are thus built up to within 6 ft. of the roof, the whole stack or "blue-bed" being about 20 ft. high. The fourth side of the room is now closed in for 100-130 days. Fermentation takes place in the tan, carbon dioxide is evolved, and with the acetic acid vapour results in the chemical action described The temperature rises and is regulated by suitable vents, since too rapid corrosion must be avoided. When the process is complete some 70% of the metal has been converted and the stack, now called a "white-bed", is emptied.

Making up the blue-bed is not regarded as especially dangerous work, although plumbism may easily enough occur. Women are permitted to do it. Stripping the white-bed, however, is very dangerous work, particularly if the bed be not well sprayed to allay dust and if any considerable proportion of soluble lead acetate remain unconverted into carbonate. Women are not allowed to do this work.

The white lead is.picked off the uncorroded metal, washed, packed in pots or boxes and placed on shelves in the drying stove. Here it is dried by steam heat for about forty-eight hours. The dry product is ground and packed in barrels, or mixed with linseed oil and sold as paint. Like the white-beds, the stoves and packing/

Incidence of Lead Poisoning in White Lead Factories 1901 - 1912.

Constructed from the Annual Reports of the Chief Inspector of Factories & Workshops.



packing houses are a fruitful source of poisoning. Much of the danger is eliminated in those works where the white lead from the white-bed is transferred mechanically to the mixing department, washed, and subsequently ground by rollers with oil to form paint. The oil gradually replaces the water, and a finished product is obtained with the minimum amount of handling.

2. In the Chamber Process strips of lead hung over bars in a suitable chamber are acted upon by carbon di-oxide produced from burning coke and hot acetic acid vapour. Corrosion is quicker and more complete, but the finished product is stated to be inferior to that made by the Dutch method. The resulting white lead is moistened by steam, and the contents of the chamber dealt with as in the first process.

The Thénard or precipitation process used in France and an electrolytic method used in America produce inferior white lead and call for no further comment.

It will be seen at once that dust is the enemy of the white lead worker. The accompanying graph demonstrates the improvement in conditions between 1901 and 1912, and the table given at the beginning of this section shows that the improvement is maintained.

According to a recent[6] report (Jan. 1921) from the/

the Home Office diminution in reported plumbism is due to:- 1. Improved structural conditions. 2. Adoption of mechanical means (cranes, rails, hoists etc.) for conveyance of material in substitution of hand carrying. 3. Exhaust ventilation where dust arises, as in packing and paint mixing. 4. Periodic medical examination. 5. Diminution in the height of the stoves or adoption of mechanical drying stoves. 6. Conversion of white lead into paint by means of direct mixture with oil while in the pulp stage.

The manufacture of white lead is a key industry, and for that reason I have dealt with it rather fully. Despite world-wide * opposition to its use, no general substitute for it has been found.

Red Lead. The manufacture of red lead or minium (Pb_3O_4) is less dangerous than that of white lead. It is made by placing pure lead on the open hearth of a reverberatory furnace, heating it to dull redness and keeping it stirred with a long handled rake introduced through the furnace door. Slow oxidation forms litharge or massicot (PbO). This is washed, dried and heated at a/

* See notes on Continental legislation re paint.

a lower temperature until it assumes the characteristic colour of the higher oxide.

Workmen may be affected by fumes from a furnace which is badly hooded or in which the draft is defective, or by dust when raking the litharge, or in packing the finished red lead.

Red lead is now largely made by patent automatic processes, and the mechanics who repair the machinery are the persons likely to suffer.

The Manufacture of China and Earthenware.

This industry demands extended notice on account of the number of cases of lead poisoning to which it has given rise, and because of the Public and Parliamentary interest which this has excited. In addition to the general provisions of the Factory Acts, the Home Office have issued special rules upon several occasions for the regulation of potteries in which the operations were considered dangerous, viz:- 1894, 1898, 1901, 1903, and 1913.

In 1898 Professors Thorpe[7] and Oliver were appointed to make a special enquiry, and their findings were taken in evidence at an Arbitration Court[8] which gave its decisions in 1903. In 1908 a Departmental [9]Committee/

9 Committee was appointed to investigate the dangers attendant on the use of lead and other causes of ill health in the earthenware and china trade. The report of this committee, published in 1910 contains very full statistical and technical information concerning the whole subject.

The bulk of the trade is carried out in that part of North Staffordshire known as the potteries (329 out of 550 factories), but scattered up and down the country are small centres and isolated works - especially in Dorsetshire, Shropshire, Derbyshire, Yorkshire and parts of Scotland, notably the Kirkcaldy district and round about Glasgow. The trade includes the manufacture of china, earthenware, tiles, majolica, jet and "Rockingham", china furniture, electrical fittings and sanitary ware.

The stages of manufacture consist of (1) making the body (2) glazing (3) decorating.

The body is made of some kind of clay, or of a mixture of substances such as clay, cornish stone, flint and calcined bone, shaped and moulded in a *plastic state. After being dried, smoothed and perfected, the body is fired when it becomes "biscuit ware". This is porous and useless for holding liquids/

* Tiles are made by compressing damp powdered clay. This description is a general one.

liquids until impervious glaze has been applied. The glaze is a suspension of raw lead (carbonate, oxide and sometimes sulphide) with silicates and silico-borates in water, or of "fritted lead" and similar substances, or of leadless silicious material.

The biscuit ware is dipped into the glaze, swirled round and allowed to partially dry. Superfluous glaze is removed (ware cleaning) and the ware is again fired in a "glost" oven, whereby the glaze is fused and the familiar smooth finish is obtained. Further stages of finishing and polishing are gone through, depending upon the grade of the ware.

Decorating may be accomplished by (1) using a coloured glaze, e.g. majolica, which is applied to the biscuit ware by dipping, painting on, or blowing on with compressed air; (2) by under-glaze decoration, and (3) by on-glaze decoration. The two latter terms explain themselves, the coloured pattern being applied by various means, e.g. printing, painting, ground-laying, colour dusting, colour blowing, or the use of lithographic transfers. In the case of on-glaze decoration a further firing is required to fix the pattern.

Many of the pigments used contain lead and are a source of danger, but the majority of cases of poisoning occur from the use of raw lead glazes. Dipping/

Dipping is uncleanly work and much splashing occurs. The splashes dry and crumble, filling the air with noxious dust. Dust also arises in ware cleaning, glost placing, i.e. the various stages of placing and arranging glazed ware in the glost oven and removing it again; and, of course, in colour mixing and glaze making.

Fritted lead is lead which has been made comparatively insoluble by being mixed with silicates and borax and vitrified by heat in a frit-kiln. The glass-like product is ground by machinery and mixed with more silicious material to form glaze. A glaze which yields less than 5% of lead (calculated as monoxide) to excess of 0.25% hydrochloric acid in one hour at ordinary temperatures is spoken of as a low-solubility glaze. It is, however, a mistake to suppose that all lead silicates are insoluble in weak HCl or gastric juice, for the so-called mono-silicate, containing one molecule of lead oxide and one of silica, has been found to be freely soluble and has given rise to poisoning.[10.] *

It is evident that it is highly desirable to use leadless or low-solubility glazes whenever possible, and/

* Metallic lead, lead oxide etc. may occur in fritted glaze in an uncombined state.

and the evidence for and against was heard in great detail by the committee mentioned above.

There is nothing new in the use of leadless glaze; ancient glazed pottery free from lead has been found. In 1820 the Society of Arts awarded a medal for a leadless glaze which was supposed to be satisfactory, and manufacturers themselves have made numerous experiments in the past.

The arguments for and against may be summarised as follows:-

Raw lead glaze is readily maintained in a state of suspension, and the ware is easily coated. The ware is easily handled between the processes of dipping and glost firing. The glaze flows easily and conceals defects. The loss from "seconds" (pieces spoiled in firing) is small.

Leadless glaze can be used for most common ware, and some medium and better grade articles without appreciable increase in cost of production. There is, however, a greater tendency to "crazing",* less uniformity, more accidental defects, more opalinity and a more limited range of colours.

* The appearance of fine cracks throughout the glazed surface. This may take place after the goods have left the factory.

Low-solubility glaze is suitable for common and medium class ware, but owing to increased loss from "seconds" it is unsuitable generally for best class goods. At the same time it is to be noted that some firms like the Worcester Works are able to use it for their finest productions, but this firm admits being able to stand the increased cost owing to its holding a monopoly in certain lines.

The nature of the body used, the type of existing plant, and the class of goods made seem to be factors in determining the use of one glaze or the other by individual manufacturers. For the reproduction of old patterns, an important branch of the trade nowadays, raw lead glaze appears to be essential.

In 1913, the year before the War, 7085 persons were employed in pottery manufacture, 62 cases of lead poisoning were reported, and the attack rate per thousand was 9. Potters are an unhealthy class. "High in all age periods, the mortality figure beyond the 35th year exceeds the standard among occupied males generally by from 64-72%".[11]

While emphasing the part played by lead, it is well to remember that much of this ill health is due to pulmonary diseases caused by dust. Only 11%[12] of the workers are exposed to lead, whereas about 36% are/

are liable to inhale the dust of clay, flint and similar materials.

Diminution of plumbism in this industry is due chiefly to improved ventilation and exhaust appliances, the increased use of low-solubility and leadless glazes, medical inspection, and better personal and general cleanliness.

In this country we see nothing of pottery as a home industry, but it is practised on the continent, especially in Hungary, with all the attendant evils of lead-contact work in the domestic circle.

Litho-transfer making, is closely allied to the manufacture of pottery, although generally carried on in separate works. It consists in making paper transfers of coloured patterns for the decoration of ware in the white glazed state. Powdered enamel colours which frequently contain lead are used. Persons dusting these powders on to the transfers and those engaged in cleaning the machinery are exposed to lead poisoning.

Glass Cutting and Polishing, Poisoning may arise in glass making from the red lead used, and in cutting and polishing from the lead in the putty powder.

Enamelling, The making of enamelled iron plates for advertisements and similar purposes is carried on principally in the "Black Country". The plates are first cleaned, then smeared with gum solution and next dusted over with powder containing metallic dust, or a liquid containing the dust is allowed to trickle over them. The powder may contain as much as 20% of fritted lead.

The plate is now exposed to a high temperature in an oven, and subsequently cooled and washed. The required colours are painted on with brushes and allowed to dry. All letters, figures etc. are then formed by placing appropriate stencils on the plate, the dried paint surface over the parts exposed through the stencils being wiped off by women and girls. This part of the process raises clouds of dust, and unless this is removed by proper exhausts it is certain to be inhaled and swallowed. After stencilling the plate is again placed in the oven, the whole operation being repeated if other colours are required in addition to those first used, and in accordance with the complexity of the design.

Red lead and other lead compounds are used in the trade, but it has been reported that leadless glaze is becoming commoner.[13]

Baths/

Baths and other articles are enamelled in a similar manner, the process being carried on at a high temperature.

Electric Accumulators. This industry has become very prominent of recent years Perforated lead plates are cast and the holes in them are filled with a paste composed of red lead and sulphuric acid. These plates are cleaned, trimmed and assembled, and the necessary connections fitted on with the blow-pipe.

In 1913 there were 1,475 persons employed, with an attack rate of 30 per thousand. The Chief Inspector of Factories states that [14] "The electric accumulator industry is that now exposing workers to the greatest risk of plumbism. Analysis of 200 cases shows incidence to be proportionately as follows:- casting 9.5, pasting (including mixing and drossing) 31.0, lead burning 15.5, trimming, sawing, wire-brushing, filing and cleaning 19.0, trucking and handling plates 9.5, smelting and handling old accumulator plates 5.5, other 5.5." The use of machines for pasting and mixing, and the reduction of dust and fume in the other operations will reduce the incidence in this trade.

The Manufacture of Paints and Colours.

The majority of cases occur in the manufacture of white lead paint, particularly in the grinding and mixing departments. Goadby[15] and Legge are of opinion that the poison enters the system in the form of dust in at least 90% of the cases, and that in the remainder the possibility of dust being the cause cannot be excluded. These authorities give a table constructed from the analysis of 225 cases which were closely examined. Mixing and grinding accounts for 64% (144 cases), followed by the manufacture of chrome yellow, 9.8%, and packing 8.4%.

Dust arises in unheading the casks, scooping out the white lead and discharging it into the mill. In the making of chrome yellow dust arises in the drying, grinding, sieving and packing of the finished product. The object is necessarily to reduce the colours to the finest state of division, and adequate exhaust ventilation is required to prevent poisoning.

Lead Poisoning among Painters.

Painters may be divided roughly into those employed in:-

(1) Coach Building (railway and tramway carriages, motor cars, other vehicles and perambulators).

(2)/

(2) Ship Building (Government and private yards).

(3) Paint used in other industries.

(4) House painting.

In as much as notification of plumbism among house painters is not obligatory, it is difficult to ascertain the amount of ill-health among painters as a whole. Such investigations as have been carried out, suggest that lead poisoning among them is much more prevalent than it ought to be, and that serious symptoms such as paralysis are only too frequent. Personally I have been impressed by the large number of men who show signs of lead absorption, without being certifiable. Thus in a series of 22 painters examined recently at a Royal Dockyard, I found a blue line in 13, pallor in 6, systolic blood pressure exceeding 140 mm. Hg. in 8, albuminuria in 2, tremor of speech in 1 and no symptoms at all in 4.
All but two had been employed over ten years, the majority over twenty. These men all said that they felt well and were able to do their work, but the dividing line between health and disease must be small indeed.

It is this class of worker who is likely to suffer from the very chronic effects of plumbism, viz. hyperpiesis/

hyperpiesis, arteriosclerosis, and granular kidney, with attendant symptoms and complications.

As to how lead enters the system in painters there is a unanimity of opinion that dust is the principal factor. Dust arises in sandpapering painted surfaces, and also in scraping and chipping old paint, especially in confined spaces such as bilges and double bottoms. Dust may also arise in mixing the paints, and from dried paint upon overalls and about workshops. Oliver[16] states that he has treated women for double wrist-drop who had washed the overalls of their menfolk, and that he found large quantities of lead in the water from the wash-tubs. It is uncertain how the poison entered the body in these cases. There is no doubt, too, that lead often enters the alimentary canal from unwashed hands contaminated accidentally or by holding putty and white lead paint in the palm. The opportunity to wash before meals may be neglected or non-existent, particularly in the case of house painters. Of the 153 cases of lead poisoning recorded in the "Health of the Navy" between 1907 and 1914, several are definitely ascribed to uncleanly and careless habits in painters, or to unusual methods e.g. applying the paint by means of a swab held in the hand. Animals are very susceptible to lead, and

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I have met with two cases of dogs poisoned on board ship apparently by licking paint from their coats. One case occurred this* year in a spaniel introduced into a newly re-fitted ship which was literally reeking of wet paint. The animal was young and in poor health, having recovered from distemper a short time before. The symptoms were distaste for food, apparent nausea, vomiting, evident abdominal pain coming in spasms from time to time, listlessness, reduction in amount of urine, marked constipation, progressive weakness, coma and death.

Fumes from the burning off of old paint may be a contributory cause, but this is denied by Professor [17]Julius Stieglitz of Chicago, who thinks that the rise of temperature caused by short contact with the gasoline flame is insufficient to volatilize lead. The odour produced by the burning paint is far from pleasant, and such symptoms as nausea and headache may well be due to other causes. The burnt off paint, however, should be collected promptly and removed, lest it become pulverised and cause dust.

Lead may enter the system of painters through the skin - either through cracks and cuts, or through the unbroken integument. It is believed that this method of entry is a minor factor, but this will be discussed/

* 1921.

discussed more fully when the channels of lead absorption are considered as a whole.

Lastly the emanations from freshly painted surfaces may contain lead and to determine this question an enormous amount of experimental work has been done, with results which are somewhat contradictory. It is admitted that fresh paint-work produces commonly certain symptoms, but not usually the symptoms typical of plumbism. The intelligent householder avoids sleeping in newly painted rooms, ventilates them, and frequently places large bowls of water about in the belief that the emanations will be absorbed - a popular theory having a basis in fact. It is true that typical saturnine symptoms have occurred, but such symptoms as headache, nausea, vomiting, and a feeling of intoxication coming on rapidly suggest another cause.

[18]Legge and Goadby's experiments showed that animals exposed to vapours from various paints - both lead and zinc - soon exhibit symptoms of poisoning such as excessive salivation and emaciation; that turpentine vapour rapidly produced like symptoms, and that emanations from turpentine and lead acetate produced mild symptoms. But they found that lead paste (the fumes from which contained no lead, but traces/

traces of aldehyde, formic acid and carbon dioxide) proved harmless, as also did the metallic bases unless thrown into the air in such a way as to cause ordinary lead poisoning. Linseed oil alone had no ill effects.

Practical painters attribute the effects to turpentine and its oxidation products, and I am informed that the turpentine substitute (mineral vapourising oil) used in the Navy acts more rapidly, is more nauseating and is more intoxicating.

Armstrong and Klein[19] agree with this view, for they consider that the symptoms may be produced by any paint containing turpentine or similar substances. And this is supported in practice, since a white paint used in the Dockyards for ship's storerooms contains no turpentine or substitute, and gives rise to no symptoms. It has only the disadvantage of taking a long time to dry.

Ordinary Man-of-War Grey Paint.		White Paint for Storerooms.	
white lead	80 lbs.	white lead	81 lbs.
vegetable black	4 lbs.	marine dryers	8 lbs.
marine dryers	6 lbs.	raw linseed oil	23 pints.
linseed oil	15 pints.		
mineral vapourising oil.	6 pints.		

(Amounts to make one cwt. Marine dryer is a paste of patent composition).

On the other hand Trillat found that lead-oil-turpentine paint checked the growth of the mould, Aspergillus niger, whereas zinc-oil-turpentine did not, and he concluded that something of a harmful nature is evolved only when white lead, oil and turpentine are mixed together.

Bankart[20] working with Dr Arnold Phillip (Admiralty Chemist) found that minute quantities of lead, 7 - 14.7 parts per 100,000, were present in the emanations from turpentine filtered from lead "flatting" and tested at ordinary temperatures. These small amounts were difficult to detect, and none could be found by ordinary reagents (Hydrogen sulphide) in vapours from painted surfaces or in air bubbled through paint.

Oliver[21] states that traces of lead are found in paint emanations if a sufficiently delicate test (Trillat's) be used. These small amounts of lead may be contributory to the poisoning of painters, but can hardly be responsible for the acute symptoms experienced by many persons in the presence of fresh paint. Gardner[22] has shown that the vapours of drying paint contain carbon monoxide and carbon dioxide, besides formic acid and aldehydic substances. Carbon monoxide may be the cause of some of the symptoms,/

symptoms, and its presence in the blood of animals exposed to paint emanations has been confirmed by Oliver. We must conclude, therefore, that "Paint Sickness" is not due to lead, and such cases should not be returned under the heading of plumbism. It would seem to be due to substances given off by the drying of paints in which turpentine or similar hydro-carbons are combined with linseed oil and a metallic base, especially lead hydroxy-carbonate.

Dockyard workmen painting in enclosed spaces suffer from paint sickness, but the effects pass off rapidly on reaching the open air, and it is unusual for them to go off work or to seek medical advice. Individual experience and susceptibility varies, but the chief symptoms are:- headache, nausea, vomiting, abdominal pain, pain in the back, urinary irritation, sometimes slight haematuria, and a general intoxicated feeling.

In the Service Afloat these symptoms are rarely seen, because most of the painting done is on the ship's side and upper deck, interiors being repainted usually in the dockyards during periods of refitting. After this rather long, but I venture to think necessary, digression, one most return to the technical side of painting.

Coach/

Coach Building includes the painting of railway carriages, motor cars and perambulators. A well-finished coach may have as many as 15-18 coats of paint, each being smoothed down with sandpaper, before the varnish is put on. The first or priming coats and the later coats are frequently lead paints, but the intermediate ones may be some substitute such as ground slate, gold size and turpentine. It is possible to do some of the rubbing down by wet methods, e.g. pumice and water; but the priming and finishing coats, iron surfaces, curved surfaces and spokes are almost always smoothed with sandpaper. Moreover sandpaper is cheaper and quicker. The mechanical difficulties of applying exhaust ventilation are considerable, and more progress in the reduction of plumbism among coach-builders is to be expected from the further use of leadless paints.

Ship Building. Cases of lead poisoning in ship building are due to the dust caused in sandpapering in cabins and other living spaces. In large passenger-carrying ships much of the internal paintwork is of a highly decorative and skilled kind, and much smoothing and many coats may be required. In repainting the wardroom of a small ship a short time ago, the workmen applied no less

than/

than four coats of flatting before the surface was deemed fit for the final enamel. Each coat had to be rubbed down dry.

Chipping and scraping old paint, especially in tanks, double-bottoms and confined spaces generally - splashing from injecting red lead between plates - fumes from burning off old paint, and possibly emanations from new, are all sources of plumbism.

Two processes, especially prone to create splashing and regarded as objectionable by the workers, may be mentioned, since little attention has been directed to them hitherto.

(a) "Flatting", that is putting a primary thin coat of paint on metal or wood, the paint containing much turpentine and little oil. This work is tedious, is often done carelessly and is always followed by smoothing, sandpapering and filling. Splashing occurs most when overhead surfaces are being treated. Fleet Surgeon F.H. Nimmo stated in the 1912 volume of "The Health of the Navy" that probably the most fruitful source of lead poisoning was "flatting" .....
"a good deal being scattered in painting the roofs of compartments, and which when it dries is liable to come off in flakes, to mix with the dust on the floor and be stirred up again when the latter is swept."

(b)/

(b) Painting cork surfaces. These are formed by applying a preparation of cork chips and paint to any metal surface which is likely to "sweat", i.e. be affected by condensation of atmospheric moisture. In these days when it is considered necessary to reduce woodwork in fighting ships to a minimum, cork surfaces are found on the roofs and sides of many living spaces, cabins, bathrooms, water-closets and other compartments. Re-painting these is hard and splashy work.

As in coach building so in ship building, the incidence of plumbism has shown no tendency to fall, except in government yards. The improvement in the latter is due to:- strict medical supervision, adequate time and facilities for ablution, proper changing rooms, routine use of overalls which are washed in the yard, limitation of time spent in red lead work, use of oxide of iron paint in double-bottoms etc., and realisation by the men of the risk run.

The following table, constructed from Home Office returns is of interest.

TABLE III./

TABLE III.

Lead Poisoning among Ship Painters.

Period.	cases in gmt: yards.	cases in private yards.
1899-1904	110	67
1905-1910	60	87
1910-1914.	46	107

The increase in the private yards is noteworthy.

Lead poisoning in the Navy (i.e. the Service Afloat) is not included in any of the above returns. It is almost entirely due to paint, and in the years before the War occupied the second place on the list as a cause of poisoning (15% of all cases) under which heading it was returned, ptomaine poisoning being first (75%), and the remainder being of a very miscellaneous nature.

I have constructed Table IV from the official returns for the years 1907-14 inclusive. The 1914 return is the latest available, but my personal impression is that during the War cases were absolutely fewer; the reason being that the peacetime "spit and polish" routine, as it was aptly if vulgarly called, was forced to give way to more serious considerations, and/

and in any case a large amount of painting was done when in dockyard hands. That there will be a re-crudescence of plumbism now, I feel certain, despite the fact that paint allowances are limited and that much internal work is still done in the dockyard. I have never yet been in a fully commissioned ship which did not exhibit wet paint in some part or another throughout the year. The amount of painting done is colossal, and the chief reason why more lead poisoning does not occur is that the work is divided among many men, and it is rare for ordinary ratings to be continually employed at it.

Naturally the incidence is higher among painters rated as such, as they are concerned continually with lead, mixing the colours as well as applying them.

The information given in some years is meagre and it is impossible to state an attack rate.

TABLE IV./

TABLE IV.

Year	Total cases plumbism	permanently invalided.	died.	painters affected.	cases due to paint.	cases due to other causes.
1907	37	2	-	not	stated	
1908	16	-	-	not	stated	
1909	21	-	-	7	?21	-
1910	16	-	-	4	10	6
1911	26	3	-	10	23	3
1912	13	-	-	4	13	-
1913	16	-	-	3	16	-
1914	8	3	-	1	not stated	
	153	8	0	29	83	9

The 153 cases recorded actually refer to 146 persons. The irregular incidence is accounted for partly perhaps by the varying precautions taken in different ships, but chiefly by the varying employments of the ships concerned. Even in this incomplete return paint is the outstanding cause of lead poisoning in the Navy. If we exclude the 29 painters, it is a striking fact that so many other ratings, not painters by profession, should have become affected, and it is a sound argument against the regular employment of seamen, stokers and marines in this sort of work.

House painters and paint used in other industries.

Little need be said about this group, since I have already shewn how all painters may become poisoned. Many housepainting firms are quite small businesses in which the employer is himself a working painter. The trade is free from control and inspection, apprentices may remain ignorant of risks run, and opportunities for cleanliness are never organised and are frequently non-existent.

I cannot confirm[23] Garrod's often quoted observation that painters are especially subject to gout, nor have I found them particularly intemperate.

There is a feeling among dockyard workmen that painters/

painters are rather short lived. Thus at one of the smaller Royal Dockyards about 20 established painters are employed in addition to assistants, etc.
A chargeman of many years' experience did not remember more than two painters drawing a pension at any one time. The pension age, however, is sixty, and it is difficult to produce figures of definite value to prove or disprove this contention.

Lead paints versus leadless paints.

At this point it is convenient to discuss briefly this important question, affecting as it does the matter of prevention so largely.

Paint made with white lead has several important and outstanding qualities. White lead made by the Dutch process is a fine amorphous powder, consisting of particles of varying size. This and the fact that it is basic, cause it to combine easily with linseed oil, part of the oil becoming saponified, to form a smooth, opaque paint with great covering power and ease in working, such as painters require. Again, as pointed out by Dr Lawrie[24] of the Heriot-Watt College, Edinburgh, it is itself a "dryer" - that is to say its presence expedites the absorption of oxygen by linseed oil, whereby the fatty acid becomes converted into oxy-linoleic acid, and the oil assumes its most stable/

stable form. Paints made with other substances are practically mechanical mixtures, and crystalline pigments like barium sulphate find little favour.

White lead paint is darkened by hydrogen sulphide, but withstands sulphurous acid gas (found in coal smoke) better than zinc paints. It is generally conceeded that for all internal decoration zinc-white paints and lithopone* may be used and that their actual cost is no more. Zinc flatting is preferred in Naval Dockyards prior to enamelling on account of its whiteness. Lithopone paints are useless outside, but zinc-white paints give good results so long as they are not exposed unduly to the weather, damp, or the action of sulphurous acid gas.

Re-painting woodwork outside with zinc paint is more costly since the wood requires more preparation than in the case of lead paint. The covering power of both is about the same when applied by skilled workmen, but lead paint is much easier to put on.

In shipbuilding red lead paint must be used for under-water structures, but above water oxide of iron may be used for first coats. The latter is cheaper, but subsequent covering coats require more technical skill in the application than is the case with red lead./

* Lithopone is a mixture of Zinc Sulphide and Barium Sulphate.

lead.

Probably in shipbuilding a large quantity of lead paint will always be used (4/5 of all paint used in Royal Dockyards), but considerable progress has been made in the use of leadless paints in other directions.

Almost all the Continental Powers have given this matter their attention and have drafted regulations to diminish the use of lead paints. It is unnecessary to consider these in detail. They seek to prohibit the handling and transportation of white lead unless previously mixed with oil, the use of lead paints for interiors, the practice of dry rubbing and sandpapering painted surfaces, and to provide for medical inspection and personal cleanliness.

The French passed a law in 1909 prohibiting the use of white lead in paint altogether after 1914, but it is doubtful if this can be made an effective measure. In this country the whole subject of paint and painters is engaging the attention of the Government at the present time.

Other industries in which lead occurs.

It is enough to indicate briefly those in which cases of poisoning have been known to occur.

(1) The tinning of harness furniture.

(2) Buffer springs are tempered in a bath of molten lead.

(3) In several trades old metal is sorted and old lead re-melted. I have notes of a case of colic in a workman employed in melting down old submarine accumulator plates which had been sent home from a foreign station. These casual jobs are often undertaken without proper precautions.

(4) Shot making.

(5) Manufacture of solder.

(6) Coating cables.

(7) Tinning nails.

(8) Making capsules for bottles.

(9) Polishing precious stones. They are first embedded in an alloy of lead and tin, and then polished by a rapidly revolving wheel.

(10) Heading of cotton yarn dyed with lead chromate - baking[25] powder has been found contaminated with this pigment.

(11) Manufacture of india rubber. Litharge, massicot, red lead and lead sulphide are mixed with the raw rubber in the process.

The supply of Water is sometimes an industrial undertaking, but usually the responsibility is accepted by the municipality. In any cases it is, of course, the consumer who suffers when the supply becomes contaminated with lead.

Waters which may be plumbo-solvent are:-

1. Very soft waters.
2. Acid waters from peaty uplands.
3. Waters from polluted shallow wells containing excess of carbon dioxide and nitrates (Thresh).

Erosion of pipes may be due to highly aerated water or to the intermittent supply system, and iron-lead junctions may cause solution of lead by galvanic action.

Bottled mineral waters have been found on occasion to contain appreciable amounts of lead.[26.]

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17./

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AETIOLOGY, SYMPTOMATOLOGY AND DIAGNOSIS.

General aetiological and pathological considerations.

In the present thesis I am more concerned with what have been called the sequels of long continued lead absorption, than with the signs and symptoms which are accepted as indicating lead poisoning.

But before describing either it is desirable to discuss the channels by which lead enters the body, the manner of its absorption and ultimate fate within the body so far as these are known, and the mode of its excretion. This will lead naturally to the questions of susceptibility, tolerance and predisposition.

Consideration of the trades in which plumbism is prone to occur has emphasised the importance of dust in no uncertain manner. Throughout the whole realm of industrial medicine dust in one form or another is the most dangerous enemy. The danger arising from lead dust will depend upon its solubility and fineness, and it is interesting to note that Goadby[1] has shown by means of micrometric investigations that particles of lead frit average ten times the size of particles of/

of white lead. The latter will therefore remain suspended in the air longer than the former - a fact which can be demonstrated by comparing the rate of settling of the two dusts in parallel beams of light. It is obvious that lead dust may enter the body in two ways:-

(a) Through the Respiratory System.

(b) Through the Alimentary System.

The alimentary channel is favoured by Professor Oliver, who considers that the larger part of the dust is arrested by the moist mucous membranes of the mouth, nose and throat, to be swallowed eventually and dissolved by the acid gastric juice. He supports this contention by the fact that lead dust may be found about the gums and teeth of men working in dusty processes, by the large amount of lead found in the liver of fatal cases, and by the fact that persons commencing work on an empty stomach are far more liable to lead poisoning than those who come to the factory after a proper meal. He[2] quotes observers (Lehmann of Warzburg and Saito) who have found that only 12% of lead reaches the lungs, whereas 70% may be found in the alimentary canal, notwithstanding the fact that the upper respiratory passages are the initial channel of entrance. Meillère[3] supports these views.

On/

On the other hand Alderson and more lately Goadby and Legge have drawn attention to the lungs as a definite and dangerous site of absorption. The last named observers have demonstrated in a striking[4] experiment that less lead dust is arrested by the upper air passages than one is disposed to think. They point out that white lead, red lead and litharge are not easily suspended in water without long continued mixing, and that these dusts are not very easily layed by means of water sprays. To one end of a series of wash-bottles containing water they attached a flask containing dilute nitric acid saturated with hydrogen sulphide, and to the other end a flask containing dry white lead powder. The connections were so made that dust from the lead flask had to pass four 2 inch water seals and through eight feet of wet ¼ inch rubber tubing before reaching the sulphide solution. Air was now drawn through the apparatus at the rate of ordinary respiration, while the white lead flask was agitated to impregnate the air current with dust. Despite the tubing and water seals, lead was quickly detected in the last flask.

The same observers[5] carried out a series of experiments upon animals (cats) which demonstrated that animals were more easily poisoned by inhaling lead dust than by lead given with the food. It must, however,/

however, be admitted that whether lead dust is ultimately swallowed or is inspired into the pulmonary alveoli is largely beyond experimental control; and further that the mucus-moistened and complicated upper respiratory tract, designed among other things expressly to arrest dust, can only be compared in a rough way with a system of rubber tubing and glass bottles. That large quantities of dust can and do reach the lungs is amply demonstrated by the pneumokonioses, and should these dusts be toxic it is reasonable to suppose that serious consequences will ensue.

A more up-to-date and perhaps more striking instance is found in the development of the latest and most lethal "poison gases". These are particulate clouds analogous to smoke, and are not gases in the strictly physical sense. They can be arrested by cellulose and cotton-wool filters.

Whichever channel one deems the most important, the discussion has served to emphasise the position of dust. Fume certainly affects the system via the lungs, and the high toxicity of lead in this form is probably due to the fine state of subdivision in which it is deposited in the alveoli, as is the case with nickel carbonyl. Then, too, lead in the lungs remains liable to absorption, whereas lead in the bowel is/

is not yet within the system: in the presence of food in the upper tracts and of hydrogen sulphide in the large bowel, the bulk of the lead in the alimentary canal stands a good chance of excretion with the faeces.

I think it would be fair to sum up the controversy by saying that lead which enters the lungs is more dangerous than lead which enters the stomach, but that in the majority of lead-contact trades less lead enters the pulmonary than the alimentary system.

Of the ultimate fate of lead compounds within the pulmonary alveoli little is known. It is generally considered that solution is facilitated by the excess of carbon dioxide in the air and fluids of the lung, and that phagocytosis plays a part in removing whole particles to situations within the tissues where they are gradually acted upon by the serum.

What may be termed gross alimentary intake of lead occurs in the careless and uncleanly, as well as in persons poisoned by contaminated food and water. I am of opinion that this is not an infrequent source of poisoning in painters, and in this I am supported by opinions quoted in the Statistical Reports of the Health of the Navy. At the same time I do not underestimate the importance of dust.

What happens to lead compounds on reaching the stomach?

It was taught formerly that lead was absorbed principally/

principally from the stomach and that it was absorbed as the chloride. It was stated that the chloride was fairly soluble in acid solution and was dialisable, whereas the albuminate was not. Goadby, Legge and numerous continental workers have shown by means of artificial gastric digestions that very little solution of lead compounds takes place in the normal stomach, and that an albuminate of lead is readily formed in the presence of food. It is admitted that more gastric solution and absorption may take place when hyperchlorhydria is present, or in the presence of appreciable quantities of organic acids - lactic, acetic and butyric acids - due to disease.

Peptonate or albuminate of lead passes the pylorus, and under the influence of pancreatic digestion soluble and absorbable compounds are formed in the upper part of the small intestine. Pancreatic digestion alone (in vitro) has very little effect upon insoluble lead compounds, but it would appear that the maximum effect is produced when it follows normal gastric digestion. The authorities[6] cited have shown that soluble lead compounds are easily absorbed from the upper part of the small intestine of cats, and that lead can be recovered from the blood of the mesenteric vein. The precise form in which the lead is absorbed and in which it circulates is unknown.

Possibly/

Possibly it is colloidal lead, a form not precipitated by hydrogen sulphide. Histological evidence suggests that phagocytes assist absorption and it is thought that the lead particles are converted into colloidal form within them. The alkaline bile is stated to favour solution and absorption, and it is not unreasonable to suggest that some of the lead is absorbed as a soap, especially in view of the ease with which diachylon causes poisoning in human beings and white lead paint (when swallowed) in animals.

The skin, as a channel of lead absorption, has been forced into the background by the importance necessarily attached to the pulmonary and alimentary routes, and by the controversy as to their respective positions. The majority of British observers have been content with the statement that it is an uncommon and important mode of entrance.

That this is true of many lead-contact trades I do not doubt. But in paint and putty we have lead in a form capable of passing through the skin. If contact were confined to the thickened skin of the palms little absorption would take place, but one has only to see painters at work, especially in awkward parts of ships, to realise that the palms are not the only skin surfaces exposed, apart altogether from uncleanly/

uncleanly or careless habits. There is no getting away from the fact that the most efficacious and rapid method of bringing a patient under the influence of mercury (outside the intravenous injection of a soluble salt) is inunction, and that in infants the rubbing may be omitted and the mercurial merely applied upon a binder. It is difficult to see why other heavy metals should behave differently even if their atomic weight be lower. Moreover soaps penetrate the skin better than ordinary ointments, and white lead paint is a soap in part. It is for this reason that I consider the skin to be a definite and constant, though possibly minor, channel of absorption in painters. The evidence is circumstantial. To obtain direct evidence is made difficult by the fact that the skin is also a path of elimination. This is the rationale of the double electric bath so strongly advocated by Professor Oliver, and moreover lead was found by Bedson[7] in the sweat of some of Oliver's lead poisoned patients. From both points of view, absorption and elimination, the practical lesson is to advocate the frequent use of the hot bath for all lead workers, in addition to the ordinary ablutions practiced by the industrial classes. Lead has occasionally been absorbed from the skin in fatal amounts as the result of/

of the use of hair dyes and cosmetics. Oliver relates a striking case[8] in one of his books where the symptoms were not recognised, and a fatal issue was precipitated by the potassium iodide administered for their cure.

In whatever form lead circulates, the weight of its attack is borne by the blood and smaller blood vessels, as a consideration of the pathology of the individual symptoms will show.

Numerous post-mortem examinations have demonstrated that lead may be found in all the organs of persons who have died of saturnine intoxication, but its distribution is rather inconstant and its presence has not always been recognised in organs where one might expect to find it, e.g. in the brain of persons dead of saturnine encephalopathy. It is found most constantly and in the greatest amount in the liver, large intestine, small intestine, bone and bone marrow. Parenthetically it must be added that it is believed by some that traces of lead may occur "normally" in the body, being ingested with the food. This may well be so at the present day, owing to the large use of tinned food stuffs and the amount of manufactured products consumed. Gautier* found two milligrammes of/

* Quoted by Goadby.

of lead in sixty millegrammes of rat liver, but mus decumanus is omniverous in the fullest sense of the word.

As regards the minimal lethal dose, Goadby in his experiments found that animals invariably succumbed when exposed three times a week for half an hour to air containing 0.0001 to 0.0003 grammes per litre of lead dust, but that when the lead content was only 0.00001 gramme per litre symptoms were delayed and even a degree of tolerance might be established.

The principal channel of lead excretion is the large intestine. Dixon Mann[9] conducted experiments which showed that about two thirds of the lead taken by the mouth appears in the faeces, and he demonstrated this method of excretion in cases of lead poisoning to which potassium iodide was administered. Lead in process of excretion through the intestinal wall, as well as lead which has not been absorbed into the system, is brought into contact with sulphuretted hydrogen within the bowel and fixed in a comparatively insoluble form - the sulphide. The routine administration of a sanitary drink to lead workers has a similar object in view, viz. the production of the insoluble sulphate.

The kidney is the only other excretory channel of/

of importance. I have mentioned the skin. The saliva, milk and bile may be added.

In cases of acute poisoning a good deal of lead may appear in the urine at first, but the amount falls rapidly. In chronic cases it is rare that more than five millegrammes are excreted in the twenty-four hours. But this in no way mitigates the evil effects of lead upon the kidney, affecting both the secretory tissue and the blood vessels. The amount found in the urine is usually small and in a form difficult to detect,* but its detection where possible is a valuable aid to diagnosis. Lead in the urine, in the absence of other symptoms, no more connotes lead poisoning than does albumin indicate nephritis. It means that lead has been absorbed into the system and is being removed. That is all.

Unfortunately, although the detection and even the quantitative estimation of lead in water is fairly easy and within the compass of most medical officers in the Public Services, the detection of lead in urine is rendered difficult owing to its combination with organic substances. Where such investigations are required they are best referred to a competent chemist and a fully equipped laboratory.

* A rough method is to suspend a small bag of calcium sulphide in the urine and to observe if blackening occurs. Other heavy metals used in medicine must be excluded.

Lead is essentially a cumulative poison and its effect upon any individual will depend upon the amount actually in circulation at a given time. "Long[11] continued contact with the metal does not necessarily confer immunity. Lead is unlike many poisons. There can be no trifling with it." Personally I doubt if it is wise to use the word immunity at all in connection with lead. One does not see among lead workers that immunity or tolerance which may be acquired in the case, say, of tobacco, alcohol or morphia. A balance of absorption and excretion is reached: should anything occur to upset this balance, poisoning will ensue. Moreover the presence in the body of small quantities of lead over long periods is definitely productive of harm, so that a man who has never suffered from certifiable plumbism may have his life shortened by it. In a way this is comparable to the chronic tippler of spirits, who, while never drunk, is an infinitely worse insurance risk than the man who has an occasional but downright debauch.

That it takes some time to arrive at a state of balance or tolerance is seen clinically in young lead workers who have recently taken up the trade. They lose colour and weight rather rapidly at first, the process/

process then comes to a standstill, and they regain finally much of their physical condition without at any time actually suffering in health or being under treatment. Where the process is too rapid, alternative employment can sometimes be arranged temporarily. This process could be observed very plainly at a Royal Naval Establishment, where many of the workmen were country-bred and had the fresh complexion characteristic of the country. I would hesitate to call this acquired immunity or even a degree of immunity. As with other poisons, so with lead, some people are more susceptible than others. Apart from personal habits and methods there is a definite individual susceptibility, and some observers have stated that persons with red[12] hair and fresh complexions react more readily. Oliver and others have cited striking instances of family susceptibility. As regards age there is universal agreement that young and growing persons are influenced more easily than those whose tissues have reached an equilibrium. Then there is sex susceptibility. The Admiralty do not employ women in lead contact work in ordinary times, so that medical officers in the Navy have no practical experience of women workers. It is, however, accepted by the majority of observers throughout the world that women are much more susceptible to saturnine/

saturnine poisoning than men. Goadby and Legge[13] state that "females are at least twice, and probably three times, as susceptible to lead poisoning as are males. Much of this susceptibility is determined by the extra stress thrown on the female generative organs". Sir Thomas Oliver, whose strenuous advocacy of this point caused the Home Office to withdraw female labour from certain white lead processes in June 1898, adds[14] that "females suffer from the worst forms of lead poisoning. They experience severe headache, and without having colic or wrist drop they may pass without warning into convulsions in which they die, or if they recover from these their eyesight is temporarily or permanently lost".

There is overwhelming evidence throughout the literature of the baneful effect of lead upon women, and as stated the doctrine is accepted by most observers in this country, on the continent and in America. So far as it is possible, the clinical evidence is supported by experiments upon animals referred to in the works of the authorities quoted. Even if a "leaded" woman reach term, it is likely that the child will be still-born or die shortly after birth.

A heavy inheritance of lead may be passed from the mother to the child - a fact recognised years ago by Tyneside/

Tyneside lead workers as possibly benefitting the mother at the expense of the offspring.

I have emphasised the position of women deliberately because I find that sexual susceptibility is flatly denied in a recent[15] work, and because I feel that such teaching is dangerous in view of the accumulated evidence. The argument is based upon the statements (1) that there was an increase in the reported cases of poisoning when men replaced women in 1897,* (2) that there was no increase when women were allowed to partly replace men during the War, and (3) that there was again some increase when men returned from the War and once again replaced women. These authors ignore the fact (1) that precautionary measures and methods of manufacture have improved vastly, and that the white lead industry is much less harmful than it used to be, (2) that the danger of re-admitting women was realised and guarded against, and (3) that there was a slump in the industry during the War, and that the post-war activity required extra hands many of whom would be new to the work. Further the woman of 1914 was probably a cleaner and more intelligent person than her predecessor twenty years before. These authors admit that "the effect of plumbism in causing miscarriage and still-birth is a/

* Actually this did not take place until the middle of 1898.

a sufficient reason for excluding females from exposure to lead dust; but", they continue, "we do not feel satisfied that they fall victims more readily than men ..... We are unaware of scientific evidence in support of the alleged sexual proclivity and regret that a case sound in itself, should be supported by unsound arguments".

After all the function of child-bearing constitutes the female sex, and if this is constantly and seriously interfered with by lead, that fact alone justifies one in proclaiming a sexual susceptibility. One cannot separate woman and reproduction, but even if one did the balance of evidence would be in favour of the female sex being more easily and more seriously affected by lead than the male.

It has been said that an increase of miscarriages and still-births in a town should cause the authorities to turn their attention to the possibility of lead in the water supply.

An attempt has been made, notably by Verhaeghe of Lille, to prove that the male lead-carrier can also affect foetal life adversely.

Finally it would seem that certain morbid conditions predispose to lead poisoning, and that certain diseases run a more rapid course when associated with lead absorption.

Anaemia/

Anaemia is itself a symptom of saturnine intoxication but where an anaemic condition pre-exists the blood and blood forming organs are less able to withstand the onslaught of lead. Among the industrial classes two kinds of anaemia are found commonly:-

(a) The chlorosis, usually mild, of adolescents.

(b) Septic anaemia which has its origin in unclean conditions of the mouth, nose and throat, and especially and primarily in neglect of the teeth.

The former is almost a physiological result of the coincidence of sexual development and the beginning of wage-earning; the latter is an appallingly common and eminently preventable condition among the lower and lower middle classes. It is, perhaps, responsible in part for rheumatism, arthritis and other vague complaints attributed sometimes to lead, and it is doubtless responsible to a large extent for the dyspepsia, to use a wide term, which is the curse of the working classes.

Chronic alcoholism enhances the evil effects of lead absorption, and it is difficult to distinguish among workmen of some standing between the action of the two poisons upon the urinary and circulatory systems. There is evidence[16] in favour of the belief that the use of alcohol increases the absorption of lead from the alimentary canal.

Poverty/

Poverty and malnutrition aggravate any chronic intoxication, and therefore it is desirable that lead workers should be properly paid and not recruited from among the abjectly poor. Casual labour is objectionable. The importance of beginning the day's work after a meal and the diminished risk of lead absorption from a stomach which contains food have been amply demonstrated.

The association of plumbism and pulmonary tuberculosis has been referred to while discussing individual trades - especially file-cutting, printing and pottery manufacture.

The Signs and Symptoms of Lead Poisoning.

Lead poisoning may be acute or chronic. Cases of acute poisoning are rare, but acute symptoms may set in with alarming suddenness in persons who are the subjects of chronic lead absorption, or the typical symptoms may develop more rapidly than usual. Da Costa quoted by Osler[17] reported a case of paralysis after three days exposure to lead.

Acute lead poisoning proper may result from the ingestion of a large dose of a soluble lead salt (acetate) or of diachylon taken by accident, to induce abortion or with suicidal intent. The symptoms are/

are those of acute irritant poisoning - a burning rather sweetish taste in the mouth, thirst, abdominal pain, vomiting and collapse. If the bowels are open the faeces are black with lead sulphide. The patient may pass into a state of coma and die, or if he recover from the acute symptoms he may suffer from the effect of absorbed lead. In other words the case becomes one of chronic lead poisoning. Post mortem the stomach and intestines show signs of irritant poisoning; lead can be detected in the faeces and urine, and may be present in the internal organs, especially the liver and red bone marrow. Lead used medicinally rarely causes symptoms, but according to Osler poisoning has followed the use of* gr 1 three hourly for three days, and gr II every three hours for one day.

Chronic lead poisoning. In lead contact occupations such as painting and plumbing the train of symptoms follows a fairly definite course, so that medical inspection should be able to detect many cases before serious harm arises. In occupations like the white and red lead trades, a proportion of cases may develop rather rapidly. Under the influence of lead the workman loses his colour and his weight. The loss of/

* Presumably the acetate.

of weight is not often marked or rapid, and is most noticeable as a diminution of the periorbital fat. With the pallor there develops a "muddy" complexion and a dirty yellow staining of the conjunctivae. The urine is often high coloured. These evidences of blood destruction may be confirmed by clinical examination. This is the state of saturnine cachexia seen in almost all lead workers to some extent, and from it there is frequently a spontaneous though partial recovery as a condition of balance or toleration is acquired.

As absorption continues a blue line develops about the gums, especially where the teeth are decayed; the breath becomes foul and a sweetish metallic taste develops in the mouth. The man may complain of headache and loss of appetite. There is general dullness, the facial expression is dull and the eyes sunken. Constipation occurs, sometimes relieved by attacks of diarrhoea. Then, after a longer period of constipation than usual, lead colic - the dry bellyache of Hunter[18] - sets in with characteristic suddenness and severity. Colic is the most common and most typical symptom of lead poisoning, accounting for fully 75% of the notifications.[19]

It is after one or two warning attacks of colic that the serious nervous symptoms are likely to occur, although/

although their advent may be unheralded and dramatic. These nervous symptoms include saturnine encephalopathy resulting in death or in recovery with loss of vision or mental deterioration, and various forms of peripheral neuritis. More remote but serious enough are the effects of long continued absorption upon the kidneys and circulation-arteriosclerosis, hyperpiesis, and chronic nephritis.

In women disordered and excessive menstrual flow and abortion commonly occur, but it is not my purpose to refer further to this group of symptoms.

Many other ill effects have been attributed rightly or wrongly to lead - gout, arthritis and rheumatic manifestations - neurasthenic states - and gradual loss of mental and physical powers in the middle aged. There is a decided tendency on the part of work people and some practitioners to attribute many ills to lead directly and indirectly. It is thought that this is the chief reason why the deaths notified as due to plumbism have not fallen in proportion to the cases.

Death should not be attributed to lead without reasonable justification.

It will be seen that the dividing line between obvious and legal lead poisoning on the one hand and a/

a state of chronic ill-health and saturnine intoxication on the other is a narrow one, and that it is difficult to assess rightly the responsibility of the latter in bringing about death in any given case from, let us say, uraemia or cerebral haemorrhage. A more detailed consideration of the symptoms will enable one to judge their value and significance more accurately.

Pallor. As already stated this is a practically constant symptom in lead poisoning and is present in many workmen who make no complaint.

In a series of twenty-two painters seen at one of the smaller Royal Dockyards, who were considered healthy and marked 1/A* in the Health Register, definite pallor was present in six. These men had worked with lead from 1 year 8 months to 42 years. Among the painters, plumbers and tin-smiths under my charge at a Naval Establishment, pallor was much more frequent and was almost the rule among the newer hands. In notes of cases of actual poisoning recorded at a Royal Dockyard its presence was invariable.

This pallor is due partly to blood destruction and consequent anaemia, and partly to contraction of the facial vessels thought to result from irritation of their nerve supply. Examination of the conjunctivae and of the blood itself will reveal less anaemia/

* Explained in section on prevention.

anaemia than the facial appearance would suggest. The haemoglobin may be little reduced. Such a worker may be made to flush in various ways, thus demonstrating the constriction of the facial vessels.

In more marked cases other signs of blood destruction are present - yellow staining of the sclerotics, muddy complexion and high coloured urine. Haematoporphyrin may be detected in the latter.

The symptoms are most noticeable in those whose complexion and appearance are naturally fresh and healthy, and they are accompanied by loss of facial fulness, some loss of weight and lack of energy. The onset of these symptoms, especially in a new worker, call for temporary removal from lead contact work and further investigation.

The blood bears the brunt of the attack, but it is characteristic of plumbism that the anaemic appearance of the patient is out of proportion to the changes actually found. It is rare for either the haemoglobin or the red cells to fall below fifty per cent. In the very chronic type of absorption seem among painters the haemoglobin will be found to lie between 70 and 85% with very little change in the count.

In more severe cases definite diminution of the erythrocytes/

erythrocytes is found, together with the presence of microcytes, macrocytes and poikilocytes. Osler[20] states that Cadwalader has shown the constant presence of nucleated red cells even when the anaemia is of slight grade, but Legge and Goadby[21] state that nucleated reds are rare. I have never seen them in my cases of chronic lead absorption. Other changes in the red cells include occasional vacuolation, increased[22] elasticity (i.e. lessened liability to damage when spread in a film), and the occurrence of basophil granules.

Considerable diagnostic importance is attached to the last change, particularly by German observers. Some regard the basophil stippling as a sign of degeneration, others as an indication of increased blood output on the supposition that they are the incompletely degenerated nuclei of normoblasts hurried into the circulation. This punctate basophilia is easily demonstrated by Leishman's stain.

Its presence was described in the first place by Grawitz in cases of pernicious anaemia, and it may be found in many severe anaemias, e.g. chronic malaria and nitro-benzine poisoning. I have seen it most often in cases of malaria of long standing, and have found it too in cases of lead absorption, but cannot regard/

regard it as a valuable finding. In addition to this change, general discolouration of the whole corpuscle is sometimes seen.

Before the War there was a "Lead Station" at the Hygiene Institute of the University of Leipzig presided over by Professor Hofmann. Here the blood of lead workers, either sent by the Sick Insurance Club or coming of their own accord, was examined, especially as to haemoglobin content and basophilia. When the basophil red cells exceeded 100 per million of red corpuscles counted, plumbism was strongly suspected and necessary measures taken. Professor[23] Hofmann states that the number of basophil granule red blood corpuscles in normal persons is much below 100, but that in those who have to do with lead 300,500,1000 and 5000 per million are found, and in a case of attempted suicide by lead 27,000 per million were counted. Malaria and cachexia from other causes must be excluded.

Observers in this country are less enthusiastic about basophilia, and the operation takes too long to be made a routine measure.

The white cells either show no change or a slight increase, with an absolute increase of large and small mononuclears and eosinophils.

Pallor/

Pallor is an important warning sign in a lead worker particularly when combined with loss of general health, but that it is not necessarily due to lead and that every case merits careful examination before a conclusion is arrived at, is illustrated by the following.

D.C. aged 32, complained on 6th April 1920 of loss of weight, nausea, headache and of pallor which had attracted the attention of his friends. He had worked in an Annealing Shed at a Naval Establishment for several months chiefly at tending the furnace and oven. Here he was exposed to the dust and fume of lead and lead oxides. His complexion was sallow and anaemic looking. Weight 149 lbs, height 5 ft 9". Precise loss of weight not known. Physical examination including the urine was negative. There were no other signs of lead poisoning such as a blue line, abdominal pain, weakness or tremor of muscles.

Blood examination r.b.c's 4,583,000 per cubic mm.
white cells 9,687 per " "
haemoglobin 75%
no excess of basophil granule red cells.

Differential white count polymorphs 65%
large lymphocytes 10%
small " 22%
eosinophils 3%
mast cells nil.

An inspection of the Annealing Shed showed that the ventilation was defective, and that as a measure of economy it was the custom to completely close the furnace damper thus throwing back much coke fume into the place. These conditions were remedied and after a spell of open air work and ordinary tonic treatment, the patient returned to his original occupation perfectly well and disabused of the idea that his troubles were due to lead. I have no doubt that this was a case of chronic carbon monoxide poisoning from the coke fume, and that lead was in no way responsible.

I have already drawn attention to the part played by oral sepsis in the production of anaemia among the working classes, and I have threatened suspension where men were obstinate about having their teeth put in order.

The blue line. There are two kinds of blue line seen about the gums of lead workers. The first is a dark bluish line seen at the gum margins and between the teeth. It is outside the mucous membrane, and is due to a deposit of lead dust which has become converted into sulphide by/

by sulphuretted hydrogen evolved from decomposing food particles and débris. This line, which may also be seen upon artificial dentures, can be produced by a few hours exposure to lead dust, and can be removed fairly easily by the vigorous use of a tooth brush. Similar lines occur in other occupations. They have no particular significance, but their presence may indicate to the factory inspector that workmen are not using the respirators provided in certain dusty processes, or that exhaust ventilation is unsatisfactory.

The true blue lead or "Burtonian" line is within the mucous membrane and cannot be removed by washing. Its presence is a valuable indication of lead absorption. This line, when present in the gums of both jaws, is more marked in the lower as a rule; or it may be present in the lower only. It appears as a bluish line along the gum margin gradually shading off as it passes away from the teeth. Examination with a hand lense will show that it is punctate, consisting of minute particles of bluish-black lead sulphide lying below the surface of the mucosa. Microscopic examination of sections shows this substance lying within the lymphatics, and within and between the tissue cells. This line is always found in association with diseased gums and decayed and tartar-coated teeth. Bluish/

Bluish patches may sometimes be found opposite the latter upon the mucosa of the cheeks. The gingivitis may not be of a gross and obvious order, but the spongy condition and tendency to bleed may be demonstrated by gently pushing an orangewood tooth pick between the teeth. Where the teeth and gums are sound, or the teeth absent and the gums cleanly healed, no blue line is seen. I have noted this line in men employed painting for a little over a year and in old lead contact workers it is very common. It was present in thirteen out of twenty-two painters examined recently.

The examination should be made in daylight and the above points noted. The bluish appearance of the gum brought about by pyorrhoea alveolaris is not to be confused with Burton's line.

There is some dispute as to whether the line is produced by lead deposited from the blood or absorbed directly from the mouth. Apparently it is produced in both ways, for it can be made to appear in normal men and animals by painting the gum daily with liquor plumbi subacetatis, and it has been found in persons poisoned by diachylon pills in whom oral contact must have been negligible. Irritation and breach of the surface seem to be essential for the formation of the/

the sulphide. Similar stained patches have been recorded in the intestines of lead workers brought to autopsy, where the mucous membrane has been irritated by scybalous masses.

A blue line around the anus has been described as a sign of plumbism.

Constipation and Colic. The lead worker who permits himself to become constipated is on the high road to an attack of colic. He has closed the main channel of excretion, and has upset the balance of intake and output in the most definite manner. Not only is excretion diminished, but absorption is likely to be facilitated by the longer stay of the faeces within the bowel.

The astringent action of lead upon mucous membranes is sufficient to account for its constipating properties. In fact to this action is due the small position which the metal still holds in internal therapeutics.

Lead workers suffer sometimes from attacks of diarrhoea and these attacks may alternate with periods of constipation. It is hard to say whether this is due to the irritation of scybala, or to the action of/

of lead upon the muscle of the intestinal wall causing irregular and excessive peristalsis. The former seems the more probable as it is not an uncommon cause of apparent diarrhoea in persons who are not lead contacts, and it is doubtful if lead does act directly upon unstriped muscle - a point to be referred to shortly when discussing the cause of colic.

Colic is most likely to supervene after an unusually long and obstinate period of constipation. A number of cases come on suddenly without warning, in others dyspepsia, abdominal discomfort and twinges of pain precede the attack by days or weeks. Lead colic has the following features which taken collectively are characteristic.

(1) The onset is frequently sudden, the attacks of pain are severe causing the patient to double up and cry out in agony.

(2) The pain is mainly related to the umbilicus and lower part of the abdomen. The actual spasms are intermittent but there is usually dull aching in between, often worse on one side than the other. Sometimes the patient complains that the pain shoots towards the scrotum and perineum, or down the legs.

(3) During the attacks there is marked slowing of the pulse, and the systolic blood pressure is raised considerably.

(4) Firm pressure on the abdomen affords decided relief, so also do vasodilator drugs such as amyl nitrite. It is to be noted, however, that cases have been reported where great tenderness of the abdominal wall precluded examination, let alone pressure.

The urine is usually scanty and high coloured. Inequality of the pupils and of the radial pulses[23] has been recorded, also tenderness over the course of the pneumogastric nerves in the neck. It is stated that sulphocyanide of potassium disappears from the saliva during the attack and re-appears in convalescence.

Other symptoms are seen which may be present in any acutely painful abdominal condition. Thus there may be vomiting with apparent but temporary relief. There may be frequent calls to stool without result, or with the passage of a little blood and mucus. The temperature is subnormal, the features pale and drawn, and the surface of the body covered with cold sweat.

Death from heart failure is said to have occurred during the attack, but such cases must be rare.[25]

On examination the abdomen is retracted and firm during the spasms of pain. When the wall is thin contracted loops of intestine may be felt, and these/

these mobile tumours may assist the diagnosis. Unilateral pain and tenderness is apt to cause confusion. The history, occupation and the presence of one or other of the signs of lead absorption are valuable links in the chain of evidence.

The attacks do not pass off when the bowels are opened, but gradually subside. In some cases there is a condition of Chronic Colic, the picture being much less severe and definite but more protracted.

Colic constitutes the most common and early symptom of definite and notifiable lead poisoning as opposed to signs of mere lead absorption. Its presence calls for suspension and energetic treatment. The cause of the colic is not clear.
That there is cramp-like contraction of the circular muscle fibres of the intestinal wall has been proved by Oliver and others, who have found the lumen of the small bowel obliterated in parts in animals dead of acute lead poisoning. The pressure upon the nerves in the contracted areas, and the futile and irregular peristalsis set up above the constrictions, would account for the pain. Some regard this as the direct action of lead upon the unstriped muscle, others think it acts by irritating the nerves of the abdominal sympathetic system. Continental observers lay/

lay stress upon the vaso-constriction which takes place in the splanchnic area, and point to the relief obtained from amyl nitrite, nitro-glycerine and chloroform in support of their view. It is difficult clinically to say whether the colic causes the vaso-constriction, or whether the rise of intravascular pressure precedes the colic. Legge and Goadby, in their experiments on cats, have demonstrated that one of the early and constant results of saturnine intoxication is degeneration of the smallest blood vessels, especially the venioles, with consequent small haemorrhages. To this primary change they attribute the pathological picture seen in the peripheral neuritis and nephritis of plumbism, as well as lumbago, joint swellings and vague "rheumatic" pains found in old workers. Degeneration of the finer splanchnic vessels, microscopic haemorrhages and nerve irritation may be the early steps in the pathology of lead colic.

The clinical condition which most nearly resembles lead colic is the iced-water colic seen in firemen in ships in the tropics. It seems to depend upon vaso-constriction in the splanchnic area reflexly induced by copious draughts from the iced water tap provided in the bigger steamship lines. The/

The colic is strikingly acute, but I have never failed to relieve it promptly and permanently by means of an hypodermic injection of morphia (gr $\frac{1}{4}$) and atropine (gr 1/120).

Various degenerative and cirrhotic conditions have been described in the gastro-intestinal tracts of persons come to autopsy, who have suffered from lead poisoning in life. None of these seem to me clearly separable from the results of alcoholic intemperance, with which evil lead poisoning is frequently associated.

Severe cases of saturnine colic have become rare in the Navy and Royal Dockyards.

Symptoms referable to the Nervous and Muscular Systems.

It is convenient to consider these together, at all events so far as lead paralysis is concerned. Paralysis, more particularly "drop wrist", is one of the classical signs of lead poisoning and is well known to the general public. All the cases shown as permanently invalided in Table IV were thus affected. H.M. Thomas[26] of the Johns Hopkins Hospital, Baltimore, reported 30 cases of paralysis out of 54 consecutive cases of lead poisoning treated there. In the years 1910-14[27] 348 cases of industrial plumbism exhibited paretic symptoms in Great Britain, 937 marked anaemia and 2078 abdominal symptoms. This gives some idea of the relative frequency of these three leading features.

Weakness of muscle groups, such as the extensors of the wrist and forearm, may precede paralysis by many weeks and sometimes this weakness may clear up completely without paralysis becoming established. It is generally considered that lead may affect the nutrition and contractility of the muscles themselves, and some degree of chronic weakness and tremor is not uncommon in old workers. Fine tremor may be the

forerunner of paralysis and it is often of the "intentional" type, but, in estimating the value of this sign, it is to be remembered that it may also be due to industrial fatigue or to alcoholism. A man aged 59 seen recently, who had been a painter for 44 years, exhibited a peculiar fine tremor of the labial and facial muscles when speaking. In the absence of other signs and symptoms this could not be ascribed to lead.

The onset of paralysis is sudden as a rule, without pain and without fever. A man passed as fit for lead work in the morning may be suffering from paralysis by the afternoon. The extent of the paralysis tends to increase for a week or so after the onset, in spite of treatment and removal from exposure. The lesion is bilateral usually, but it frequently affects one side first and becomes more extensive and complete on that side. Changes in the skin are inconstant. Cyanosis may occur over the affected muscles; hyperaesthesia, and anaesthesia or analgesia may be found. Pain, where present, is likely to be referred to the joints or there may be deep-seated tenderness of the muscles. The paralysis is of the lower neurone type being dependent upon a peripheral neuritis which picks out the motor fibres in particular. The affected muscles show the electrical reactions typical/

typical of this condition, and in time contractures and deformities occur in severe and neglected cases. There has been considerable speculation as to why certain nerve-muscle groups, such as the musculo-spiral and the extensors of the wrist and fingers, should be picked out in preference to others. Much that has been written is vague, but three theories may be said to emerge from the mass of literature. Of the three the third alone seems likely to survive, and it alone is supported by clinical and experimental facts. These views are as follows:-

(1) That lead has a selective action upon certain nerves.

(2) That lead affects the muscles and nerves via the skin, hence the frequency of anti-brachial paralysis in painters, paralysis of the left hand in file cutters, and paresis of the small muscles of the hands in lead rollers.

(3) That the microscopic haemorrhages from degenerated vessels, which have been shown to occur constantly in lead poisoning, are the cause of the neuritis, and that these haemorrhages are most prone to occur in the nerves supplying those muscles upon which most strain falls. This theory, propounded originally by Edinger, has received much confirmation from the work of Teleky of Vienna and Goadby in this country.

The haemorrhage theory explains the sudden onset, the tendency to progress after onset, and the fact that complete destruction of all the fibres in a nerve trunk does not always take place.

In animals and children most strain is thrown upon the muscles of the lower limbs, and it is in the legs of animals and children that paralysis occurs most commonly when they are exposed to lead. The file-cutter uses his left hand for gripping the heavy chisel, and the lead sheet maker his palmar muscles for pressing the metal towards the rollers. The painter uses his forearms and wrists, the right more than the left, but both to some extent. Instances have been recorded where much overhead work seems to have determined the onset of the brachial (Duchenne-Erb) type of paralysis in painters. Another interesting example cited by Teleky is the peculiar right sided palsy chiefly affecting the thumb, seen in lead capsule polishers, and determined apparently by the special movements necessary in the process.

The following are the principal types of localised lead palsy:-

(1) The Antibrachial Type, sometimes associated with the name of Madame Déjerine Klumpke, in which the muscles supplied by the musculo-spiral nerve are affected with the exception of the supinator/

supinator longus. The latter has an additional nerve supply from the median and belongs functionally to a different group. The extensor communis digitorum is usually affected first, causing drooping of the two central fingers, the extensors of the index and little fingers follow and then those of the carpus. The result is "wrist drop". This is the most common form of paralysis. When other forms occur, anti-brachial paralysis is often associated with them.

(2) Brachial Type affecting the muscles of the upper arm, - deltoid, biceps, brachialis anticus and supinator longus (Duchenne-Erb group). The scapular muscles may be involved also.

(3) The Manual Type (Aran-Duchenne Type) where the muscles of the thenar and hypothenar eminences and the interossei are affected. This resembles progressive muscular atrophy, but is distinguished by the electrical reactions, the presence of pronounced paralysis and the fact that it is commonly combined with the anti-brachial type.

(4) The Peroneal Type is rare. The peroneal muscles and extensors of the toes are affected while the tibialis anticus escapes. It produces "drop foot" and a high steppage gait.

Other/

Other localised lead palsies have been described:- Unilateral paralysis of the adductors of the larynx (Morrell Mackenzie)[28]. Paralysis of the muscles supplied by the 3rd, 4th and 6th nerves, particularly the external recti, causing ptosis and strabismus (Oliver[29] and Lockhart Gibson)[30].

Cases of generalised paralysis due to lead have been recorded, in which the disease has begun with one of the types described and has gradually involved consecutive groups of muscles. These cases are very rare.

The following table illustrates the forms of paralysis due to industrial plumbism in the years 1910-14.

TABLE V.

Part Affected		Paralysis.	Weakness.
Arms & legs	(complete	6	-
	(partial	14	30
Legs	(complete	3	-
	(partial	6	20
Both forearms	(complete	102	-
	(partial	100	161
Right forearm	(complete	30	-
	(partial	22	20
Left forearm	(complete	9	-
	(partial	10	16
Fingers		19	4
Neuritis, numbness of hands and arms		18	-
Paralysis of deltoid, muscles of speech, locomotor ataxy & general paralysis etc.		14	2

Infinitely more serious than the palsies are those cases which manifest various cerebral symptoms and which are grouped under the general term of saturnine encephalopathy. Transient headache may accompany colic or anaemia, and in many instances it is due to causes other than lead, e.g. turpentine, paint fumes and coke fumes. Persistent severe headache, usually vertical or occipital, sometimes with attacks of vertigo, is a late symptom and is of serious import. These cases may develop mental symptoms which have been grouped as follows:-

(1) Toxaemic with sensory disturbances and tending to improve rapidly under treatment.

(2) Cases showing hallucinations of sight and hearing which may become permanently insane.

(3) Cases resembling dementia paralytica with tremors, altered speech, increased knee jerks, incoordination and some degree of mental impairment. These cases do not exhibit the grandiose ideas of general paralysis of the insane and, moreover, tend to get well.

It has been suggested by some observers (Oettinger, Marie, Pierre-Louis and others) that the Wassermann reaction may be positive in plumbism where there is no syphilis, but exclusion of luetic infection is almost impossible/

impossible and the two conditions may co-exist. The pathological findings in the two diseases (cerebral syphilis and cerebral plumbism) may be very similar.

The acute cerebral manifestations, which include epileptiform convulsions, delirium, coma and amaurosis, are a serious menace to life. They have been found to attack young women most frequently. Hysterical symptoms are a prodromal condition to be noted. Post-mortem minute haemorrhages throughout the brain substance have been described. The occurrence of such a case calls for the fullest inquiry. Neuro-retinitis may be associated with these cerebral forms of lead poisoning, and may be followed by optic atrophy.

The diminished incidence of cerebral plumbism is one of the notable features in the returns of recent years.

Saturnine encephalopathy during the last 20 years.

* TABLE VI.

Symptoms.	Total 1905-1909	Total 1910-1914	Total 1915-1919.
Epileptiform attacks	64	39	8
Mental defect	13	16	3
Optic neuritis	20	5	6
Total	97	60	17

* Tables V & VI are compiled from infirmation issued by the Factory Dept. of the Home Office. Memorandum Jan. 1921.

On examining some cases of paresis deep-seated tenderness is found in the muscles in no way relating to named nerve trunks. Lumbago-like attacks and other rheumatic symptoms are rather frequent in lead workers. It is thought that these may be due to minute haemorrhages in the muscle substance, in which case these conditions would be analogous to the "bends" found in caisson disease and after deep sea diving.

Cases of colic and paralysis have not been numerous in the Dockyards or Service Afloat of recent years owing to reduction of work and shorter hours as well as the vigilance of the authorities concerned. Cases showing pronounced symptoms are either discharged to a Naval Hospital or, if this is declined, the workman must obtain treatment from his own medical attendant at his own expense and risk. The Hospital treatment is very rarely refused, but in either case the original medical officer is robbed of his patient, which is one of the disadvantages of practice in the Services. The following cases therefore lack full clinical details:-

(1) H.J.H. aet 45. Skilled Labourer employed painting. It is difficult to state the exact period of lead contact employment in these cases. This man was employed painting off and on for a large number of years.

He complained of severe colic 5th Sept. 1919. There had been abdominal pain and discomfort for several days previously, but up till then his health was good and there was no history of lead poisoning.

This attack of colic completely incapacitated him and showed the several features already described as/

as typical of the condition, viz:- accompanying constipation, pain chiefly in lower part of abdomen relieved by warmth and pressure, slow pulse and raised tension as felt by the fingers.

On examination there was a well defined blue line with the accompanying unhealthy state of the mouth and teeth.

There was some degree of weakness of the extensors of the wrists and fingers, but no tremor or definite paralysis.

The blood showed no changes and excessive basophil degeneration of the red cells could not be demonstrated. The urine did not contain albumin or lead.

The patient accepted treatment at a Royal Naval Hospital, and was admitted 6th Sept. He made a good recovery under ordinary treatment with diet and salines, and was discharged cured 20th Sept.

The case represents a mild straightforward attack of colic. Such a patient should be temporarily suspended from contact work, and when he resumes he should be a special object of attention by the inspecting medical officer for some time to come.

The following case of colic is included because it illustrates several points. It occurred during the War and the records have been lost.

(2)/

(2) R. T. aet 43, had been a plumber in one of the smaller Royal Dockyards all his working life and had enjoyed good health.

Plumbing includes a certain amount of miscellaneous lead work, and he was one of half a dozen men put on the job of melting down old submarine accumulator plates sent Home from Malta Dockyard. After working at this for a fortnight or so, he came to the Yard as usual one morning and stated he felt quite well. In the afternoon he was suddenly seized with severe cramp-like pains in the lower part of the abdomen, which doubled him up and caused him to cry out. Pressure relieved the pain. He was assisted to the Yard Dispensary with difficulty and given some medicine (white mixture) which caused vomiting and brought about temporary relief.

There had been no constipation before the attack, but constipation and headache were present during his illness. He was treated as an outpatient of the Local Hospital. The pain subsided gradually and he resumed work after six weeks and has remained well. Notes of the clinical and blood examination have been lost, but there is little doubt as to the diagnosis.

Quite recently (1921) I was able to examine this man four years after his attack of plumbism. Although he has continued to work as a plumber, I could find

no/

no sign of plumbism, and he felt in the best of health. The case not only represents a very typical mild attack of lead colic, but suggests that this man was a good deal more susceptible than his fellow-workmen. It also illustrates the objection to doing odd jobs in an improvised fashion without proper precautions, i.e. melting lead in bulk in an unhooded melting pot in an ordinary plumber's shop.

(3) T. J. aet 57. Skilled labourer employed painting. Painter's assistant for last 20 years. Stated to have had lead poisoning (?colic) in 1900.
Complained 15th April 1917 of left wrist drop and abdominal pain.

On examination there was a well marked blue line. There was tenderness and pain in the lower part of the abdomen not amounting to colic but accompanied by constipation. There was paresis of the extensor muscles of the left wrist and fingers, with inability to extend the hand completely, especially the two central fingers. No sensory disturbances were detected. The right hand appeared unaffected.

Auscultation of the heart revealed accentuation of the second sound in the aortic area, but there was/

was no enlargement or valvular disease.
The tension in the radial pulse seemed raised to the finger and the peripheral arteries were noticeably thickened. A blood pressure reading taken a few days later gave the systolic pressure as 145 mm. Hg. and the diastolic as 100.
Examination of the blood gave the following:-

Red blood corpuscles 4,600,000 per cm.

White corpuscles 6,000 " "

polymorphs	59%
small lymphocytes	30
large "	6
transitionals	2
eosinophils	2
mast cells	1

No abnormal red cells seen. Haemoglobin 85%.

Urine contained no albumin or lead.

The case proved to be a mild one and cleared up* under ordinary treatment within a month. The only other symptom which arose during treatment was transient headache.

* So far as subjective symptoms were concerned.

Two other cases may be mentioned briefly as illustrating other symptoms. They occurred before the War.

(4) T. J. aet 39. Skilled labourer employed painting. This man complained of abdominal pains, pains in the right hip, both wrists and both ankles, and defective vision. He had felt out of sorts for six months previously.

On examination he had a typical blue line and lead was found in his urine.

He was sent to a Royal Naval Hospital, whence he was discharged to duty exactly one month later. It is regretted that an ophthalmic report was not obtained.

(5) H.G.E. aet 33. Casual labourer. Complained of attacks of colic and increasing weakness of both arms. On examination he was found to have a blue line, was anaemic and had a trace of albuminuria. The arteries were hard and the second sound in the aortic area accentuated, without marked enlargement of the heart or valvular disease. There was weakness of the extensor muscles of both forearms and deep muscular/

muscular tenderness. He accepted hospital treatment, but changed his mind five days later and was discharged at his own request.

Hyperpiesis, Arteriosclerosis and Chronic Nephritis.

The symptoms of lead absorption and lead poisoning which have been considered already occur most frequently in trades where the worker is brought constantly and intimately into contact with lead: but where the amounts absorbed have been exceedingly small and over comparatively long periods, somewhat different results must be looked for.

During 1919 and 1920 I had a number of workmen under my charge engaged in painting, plumbing and tin-smith's work at a Naval Establishment. Most of these men had been employed for many years, the work was regular, and all the paint used was lead paint. Conditions were favourable, therefore, for studying the effects of very chronic lead absorption - effects most noticeable in the vascular and urinary systems, which is my reason for considering the symptoms referable to these systems together. In addition I was permitted to make investigations in several Dockyards.

It is this aspect of plumbism which interests me/

me especially, partly because there is much that is indefinite in the literature and which requires investigation, and partly because there is an increasing tendency among practitioners in industrial districts to attribute to lead cases of sickness and deaths among lead workers directly resulting from arteriosclerosis, high blood pressure and chronic interstitial nephritis. It has been recognised for a number of years that old lead workers are subject to vascular disease with its concomitants and sequels, and saturnine nephritis has been admitted in the law courts as the basis of a claim for compensation. But very few observers have given definite figures, and other factors such as the condition of labour, the possibility of syphilis, and the question of alcoholic indulgence have been introduced to obscure the issue.

I may say at once that high blood pressure, arterial disease and chronic nephritis do occur rather frequently among old lead workers, but my object has been to estimate the extent to which these conditions are found, and to decide how much they are due to lead and how much to other causes.

The elucidation of this problem is, unfortunately, but little furthered by most of the experimental work on record. It is true that well marked lesions have been/

been produced in the kidneys and blood vessels of animals poisoned by lead, but in these cases the dose has been too massive and the action too rapid to be comparable to the process occurring in industrial life. Goadby[31] and Legge (experimenting on cats) produced parenchymatous nephritis and that feature which seems to underlie the whole action of lead - namely minute haemorrhages from capillaries and venioles in the kidney substance. They record somewhat similar appearances in human kidneys. Continued repetition of these haemorrhages together with degeneration of the walls of the blood vessels, attempts at repair and scarring, would go far to explain the clinical condition found in old workers, and the conditions which have been found post-mortem.

Reigel's original clinical observation that the blood pressure was raised in lead colic has received general confirmation, but the conclusion drawn therefrom - namely that lead acts directly upon the unstripped muscles of the blood vessels - is not supported by experimental evidence. Professors Oliver[32] and Bolam (using dogs) found that the injection of a soluble lead salt into the circulation of an animal caused a fall in blood pressure, a fall which was rapidly recovered from if the amount were small. If larger doses were given a more profound fall took place until the heart ceased to contract and/

and respiration came to a standstill.

So far as I am aware, the condition of the heart, arteries and kidneys of animals exposed for long periods to very small doses of lead, has not formed the subject of an investigation. Such an investigation, combined with a series of autopsies upon old lead workers, would be very interesting and would throw considerable light on the matter.

Turning to the practical and clinical side, I have been struck by the number of cases of high pressure and arteriosclerosis among the men I have examined, men who were otherwise healthy in so far as they made no complaint, were able to do their work and had never suffered from notifiable lead poisoning.

The first [33] series examined consisted of 45 men. One man, found to be the subject of chronic parenchymatous nephritis, was excluded. The ages of the remainder varied from 16 to 64, the average being 45. The series consisted of 18 painters, 22 tin-smiths and 4 miscellaneous lead workers. The time during which they had been employed varied from 4 months to 29 years, mostly over 20 years.

The average systolic blood pressure was 154 mm. Hg, the lowest being 108 and the highest 225. These pressures may sound a little high, but as the same/

same instrument (Tycos) and method were used throughout the investigation, they are sufficiently accurate for purposes of comparison. Moreover frequent checks were made with persons known to be healthy and lead free. A number of the more striking cases were examined upon various occasions and the results confirmed. The number of men showing albuminuria and casts or albuminuria with excessively high pressure was 12, of which two were probably early cases of lead nephritis comparable to that which occurs in patients taking mercury, and one was due to causes other than lead (chronic cystitis). All the remainder had been employed at least two years, and most for many years. Looking at individual cases, there was no definite relationship between the length of time in lead work and the height of the blood pressure, for here the personal factor comes in, viz:- susceptibility, habits and previous occupation: but when the cases are grouped, men who have worked longer than others show an average rise in blood pressure not wholly accounted for by age. Thus among men who had done lead work between three and five years and whose average age was 47, the average systolic blood pressure was 166 mm. Hg; while among those who had worked less than three years and whose average age was 38, it was only 141.

In/

In an investigation of this sort it is impossible to eliminate the effects of syphilis, but an attempt was made to gauge the influence of alcoholic consumption. I think the following table of results will show that alcohol is a less important factor than the majority of writers think, and that the consequences of its use are quite irregular. I admit that its continued abuse by lead workers predisposes them to poisoning, but this is only to be expected. The alcohol factor in plumbism has been exaggerated.

Previous occupation, however, is important, as men who have done a measurable amount of hard manual labour almost invariably have higher pressures than the accepted normal.

TABLE VII.

Nominal list of lead workers over forty years of age at a Naval Ordnance Depot showing ages, systolic blood pressure, consumption of alcohol and condition of urine.

Initials	Age	Blood Pressure in mm.Hg.	Use of alcohol.	Urine.
E.D.	62	250	moderate	Marked trace albumin granular casts.
H.G.	63	170	teetotal	-
E.H.	64	200	liberal	Slight trace albumin hyaline casts.
J.T.	60	135	teetotal	-
H.L.	62	170	moderate	-
A.L.	60	165	teetotal	-
E.T.	59	220	beer only	-
F.M.	50	190	moderate	-
W.W.	62	210	moderate	Trace albumin no casts.
J.C.	62	140	moderate	-
S.P.	61	180	moderate	Slight trace albumin no casts.
W.W.	64	155	irregular	Trace albumin, a few leucocytes and R.B.C's.
A.D.	50	255	teetotal	Slight trace albumin no casts.
E.M.	44	130	very moderate	-
A.M./				

Initials	Age	Blood Pressure in mm.Hg.	Use of alcohol	Urine.
A.M.	48	132	moderate	-
F.B.	45	150	teetotal last twenty years, previously moderate.	Slight trace albumin, a few leucocytes & granular casts. Many crysts of calcium oxalate.
C.C.	55	140	very moderate	-
A.K.	43	140	moderate	-
A.B.	45	135	very moderate	-
W.O.	50	155	teetotal	-
L.C.	53	138	very moderate	Slight trace albumin, hyaline casts, numerous leucocytes, R.B.C's and epithelial cells. Some calcium oxalate crysts.
W.L.	46	160	moderate	-
E.F.	45	132	moderate	-
W.R.	44	145	moderate	-
C.B.	49	140	moderate	-
A.G.	46	138	moderate	-
J.F.	49	135	moderate	-

Where a number of blood pressure determinations were done, the lowest reading obtained has been given.

The presence of albuminuria in a lead worker demands careful investigation as to its source, and if possible the presence of casts with or without high blood pressure, together with the absence of commoner causes, should be demonstrated before the condition is set down to lead. I think it will be agreed that this first series does show an unusual incidence of albuminuria and an unusually high average blood pressure.

A second series of painters examined (39 men), whose average age was 35, had an average systolic blood pressure of 139 mm. Hg., fourteen men having pressures over 140. These men had been employed for a number of years in a Dockyard, but the type of work was less continuous than that of the first series and, taken as a whole, the men were younger.

Dr Edgar Collis[34], quoted by Oliver, found the average systolic blood pressure of 141 lead smelters to be 148.2 mm Hg, and of 38 white lead workers 156. The average age and length of employment of the men is not stated, which is an important omission. Legge and Goadby in their book on lead poisoning state that blood pressure tends to be high among lead workers, and that pressures of 150 to 170 mm. Hg. are common. They/

They give the mean of one hundred observations as 150, the highest being 178 and the lowest 115. They*, too, omit particulars of age and length of employment. I doubt if anyone has had the opportunity of observing so favourable a series as my first.

Oliver draws attention to the great individual variation in the blood pressures of lead workers, and states that he has failed to find a persistent rise in pressure as employment continues, at all events during the early years of a worker's career. As time goes on, he considers that a rise of pressure generally occurs "due to structural changes in the arteries and interference with the functions of the eliminating organs". Oliver instances the number of deaths from cerebral haemorrhage which occur in persons who have worked in lead, and adds "that 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".

As regards variation, one finds in any series of records a number of cases of hypotension (104 to 112 mm Hg.) which are of no particular significance. Should/

* The omission of these particulars and of the type of instrument used detracts greatly from the value of the figures quoted by these authorities.

Should one chance to include two or three such persons in a small series of lead workers, the results will be misleading. Low or varying pressures seem to be rather frequent during the early years of employment of young persons, and are due perhaps to anaemia and debility, or to causes other than lead.

In another series of twenty-two painters the average age was 38.6, the average length of employment 26.84 years and the average systolic blood pressure 134 - the highest being 174 and the lowest 104. The findings in this series are reproduced in full since they illustrate the number of men who may show signs of lead absorption without ever having been poisoned or being unfit for work, but who, having lead in their systems, are liable to sustain injury and subsequent ill-health. These men were not under my charge and were shown as 1/A in the Health Register. If one accepts a systolic blood pressure of over 140 as probably pathological in men under sixty years of age, then only four of these men are absolutely healthy.

TABLE VIII.

Series of 22 painters.

Initials	Age	Time in lead work in years.	Signs of absorption.	Systolic blood pressure	Urine.
J.H.	31	17	pallor	150	-
J.F.	59	42	pallor blue line	174	-
B.J.W.	24	?14	slight blue line	118	-
I.C.	39	26	-	104	-
J.H.	53	37	blue line (oral sepsis)	156	-
J.E.	38	25	Pallor. blue line	165	-
W.R.	38	25	very slight blue line	148	-
A.R.	39	25	blue line (oral sepsis)	114	-
A.J.	35	20	-	144	-
W.B.	45	25	blue line	130	-
R.J.	47	33	-	123	-
R.L.	31	11	very slight blue line	134	-
F.J.E.	31	16	pallor	131	-
E.P.	23	8	-	133	-
A.T.	17	$1\frac{2}{3}$	pallor.Slight blue line	120	-
R.M.	31	12	blue line	150	marked trace albumin.
A.H./					

Initials	Age	Time in lead work in years	Signs of absorption	Systolic Blood pressure.	Urine.
A.H.	59	44	(tremor of muscles of speech.)	133	-
J.H.	47	33	marked arterio-sclerosis.	162	faint trace of albumin.
T.J.E.	34	15	pallor. slight blue line	112	-
R.J.P.	27	13	-	111	-
J.S.	57	35	blue line	134	-
W.C.	47	32	slight blue line	105	-

In finding a standard with which to compare blood pressure readings, some difficulty is encountered. The best figures obtainable are those of Insurance Offices which are drawn principally from a different class to that under consideration.

Thus one table gives healthy systolic pressures for different ages as follows:-

for ages 18 - 40 121 mm Hg.
" " 40 - 50 130 " "
" " 50 - 60 138 " "

Another table gives figures from five to seven millimeters higher, that is for ages 40-60, 130-145 mm Hg. Osler stated that "the normal blood pressure is from 120-130 mm Hg, but in persons over fifty it is very often from 140-160 mm. A permanent pressure above the latter figure may be called high, but there are great/

great regional variations."

A ship's company in the Navy is fairly youthful, having an average age round about 25 years and an average blood pressure of 122.4 mm Hg. (Author)

Probably no one cause, I may almost say natural cause, influences the development of arterial disease so much as hard manual labour, accompanied, as it usually is, by the free use of alcohol and tobacco. I therefore carried out the following severe test.

Two series of thirty men each aged between forty and sixty years were taken, the average age of both series being between forty-eight and forty-nine. The first group were lead workers and gave an average systolic blood pressure of 155, the second group consisted of men who had been engaged in hard manual labour for years but who were not lead contacts. These gave an average systolic pressure of 148, - 7 mm. lower. This result is distinctly in favour of lead being a cause of high blood pressure.

It is impossible to state with certainty how lead causes high pressure, but we have seen that experimental evidence is against there being any direct action upon the involuntary muscle of the vessels. I incline to believe that lead may damage the kidney at a fairly early period, both by those inflammatory and degenerative changes in the small blood vessel with consequent haemorrhages emphasised by Goadby,/

Goadby, and by injury to the secreting epithelium similar to that produced by mercury. The damaged cells then fail to excrete certain toxic substances from the blood, and these being retained cause a rise in pressure. Possibly the initial rise in pressure is a defensive action intended to bring about excretion of the poisonous substances. If a balance be reached the kidney recovers; if not, the damage is repeated as also are the attempts at regeneration and repair, so that in time we have a scarred and contracted kidney. The ultimate contracted kidney brought about in this manner, or, for that matter by, say, repeated slight infections, is difficult to distinguish from one produced in the course of general arteriosclerosis. Whether the vascular sclerosis is the result of the increased pressure, or is a separate effect of the poison remains undecided, in fact pursuit of this question leads to one of the battle grounds of medicine. So far as my own observations go, arterial changes in plumbism do not seem to bear a definite relationship to alterations in pressure and other symptoms. But this impression is clinical and would probably have to be modified in the post-mortem room.

Renal and vascular disease, however originating, tend to work in a vicious circle and to progress.

As/

As evidence of the early effects of lead on the kidney I may mention the cases of three youths who were found to have a trace of albumin in the urine during the routine examination of workmen. They were under observation from 23rd February to 7th May 1920, when they were suspended finally from further lead work. They were A.T., aet 17, C.B. aet 16 and W.S. aet 16. The last had been employed for four months, the other two over a year. Their work was painting, and all seemed to enjoy good health and no history was forthcoming of any disease* which might have injured the kidney. While under observation they showed a <u>persistent</u> trace of albumin in the urine, most marked in the case of A.T. Two had granular casts at times (A.T. and W.S.) and W.S. had a few red blood corpuscles in his urine on one occasion. The presence of red corpuscles in the urine of lead workers is of interest in connection with the action of lead on capillaries and small vessels. I have found them on several occasions, but where they have been present with numerous calcium oxalate crystals it is most likely that they result from the irritation of small stones and not from lead.

I am aware that Leube pointed out that 4% of healthy/

* e.g. scarlet fever.

healthy persons exhibit albuminuria so long ago as 1877, and that during the War Maclean[35] demonstrated that 6% of a series of 50,000 "fit" soldiers had protein of some sort in the urine. Further, in addition to this so-called functional albuminuria (to give it one of its many titles), we have physiological albuminuria after strenuous exercise. Possibly C.B. was a case of the functional variety, but the other two exhibited other signs (granular casts and blood corpuscles) pointing to some damage to the kidney. Nevertheless I am of opinion that any young lead worker showing this symptom, whether definitely of pathological origin or not, should be encouraged to change his trade. Needless to say no decision is taken upon a single observation, the case is watched for a reasonable period, as was done in these instances. The question of albuminuria arising in older workmen is discussed under treatment, but it may be stated here that the factory surgeon has neither the time nor the opportunity to carry out extended examinations of individuals and complicated chemical tests.

The effects of lead upon the kidney and the vascular system are important and interesting because they may result from the long continued absorption of amounts/

amounts too small to produce obvious signs of poisoning. Their origin and progress are insidious, and the damage done may be realised too late.

For their further study three lines of research are necessary:-

(1) Animal experiments under conditions approximating to those found in industry.

(2) A series of autopsies on old lead workers.

(3) Clinical observations extending over several years and following up the histories of individuals. These may be made conveniently by means of the system of medical history sheets described in the section on prevention.

Diagnosis. The diagnosis of industrial plumbism is frequently very easy. Knowledge of the patient's occupation combined with signs of absorption and one or other of the typical symptoms make it unlikely that an ordinary case could be missed. There is more possibility of attributing to lead some condition due to other causes, and this error can only be avoided by a general examination. It is to be remembered that lead workers sometimes go to a practitioner with the diagnosis ready-made, and that, unless the practitioner is conscientious or interested in the possibility of subsequent compensation proceedings, he may accept the situation and treat the patient accordingly, thereby establishing and perpetuating the mistake.

More difficulty is encountered naturally in cases where lead has been taken to produce abortion or taken by accident, or in an industry where the connection with lead is not clear. The ignorance or reticence of the patient will not assist matters, but in many of these cases sufficiently clear and striking symptoms may be present to point to the cause. If in obscure abdominal and nervous cases one/

one bears plumbism in mind, just as most physicians think of syphilis in similar circumstances, mistakes are less likely to happen. Probably the most difficult cases occur when the water supply is contaminated. Professor Oliver has drawn attention to what he calls endemic areas, and to a rise in the incidence of miscarriages and still-births as an indicator which may prove useful.

With regard to some of the more remote manifestations of lead poisoning, it may be almost impossible to decide definitely in individual cases. We know that lead causes arthralgia, lumbago-like attacks, renal and arterial disease, and such conditions among lead workers must receive careful consideration. The effects of treatment and absence from exposure to lead may be tried, and in this connection the double electrical bath promises to be useful, but in the end our diagnosis may be little better than conjecture. Although basophilia is not accorded the same degree of importance in Great Britain as it is in Germany, examination of the blood is of material assistance.

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19./

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PREVENTION AND TREATMENT.

While discussing the pathology and symptoms of lead poisoning an attempt was made to distinguish very carefully between definite notifiable plumbism and the state of lead absorption - the "presaturnine" or prodromal period. Many workmen are found in the latter condition and they require treatment, in addition to supervision and the enforcement of mechanical and legislative preventive measures. This treatment may be referred to conveniently under the heading of prevention: first of all I intend to deal with the treatment of established lead poisoning.

Treatment. The guiding principles of treatment are:-

1. To check further absorption.
2. To promote elimination.
3. To relieve symptoms.
4. To facilitate the repair of damaged tissues.

Further absorption is prevented by suspension, and it is the duty of the factory surgeon to see that patients do not return to lead contact work too soon or without examination. Where the nervous system has been/

been involved it is wiser for the patient to seek other employment. Elimination is promoted by remembering that lead is mainly excreted by the bowel and that in the lower part of the bowel the sulphate and sulphide of lead are but little absorbed, so that saline cathartics are indicated, more particularly the sulphates of sodium and magnesium. The French favour sulphur, and the sulphides of soda and potash. Probably the mechanical removal of lead and faeces is more important than the chemical action. When chronic constipation is present it demands attention.

Considerable doubt exists as to the propriety of giving potassium iodide. There is reason to believe that iodine renders soluble lead lying inert in the tissues, and reliable observers have reported an increase of symptoms following the use of this substance. Oliver[1] records a fatal case. The iodides were prescribed formerly because it was thought that they aided elimination via the kidneys, but the researches of Dixon Mann[2] have shown this view to be incorrect. Under iodide medication elimination is not increased.[x] But the administration of potassium iodide in the later stages of lead paralysis often seems beneficial. It should be prescribed cautiously - grs.lll t.d.s. is sufficient to begin with.

Just/

x Elimination is stated to be increased by the bowel but not by the kidneys.

Just before the War[3] another aid to elimination was introduced in the form of the double electrical bath, associated with the names of Professor Oliver and Mr T.M. Clague of Newcastle-upon-Tyne.

The process is essentially one of de-ionization and had its origin in an observation of the late Dr Lewis Jones, viz:- that cases of lead paralysis made a quicker recovery when treated with electricity applied by the single bath method than without it. The apparatus in its simplest form consists of two tubs containing warm salt solution, one for the feet and the other for the hands and forearms. The electrodes are aluminium grids, the positive one being placed in the foot bath and the negative in the arm bath. The current employed is reduced by suitable resistances to a voltage of 16 and a milliamperage of 20-40. By means of a rheostat in the circuit the current is gradually increased from zero and controlled as requisite. Half an hour twice or thrice a week is the usual time for a sitting.

According to Lewis Jones the lead appears at the positive pole as peroxide and at the negative pole in a spongy metallic form. Whether this lead really comes from the body or merely from the skin has been questioned, but the experiments of Oliver[4] and Durnford Smith/

Smith are decidedly in favour of the genuine value of this method. Another theoretical objection is that iron as well as lead may be removed from the body. It has been shown that lead as the more electrolizable metal comes away first, and that only the smallest traces of iron are removed.

About two years ago, one of these baths was set up in a Royal Dockyard. It has been found useful in the preventive treatment of borderline cases detected at the monthly inspections. The patients report a general improvement in health, increased energy and a sense of well-being. Pallor and weakness disappear rapidly.

In using the bath care must be taken to avoid contact between the electrodes and the skin, otherwise painful sores may result. In two cases treated recently, lead was found in the bath water in small amounts during the earlier part of the course, but it disappeared later.

The double electrical bath is probably the most valuable single measure we can employ at the present time in the treatment and prevention of plumbism.

It is necessary to consider the treatment of the leading symptoms individually.

<u>Colic</u>./

Colic. In acute colic pain is the predominating symptom. The patient is unable to come to work and is seen at home. The pain may be eased considerably by a large fomentation or poultice frequently renewed, and when the spasms are agonising amyl nitrite or a whiff of chloroform may be tried. The action of these substances is temporary. I have no experience of sodium nitrite or nitro-glycerine, but consider the hypodermic injection of morphia (gr.$\frac{1}{4}$) combined with atropine (gr 1/120) of decided value.

Although some physicians recommend the use of croton oil and other drastic purgatives to clear the bowel, it is better to rely upon enemata, and when constipation has been persistent these should be preceded by the injection of warm olive oil. Magnesium sulphate has been added to enemata for its reputed "neutralising" action. To promote the thorough emptying of the bowel sodium or magnesium sulphate is given by the mouth in small repeated doses until the desired effect is obtained. This is less likely to provoke vomiting than huge doses of salines. Where constipation is extreme, a preliminary dose of castor oil or olive oil is called for. The latter was suggested by Hoffman in 1760, who claimed that it/

it was especially useful in the relief of vomiting. associated with colic. When vomiting is troublesome it may be combated by sipping hot water or by the administration of an effervescing bismuth draught.

Sometimes the pain persists and the colic takes on a chronic or relapsing type. This kind of pain is apt to be aggravated by pressure and is said to be due to the irregular excretion of lead. In these cases calcium permanganate (gr ¼ t.d.s.) has been recommended by Dr G.A. Stephens of Swansea, also sodium monosulphite (gr ½ - 1 t.d.s.).

The patient must remain in bed while the attack lasts. During the attack the diet should be very simple - diluted citrated milk in small feeds and barley water. As convalescence is established the patient may proceed to farinaceous "slops", and gradually ascend the scale until he reaches what the late Professor Wyllie used to call the top rung of the alimentary ladder - roast meat and potatoes. Alcohol is altogether interdicted. During convalescence anaemia, oral sepsis and constipation if present should receive attention. For the anaemia the mistura ferri aperiens is useful, for the constipation morning salines may suffice, but when it is troublesome liquid paraffin should be ordered. I have found liquid paraffin with a drachm of castor oil/

oil in each ounce flavoured with peppermint useful in many forms of constipation, the dose being regulated by results. In patients convalescent from lead colic cascara sagrada, aloes and nux vomica are better avoided. When circumstances permit the patient should receive a series of double electrical baths.

It is usual for a man to return to work so soon as he has recovered from his first attack of lead colic, but he should be warned to observe precautions and kept under observation. Quite a number of workmen have a single attack of colic and remain healthy afterwards. In recurrent or complicated cases the question of final suspension has to be considered.

Anaemia. A small degree of anaemia is present commonly in lead workers, but where the development is rapid or the pallor marked, treatment must be undertaken.

When serious anaemia develops in a young lead worker, in the absence of other causes, it argues special susceptibility and the patient should be advised to change his trade. In less marked cases temporary suspension with suitable treatment will enable the patient to restore the balance between absorption and elimination, and to return ultimately to lead work. It is frequently possible to continue to employ the man/

man in some open air job not involving contact with lead, in other cases the employer may be advised to grant the patient a holiday.

In addition to securing the excretion of the poison by the regular and free action of the bowels, some form of iron should be prescribed and the patient should be enjoined to live as much as possible in the open air and to partake as liberally of milk, eggs and fresh vegetables as he is able to afford. I have prescribed as a rule the mistura ferri aperiens; the citrate of iron and quinine is useful, while others favour the syrup of the iodide. In the treatment of saturnine anaemia, mixtures are preferable in every way to pills or tablets. In cases of saturnine anaemia combined with general lassitude very marked improvement has followed the use of the double electrical bath.

When deciding whether to place a mild case under treatment or not, the fact that anaemia itself predisposes to plumbism should be borne in mind. The evil effects of oral sepsis must also be remembered, and where it is present every effort should be made to induce the patient to see a properly qualified dental surgeon and to initiate the habit of cleaning the teeth.

Before/

Before the patient exposes himself to lead again he should be thoroughly examined, the examination including a record of weight, red cell count and haemoglobin estimation.

Paralsyis and Affections of the Nervous System.

In saturnine paralysis, the common form of which is drop wrist, the objects of treatment are to bring about excretion of the poison, to prevent deformity and to restore the functions of the injured muscles and nerves. Apart from the disability involved, subjective symptoms are rare and unimportant.

Elimination is promoted by the methods described above, and in these cases the addition of a few grains of potassium iodide often seems to do good. Later nux vomica or strychnine, and quinine with iron may be given. The affected arm is supported upon a light anterior splint in such a way that the hand is dorsi-flexed to an angle of about forty-five degrees. The splint should extend from just below the level of the elbow to the tips of the fingers. For wrist drop of any sort I prefer a light sheet metal splint, made to measure and shaped to the forearm and about the ball of the thumb. In the Navy these splints are easily and quickly obtained, and prove very comfortable.

If possible the patient ought to attend the electrical/

electrical department of a properly equipped hospital, but when this cannot be arranged much may be done by massage, movements and douching instituted from the beginning. Electrical treatment includes the use of the galvanic and faradic currents. It is usual to begin with the former and to use only sufficient current as may be necessary to obtain contractions. As improvement takes place less current is required, and later faradic electricity will prove more useful. Application may be made by means of the single bath method, but wherever the double electrical bath is available it should be tried on account of its "de-leading" effect.

Other forms of paralysis are rare and are treated on the same lines. In ordinary cases of paralysis the prognosis is good, but recurrent or neglected cases may prove permanent. Peroneal[5] paralysis is apt to become progressive.

It is desirable for sufferers from lead paralysis to give up lead work altogether, and in all cases of definite paralysis a considerable interval should elapse before returning to the factory.

Acute cerebral plumbism or saturnine encephalopathy is a very grave condition and has become rare. Good/

Good nursing is the first desideratum and if possible the patient should be removed to Hospital. Treatment is mainly symptomatic. Every effort should be made to open the bowels freely, and to maintain the action of the skin and kidneys. Actual convulsions may be controlled by large doses of bromide of potash and chloral hydrate (grs. xx - xxx of each) by the mouth or per rectum. Since some of the symptoms may be due to angio-spasm the inhalation of amly nitrite and chloroform has been suggested. Two forms of treatment designed to relieve pressure and dilute toxins may be added:-

(1) Lumbar puncture.

(2) Bleeding followed by saline transfusion.

Remote manifestations. Rheumatic symptoms, arthralgia and lumbago are to be treated upon the usual lines, bearing in mind the necessity of securing the free action of the emunctory systems - bowels, kidneys and skin.

The lumbago-like pain often seems to result from chronic constipation. These symptoms do not call for suspension, but where a holiday or temporary change of work is feasible this course is recommended.

Headache./

Headache in lead workers always demands careful investigation. When a man complains of this symptom at an inspection he should be examined again thoroughly in the surgery. Frequently the cause will prove to be something other than lead, e.g. ametropia. The prescription of the coal-tar analgesics without a proper examination cannot be too strongly condemned.

Arteriosclerosis and chronic nephritis (contracted kidney). The only real treatment of these conditions is prevention; but as they are not infrequent and as their origin in an individual whose past medical history is unknown may be uncertain, it is desirable to entertain some reasonably definite and practical[6] views when we are confronted with a case.

Contrary to the opinions of others I maintain that albuminuria is fairly common among lead workers, and I believe that it would be found more frequently if it were sought for more often. I would advocate the more careful examination of workers on first entry, together with an annual overhaul, in addition to the rather casual periodic inspections.

Albuminuria in a young subject which is thought to be due to lead or is of unknown origin, and which persists, is a cause for permanent suspension.

Albuminuria/

Albuminuria, with or without casts, and high blood pressure in men over fifty need cause no concern unless other signs of plumbism are present or the general health is deteriorating. More harm than good will come of suspending these men, who are usually experienced and good workmen, and who must earn a living. Should such a man ever obtain compensation, the employer must console himself with the reflection that he has been a far more profitable workman than the youth who breaks down early as the result of carelessness or idiosyncrasy.

Albuminuria in the urine of men between the ages of twenty-five and fifty demands a very careful examination as to its cause and origin. Other signs of plumbism must be looked for - the blue line, blood changes, and lead in the urine - before an opinion can be formed. The effects of temporary suspension and treatment must be tried. Treatment may take the form of medicines to promote the elimination of lead, or the double electrical bath may be tried. From the latter, I think, we are justified in expecting the best results in combating the remote effects of lead absorption, not so much as a remedial measure in established cases, but as a preventive device when intoxication threatens.

In addition it is our duty to advise old lead workers whom we permit to carry on to take care of themselves, - to avoid chill, strain and alcoholism; to cut down their consumption of butcher's meat; to carry out the rules loyally, so avoiding undue absorption themselves and setting an example to others; and to maintain a regular daily action of the bowels by the use of salts or the sanitary drink provided.

Men suffering from renal disease due to other causes should not be employed in lead work for fear claims may be made in the future by themselves or their relatives.

Prognosis.

Prognosis in lead poisoning depends upon three factors:-

1. The susceptibility of the patient.
2. The number of the attacks.
3. The severity of the symptoms.

The majority of first attacks of colic and paralysis get better, and saturnine anaemia responds fairly readily to treatment. It is not uncommon to find workmen who, in their early working years, have had a sharp attack of colic and who have remained healthy throughout the remainder of their industrial career. In judging any particular case, note must be taken of/

of the rapidity with which the symptoms have developed after exposure to lead,as this indicates the degree of personal idiosyncrasy. Also, as stated already, certain morbid conditions predispose to plumbism. The habits of the individual as regards alcoholism, cleanliness and observance of the regulations have an important bearing. The blue line, when it exists, points to definite lead absorption, but one must remember that its presence or absence is dependent upon the state of the mouth and teeth. The blood changes, too, will afford evidence of the extent of the intoxication.

Where there have been antecedent attacks of plumbism the prognosis is correspondingly worse. In the majority of cases of severe and chronic paralysis, a history of past attacks of poisoning is forthcoming. According to Gowers quoted by Osler[7] the outlook is bad in the primary atrophic form of paralysis, and several observers have stated that the peroneal form is apt to become progressive.

The cerebral forms of plumbism are always serious. While it is true that those forms which show mental defect and symptoms resembling dementia paralytica tend to improve under[8] asylum treatment, it cannot be ignored that they are likely to have other factors contributing/

contributing to the condition - alcoholism, syphilis and neuropathic family history, - and that lead has picked out the weak spot in the defences for its attack.

Acute encephalopathy is very frequently fatal, and recovery from it may be complicated by optic neuritis ending in optic atrophy. The liability of young women to this form of plumbism again calls for remark. It is difficult to give a prognosis in the more remote results of lead poisoning, arterial and renal disease. These conditions have not been seriously investigated among lead workers to any great extent, but there is a growing body of opinion that their occurrence is too frequent, that they tend to shorten the lives and diminish the efficiency of the workmen, and that they are eminently preventible. It is in this connection that I so strongly advocate medical exàmination before entering upon lead work, together with periodical examinations of the vascular and renal systems, in addition to the usual inspections. In a given case the outlook will depend upon the chances of further lead intoxication, the amount of damage done, and the efficiency with which the heart and kidneys continue to perform their functions. Death[9] from cerebral haemorrhage is usually considered

to/

to be unduly common among lead workers.

It may now be asked, "What is the prognosis in the case of a young man taking up lead work; what are his chances of becoming poisoned?" The answer is that given reasonably good health to begin with, no special personal idiosyncrasy to lead, absence of bad habits such as alcoholism, and attention to the rules laid down in manufacturing processes where the risks are realised, such a man is in as favourable a position as in many lead-free occupations, where risks from other forms of ill-health and accidents balance those due to lead. Such a man ought to succeed in avoiding plumbism.

The preventive regulations of the British Home Office are in advance of those of any other country. The risks of many processes are known and legislated for. It is when Industry outstrips Legislation that danger arises. Reference to the Report of the Chief Inspector[10] of Factories (1920) will make my meaning clearer. "The figures for electric accumulators continue to be the highest". This trade was established in Britain practically speaking during the War, and it has grown enormously since. There is no doubt that up to the present the risks resulting from it have not been realised by either employers or/

or employed.

One other fact must be added. It is that death from plumbism may occur many years after the worker has left the trade. The report referred to above records two such cases which occurred in the China and Earthenware trade. The District Inspector for Stoke-on-Trent considered that "employment for many years under the old conditions in the Potteries" was responsible for the fatal termination.

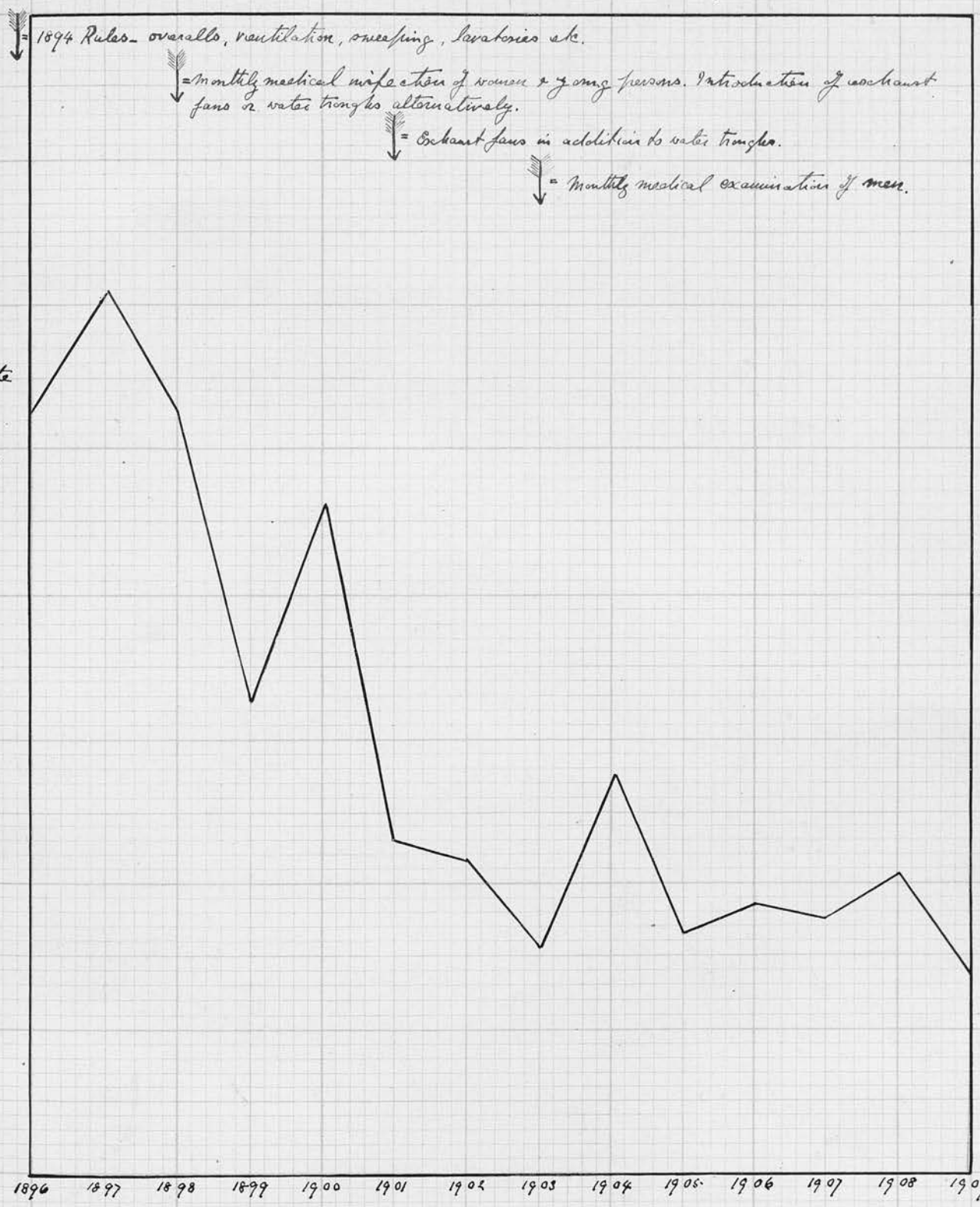
Prevention. In describing the prevention of industrial lead poisoning it becomes obvious that four groups or bodies of people need to be considered. They are The State, The Employer, The Employed and The Medical Officer. The activities of these are intimately related and it is impossible to discuss them separately.

No doubt prohibition of the use of lead in the arts and crafts would hasten the advent of an industrial millenium, but such Utopian methods are out of the question. In a certain number of instances substitutes for lead have been found, e.g. zinc white and iron oxide paints, and leadless glaze, - and in other instances lead may be used in the least harmful form/

form, e.g. fritted lead in low solubility glaze. But the application and therefore the success of these measures is only partial. By permitting lead contact trades at all the State admits, at least tacitly, their general usefulness to the community, and their very antiquity commands respect. The problem cannot be solved like the yellow phosphorus question, by an international agreement to use an equally efficient, satisfactory and harmless substitute. There is no substitute for lead in general. State action must consist of legislation designed to afford the worker the maximum amount of protection which is possible economically; by urging the manufacturer to employ the safest methods, by controlling the personal hygiene of the worker in relation to his or her particular trade, by preventing the employment of women and young people in dangerous processes, and by providing for medical inspection not only to see that the various codes are carried out, but to glean information upon which future regulations may be founded. How this has been carried out has been indicated in describing the different trades. It is preferable here to consider general principles.

There is a tendency at the present time, not altogether without justification, to regard much of our medical legislation as interfering. So far as social/

Ware Cleaners, North Staffordshire District, showing incidence of lead poisoning in relation to legislation.



Constructed from figures quoted in Pottery Committee's Report 1910. Vol I.

As examples of "wet" methods one may mention the direct transformation of white lead into paint by incorporation with linseed oil without preliminary drying, by which a most dangerous stage in the manufacture is obviated; or the wet sandpapering and pumice-stoning of painted surfaces.

Such operations as the mixing of paints and colours on a large scale, mixing accumulator paste, making up china glaze or the manufacture of red lead should be carried out within dust proof machinery. In the manufacture of red lead the maintenance of a negative pressure within the machinery prevents the escape of dust and fume. Exhaust ventilation constitutes one of the most important preventive methods in the majority of trade processes, because of its general adaptability and its efficiency. Exhaust ventilation may be obtained by means of (a) heat, or (b) fans.

Heat can be utilised in smelting, tinning and over printers' melting pots. A hood must be arranged over the pot which fits closely at the back and sides, and which only leaves sufficient space in front for the skimming, ladling and other necessary operations. From the highest part of the hood an adequate duct leads the fume and dust to the open air. Sometimes the updraught from the main furnace of a works can be/

be used to create an exhaust. The disadvantages of exhaust by heat are the uncertainty and inequality of the draught, the rather large duct required to remove the rarefied hot air and gases, and the possibility of leakage and backdraught. Fans are of two kinds - propulsion and centrifugal. Without going into details regarding mechanical ventilation, it may be stated that the former are low pressure and the latter high pressure fans. In the former the vanes are so arranged as to draw a current of air transversely through the fan in a direction parallel to the axis of rotation. They are light, cheap, use little power and are easily accessible for cleaning, but they are unable to overcome any large amount of resistance, such resistance consisting of complicated leads in front of the fan or dust filters, etc. behind it. The centrifugal fan has its vanes arranges so that air flies off into the space between the blades and the casing, and so to the outlet. It is of necessity a less accessible fan, but it is more powerful and more able to keep up a uniform exhaust than the propeller type. Fans are driven most conveniently by electricity, but sometimes other power is utilised by means of belting. The ducts in an exhaust system should be of smooth sheet metal, circular on section and/

and of correct dimensions. Sharp or right-angled bends are to be avoided and junctions should be tangential. The cleansing of a fan system should only be undertaken occasionally and under special precautions. The exhaust must empty into some place where it cannot do harm, or else suitable filters or dust traps must be introduced.

Exhaust ventilation is applicable to a large number of processes where dust or fumes arise, and it is demanded by a number of codes of regulations. (The scooping of lead compounds from tubs, the heading of chrome yarn, linotype machines, melting and tinning processes, and many stages in the china and earthenware industry). Difficulty occurs in utilising it in painting, but in the sandpapering of vehicles, agricultural implements and other painted articles, it is suggested that the work might be conducted over a grid supplied with a down-draught.

The efficiency of exhaust ventilation should be tested periodically with an anemometer, and the result recorded in the Health Register.

With the constant improvement in manufacturing methods and in ventilation plant, the value of respirators has decreased. For constant wear they are hot and uncomfortable, and so interfere with output:/

output: moreover their use leads to abuses and a false sense of security. In the French Code they are mentioned last of several alternative general preventive methods. They are of use, however, for occasional work undertaken with special precautions, such as the cleaning of roofs, rafters, air shafts and machinery, or the alteration of premises. They should be made of raw cotton wool or tow enclosed in a gauze bag, and fastened with an elastic band. This type stops dust, does not become sodden with moisture, and can be burnt after use.

In connection with the question of dust and fume, very interesting experiments have been carried out by the Principal Government Chemist (Mr G.E. Duckering) to show the value of exhaust ventilation. The results summarised by Dr Legge[12] are as follows:- If the amount of lead in the air breathed is less than 5 millegrammes per 10 cubic metres, cases of encephalopathy and paralysis will never, and cases of colic will very rarely, occur. This is a practical figure to expect in processes amenable to locally applied exhaust ventilation. Somewhere about 2 millegrammes of lead is regarded as the lowest daily dose which, inhaled as fume and dust, may set up chronic plumbism in the course of years.

Suitability/

Suitability and Cleanliness of Premises.

The provision of good and clean premises, and their maintenance in proper order, is hardly second in importance to the utilisation of modern manufacturing methods and exhaust ventilation. Legislation, therefore, makes it incumbent upon the occupier to provide and maintain workshops within certain standards.

The height of workshops ought to be ten feet or more, and they should be well lighted by windows as well as artificially. The floors should be of impervious material (concrete), and the walls of glazed brick or washable paint. Wooden or earthen floors are to be deprecated. Floors, walls and work benches should be washed down or "damp-dusted" daily; but unless the duty is delegated to some responsible person, it is likely to be seriously neglected as recent reports[13] show. It is also important to see that waste material, whether used in trade processes or for cleaning, is collected into proper receptacles and so disposed of that no harmful dust can arise from it. In workshops where lead compounds are handled in a dry state (e.g. the rooms where accumulator paste is mixed, pasting rooms etc.), the floors must be kept constantly moist in addition to daily hose-pipe washing. (Regulation 3, code for manufacturing/

manufacturing electric accumulators.)

Adequate general ventilation must be provided for: difficulty in this respect arises usually in old premises which do not lend themselves to conversion. Interference with ventilation is naturally more frequent in Winter. If foremen are vigilant and if complaints are attended to promptly, it is unlikely to prove troublesome.

In a factory where many processes are carried out, it is desirable that the more dangerous dust and fume producing stages of manufacture should be separated from the rest, so that workers who are nominally non-lead contacts should not be exposed needlessly. The necessity for this diminishes in proportion to the increase of available cubic space, and the efficiency of the general and special ventilation.

Under the Factory and Workshop Act of 1901 (Section 75), it is enacted that where lead and other poisonous substances give rise to fume and dust, meal-rooms shall be provided. In addition to meal-rooms, lavatories, bathrooms and cloakrooms must be provided also. It is frequently convenient to have all these under one roof.

The meal-room should be of adequate dimensions, well-lighted, warm and clean. Means must

be/

be provided for heating up food brought to the works and for washing plates and dishes. The room can be placed in charge of one or more cooks, who are responsible for its proper upkeep. A dirty mess room is a most unprepossessing sight and encourages careless and slovenly habits among the persons who use it. Large manufacturers, realising the value of good food to their workpeople, both as a preventive of sickness and a stimulus to output, have inaugurated canteens where meals may be obtained free or at bed-rock prices.

Tables and benches should be of scrubbed white wood; floors and walls should be painted or covered with impervious material to facilitate cleaning. Given a height of ten feet or more, Reid's figures are accepted as standard.[14]

for 6 persons or less	10½	sq.ft.floor space per person.
over 6 up to 12 persons	7½	" " " " "
over 12 up to 20 persons	6	" " " " "
over 20 up to 28 persons	5½	" " " " "
28 persons and over	5	" " " " "

Cloakrooms should be so arranged that each worker has two lockers, or two sets of pegs in different lobbies. One locker is for his overalls/

overalls and working kit and the other for his outer clothes. At a Naval Ordnance Depôt the accommodation was especially good on account of the requirements for men in contact with nitro-explosives. During working hours the room was kept locked in charge of a trustworthy man.

Lavatories. The common regulation is that the occupier shall provide and maintain in good repair:-

(1) Suitable lavatory accommodation including one basin for every five persons, or an ablutionary trough of suitable material and design, allowing two feet of trough to every five persons. A constant supply of hot and cold water.

(2) Soap, nail brushes and clean towels. Loss of the latter through pilfering causes annoyance, but can be overcome by the use of liquid or powder soaps, fixed brushes and roller towels. Special soaps containing alkaline sulphides and special solutions for the hands are sometimes used. They would seem chiefly of value in impressing the dangers of plumbism upon the workpeople.

Wash time must be allowed at the end of the morning and again in the afternoon. In Royal Dockyards ten minutes is allowed.

Baths. The provision of baths is required in special cases (white lead and accumulator works), and in other instances they have been introduced voluntarily/

voluntarily by employers. Although plunge baths are often installed, spray baths are more efficient, hygienic and economical when dealing with large numbers of men, whether in factories or elsewhere.

It will be found that the majority of large employers conform pretty well to the Official Rules. It is in the smaller workshops, especially where old and unsuitable premises have been taken over, that serious neglect is most likely to occur. Strictly speaking work done within the workshops of master painters (house painters and others) comes within the law, although in practice they are not subjected to inspection. Painting is the largest lead contact occupation which remains in great part outside control. Elsewhere I have pointed out some of the difficulties in controlling house painters, and also the fact that their ill-health is not entirely due to lead. From my experience of other painters, I consider that house painters and decorators would be greatly benefitted by inspection and control. That the men are alive to this, at all events in some countries, is shown by the following demands made by the Chicago Brotherhood of Painters and Paperhangers during a strike in 1913.[15]

"No workmen or apprentices shall be required to use any poisonous substance or material injurious to health/

health, such as wood alcohol, varnish remover, oxalic acid, or the sanding of lead, etc. unless they are protected with respirators, gloves, etc., same to be furnished by employer; nor shall they be required to use any insanitary waste, rags or drop cloths. There shall be an allowance of five minutes for wash time in each four hours work, and where lead or other poisonous material is used, the employer shall furnish hot water, soap and towels to the workmen. The officers and men of the organisation shall enforce this clause."

The employer, working in conjunction with the medical officer, should try to keep in advance of the law. Employers should remember that up-to-date hygienic methods, good premises and accommodation, and strict attention to order and cleanliness, inculcate self-respect and content among the workmen, maintain their health, increase output and save compensation together with the cost of insurance against it.

Periodical Medical Examination, Suspension, Compensation and Preventive Treatment.

The various trades tabulated in Section III of this thesis must submit their employees to periodical examination by a medical man who is "The Certifying Factory/

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. "Different trades are examined at certain specified intervals, but to some extent these intervals may be altered by the Chief Inspector of Factories in order to meet special conditions, should they arise.

Trade.	When Inspected.
Heading of yarn dyed with lead	Quarterly or at such other intervals as may be prescribed by the Chief Inspector of Factories.
Vitreous enamelling of metal and glass.	
Tinning of metal hollow ware etc.	
Electric accumulator manufacture.	
Paints and colours manufacture	Monthly.
Lead smelting and manufacture of red lead, orange lead, flaked litharge.	
Pottery and china.	
White lead manufacture.	Weekly.
Compounds of lead manufacture	

Lead workers in Admiralty Dockyards and Establishments are examined monthly.

It was formerly the custom to pay surprise visits, but/

but the inconvenience caused by this plan outweighed its advantages. It is a good thing, however, for the surgeon to visit premises without notice occasionally for the purposes of seeing the men at their work, studying new processes and testing the efficiency of preventive devices.

The periodical examination may be made conveniently during the last hour of the forenoon on a fixed day, when the workmen can first clean themselves and proceed to dinner afterwards. Moreover this plan insures the presence of day-light all the year round. The examination should be conducted with due regard to privacy in a well-lighted room, if possible a room kept for the purpose.

The men requiring examination are (1) men brought forward by the employer in accordance with the regulations, (2) men desiring examination for any reason, and (3) new entries. These last will be referred to subsequently.

The routine of one of these examinations has been described ad nauseam and with a wealth of theory in works on industrial medicine. Below is tabulated what one may hope to do in the ordinary way, but the success of the examiner will depend upon his ability to work quickly, his experience and his personal knowledge/

knowledge of individual workmen. To avoid delay cases or suspected cases of plumbism should stand aside for more detailed enquiry afterwards.

1. On the workmen coming forward observe the general appearance. Is the man slack and tired-looking, or bright and alert? Note the gait. Is he untidy and slovenly, or the reverse?
2. The face. Look for pallor, loss of facial fulness especially in young men, tremor of lips.
3. The eyes. Their lustre, conjunctival staining, ptosis, strabismus. Dilated pupils reacting sluggishly to light are seen in some cases of chronic absorption.
4. The mouth. Blue line, condition of teeth, furred tongue, heavy breath.
5. Arms and hands. Ask the man to stretch out the arms and hands palms downwards, and to separate the fingers. Look for tremor and bitten nails. Test the movements of wrists and fingers by asking him to bend the wrists backwards and forwards, and to open and close the fingers. A good and rapid method of testing the extensors of the hands and fingers is the following:- The man extends his arms and hands as before. The examiner then places his palms on the dorsum of/

of the man's hands and sees if he can prevent the man raising the arms from the elbow without bending the wrists or fingers.

6. Ask the workman if his bowels are regular or if he suffers from constipation, abdominal pain or headache.

The results of the examination, together with any comments regarding warnings or suspensions, are entered in the Health Register. This is a printed form kept by the occupier. Surgeons are requested by the Home Office to use a uniform method of entry, so that the record may be intelligible to occupier, inspector and worker alike.

The register is in two parts - Part 1 referring to individual workers (dates of examinations, names, ages, time employed in the process and state of health): Part 2 being a summary of Part 1, showing the total number of men seen on various dates, together with recommendations, orders and certificates of suspension made by the examiner.

In completing Part 1 numerals are used to indicate degrees of deviation from normal health due to lead, and letters for degrees of deviation due to other causes. Thus:-

1 = passed without comment, no observed effect of lead.

2 = blue line or indication thereof.

3/

3 = lead anaemia or other impairment of health.

4 = suspension or transfer by reason of impairment of health from effects of lead work.

A = no comment, i.e. fair general health.

B, C = Increasing degrees of impairment of general health (pregnancy without suspension is entered as C)

D = Suspension or transfer, for reasons other than impairment of health from effects of lead.

X = Carelessness, neglect of precautions or unsuitability for work in lead.

(DX = suspension from above cause)

Thus a man in good health would appear as 1/A, or if he had a blue line and remained well 2/A. A man showing marked anaemia and lassitude would be shown as 3/B or C. Other figures may be introduced and should be explained in the summary - thus 1/BT was used by me to indicate no signs of plumbism, but defective teeth of such a degree as to be likely to cause ill-health. Such a man was warned to set his teeth in order.

All orders relative to treatment, transfer or suspension are entered in the Register. As already stated, much good may be done by transfer temporarily to non-lead work together with treatment by medicine or the double electrical bath. Before deciding to suspend/

suspend a man altogether, the examiner should satisfy himself that definite signs of plumbism are present, and that, if necessary, he can face compensation proceedings with equanimity and confidence. During the period of total suspension some amount of compensation will have to be paid.

In this connection the words of King Alcock[16] serve as a warning. "When once a formal certificate of suspension has been issued, which has embodied a recognition of lead as the cause of certain existing symptoms, then it becomes almost hopeless ever to re-open the question of causation of these or other supervening troubles, be their origin independent of lead or not. The doctor, in a legal cross-examination, is, in scientific honesty, bound to admit at least the bare possibility of any fantastic chain of remote sequelae; and his protests against the probabilities of such sequelae are of no avail, as opposed to his own admission. The post, ergo propter, appeal carries the day easily."

According to the law of Great Britain, liability to pay compensation falls upon the employer or employers during the last twelve months. In a sense Compensation and the cost of Insurance against it are preventive measures, in as much as they force manufacturers/

manufacturers to do all in their power to prevent plumbism. In this country the law regards the victim of an occupational disease in much the same light as the person who sustains an injury due to accident in the course of his work. But, as Mock[17] says, if the employer has carried out all the regulations and has accepted the advice of experts trained to prevent these conditions, there seems no moral reason why he should pay compensation for occupational diseases.

When a man is suspended for lead poisoning, the place where he works in the factory should be inspected, with a view to ascertaining to what extent personal carelessness or defective conditions have been responsible for his illness.

It has been my custom to examine from time to time the urine and blood-pressure of painters and plumbers under my charge, and I am convinced that an annual overhaul in addition to the monthly examinations would prove very valuable. But first of all proper examination on entry into lead work should be insisted upon. Doctors should not be asked to make "a superficial examination".

I have suggested an entry form, a specimen of which is included here, and which I had printed at a Naval Establishment. The form is self-explanatory.

On/

Form.....1920.

Form for Entry of Lead Contact Workers into H.M. Naval Establishments.

PART I.

Name in full..... Age at Entry.....

Address.....

..... Date of Birth.....

PART II.

To be filled in by the Medical Officer. Statements made by the applicant are to be read over to him and signed by him. When the applicant is a minor the statements are to be countersigned by his parent or guardian.

1. State previous occupation	
2. Have you previously been engaged in any kind of work with lead, and, if so, was your health affected?	
3. (*a*) State what the condition of your health has been for the last five years.	(*a*)
(*b*) Have you ever had any serious illnesses or accidents? Give particulars	(*b*)
(*c*) Have you at any time suffered from anæmia, rheumatism, kidney trouble, epilepsy or fits?	(*c*)

The above statements are accurate to the best of my knowledge.

Signature..... Signature of parent or guardian } .....

Date..... Date.....

I have examined the above and find him.....for entry as a lead contact worker.

.....Medical Officer.

Date.....

The following minor defects are noted :—

.....

.....

.....

Systolic Blood Pressure in mm. of Hg.	Urine Analysis.
	Spgr. ... ...
	Reaction ... ...
	Albumen ... ...
	Sugar ... ...
	Deposit ... ...

PART III.

Mr..... is accepted as.....

in H.M. Establishment at.....

Dated..... .....

Superintendent.

363b-50 RNB 11-5-20

On the reverse is a medical history sheet giving the records of examinations to be made half-yearly for the first two years, and then annually. It is thought that this form could be adapted to the requirements of different trades, or, if desired, arranged as a card-index register.

I believe that the general adoption of some such scheme would prove most useful. It would protect both employer and employed, and cause the growth of valuable records, especially as to the time of onset of some of the more chronic and remote symptoms.

Employers should be discouraged from using casual or cheap foreign labour in lead work.

The medical requirements of new entries into lead work may be summarised here.

Candidates should be generally fit and able. Persons showing the following defects or morbid conditions should be rigidly excluded:-

Tuberculosis.

Renal disease.

Epilepsy or mental defect.

Alcoholism.

Myopia uncorrected by glasses.

Joint affections, rheumatism or gout.

Vascular disease or hyperpiesis (one Tyneside firm refuses all men with a systolic B.P. over 140).

Marked/

Marked anaemia.

Pregnancy, history of miscarriages or menstrual disorder.

Previous plumbism.

There remain two preventive measures of a more medical character, and which might be described as preventive treatment.

(1) The double electrical bath (already considered)

(2) The provision of a sanitary drink.

It has long been customary to provide lead workers with a medicine designed to neutralise the poison and aid elimination. The classical "orangeade" consists usually of syrup and infusion of orange, dilute sulphuric acid and water, with or without magnesium sulphate. During my work at a Naval Ordnance Depôt it was necessary to pay particular attention to this question of a sanitary drink, because the regulations required the provision of one not only for lead workers, but also for those in contact with high explosives (nitro derivatives of toluol and phenol). It was quickly found that very few men made use of the "orangeade", and the reason given was not the rather disagreeable flavour, but the alleged action of the free mineral acid on the teeth. This may have been so, although the cause of decay was more probably the want/

want of a tooth-brush and dental attention. Rather than struggle against a prejudice, it seemed wiser to order a sanitary drink which all would take, which was equally beneficial and which was cheap.

The formula decided upon was:-

sodium sulphate . .	one drachm.
artificial syrup of lemon (brown* sugar, citric acid & oil of lemon)	half a drachm.
water	to one fluid ounce.

"Two to four tablespoonfuls or a small wineglass-ful twice or thrice weekly".

"N.B. The mixture contains no free mineral acid".

That the change was appreciated is proved by the fact that the demand has exceeded the supply ever since its introduction. There is no point in giving sulphuric acid, since sodium and magnesium sulphates precipitate lead equally well (in vitro) and since the acid soon becomes a salt within the body. Our real object is to aid elimination by the bowel and not to form lead sulphate in the stomach. Indeed the formation of lead sulphate in the stomach avails little or nothing, since that salt itself is capable of producing[18] poisoning and can be broken up and absorbed during gastro-duodenal/

* Brown sugar is an ordinary Naval Store.

duodenal digestion. The use of small quantities of citric acid is supposed to check the pathological effects of lead on the blood. In some factories chocolate coated tablets of sodium sulphide or hyposulphite are used and are doubtless convenient; but a saline laxative mixture is considered preferable. Moreover it is hoped that the regular use of the alkaline sulphates may help to postpone the development of renal and vascular changes. This hope receives support from the writings of Langdon Brown[19], who considers that these sulphates combine with some of the products of protein putrefaction in the bowel to form harmless bodies. It is generally agreed that products of food putrefaction in chronic constipation aid the development of hyperpiesis, vascular and renal disease. The retention of these products is favoured by the action of lead, which is itself harmful to these tissues.

In emphasising the important part played by a suitable sanitary drink in the prevention of lead absorption and plumbism, I do not wish to minimise the value of other measures, and it is very necessary not to allow workmen to imagine that the mere swallowing of medicine can protect them from poisoning or permit them to relax in any way the various personal and technical precautions in use.

The/

The Worker. In some occupations such as handling metallic lead and ordinary soldering, the prospects of lead poisoning are so remote that no age limit is necessary. But in the more dangerous processes no person under eighteen ought to be employed. Persons under eighteen are definitely more susceptible, more careless and less impressed by the value of precautions. One would like to see this age standard applied to house painters' apprentices, but sixteen is probably the best that can be hoped for.

Having been selected, the new entry into lead work should receive instruction. This is best given in the form of a printed slip framed in simple language handed to him by the surgeon and emphasised verbally. Similar notices may be posted in the workshops. The pamphlet should be on the following lines:-

Lead Poisoning, How Caused and How Prevented.

1. Work with lead and lead compounds may injure the health, since lead taken into the body by breathing or swallowing fume or dust acts as a poison.

2. Always wash the face and hands with soap and hot water and rinse out the mouth before meals. Keep the teeth in order by using a tooth brush morning and evening, especially on arriving home from work. See a dentist if necessary. A weekly hot bath helps to maintain the health.

3. Do not bite the nails, and do not take any food, tobacco, sweets or chewing* gum while at work.

4./

* Towards the end of the War and later the use of chewing gum became common among the lower classes in Britain.

4. Do not begin work on an empty stomach. The presence of food in the stomach helps to prevent lead poisoning. Cocoa, milk, bread, eggs and bacon are good breakfast foods for the lead worker.

5. Never allow yourself to become constipated. Take the sanitary drink provided, and, when necessary, Epsom salts before breakfast or castor oil over night.

6. Intemperance increases the risk of lead poisoning.

7. Always wear the overalls provided weekly when at work. Do not shake the dust from overalls before they are washed.

8. Avoid breathing lead dust and fume. Work in as cleanly a manner as possible by avoiding splashing or creating dust.

9. If ventilation or exhaust apparatus is out of order, report to the foreman at once.

10. Report to the doctor if you are suffering from serious constipation, vomiting, pains in the stomach, headache, loss of eyesight, weakness in the hands, arms or legs, or if you think your health is suffering in any other way.

The enforcement of orders can only be secured by having honest and reliable foremen and by the loyal co-operation of the workers themselves, but the medical man may play an important part by gaining the confidence and respect of employers and employed.

The use of overalls is almost universal and is insisted on by many codes. They are usually washed on the premises every week. This secures uniformity, and if necessary the persons engaged to do the washing can be placed under supervision to prevent the development of plumbism. Where protection from splashing/

splashing is required, the use of waterproof aprons which can be sponged down daily is an advantage. Head coverings should consist of close fitting cotton caps, but where their object is to protect from dust, the introduction of efficient exhaust ventilation is infinitely better.

It is among house painters, once more, that we find men working in old suits and then going home to meals without changing.

The prevention of lead poisoning in water supplies.

In the main this devolves upon the companies supplying the water. It has been shown conclusively that the addition of traces of siliceous matter and lime to water prevents plumbo-solvent tendencies, whether due to extreme purity or to the presence of peat acids. The responsibility of testing and treating the water must be borne by the water companies and local health authorities.

Rather more difficulty arises in the case of private supplies in the country. I have seen one or two cases of serious ill-health caused by such supplies in the North of England. When the trouble is due to excess of nitrates and carbonic acid gas in shallow well water, another source of supply should be/

be sought upon general hygienic grounds.
When the natural and varying acidity of surface moorland water is at fault, it would seem wiser to try to avoid lead in the domestic system by the substitution of galvanised pipes and cisterns, or those coated with patent composition such as Angus Smith's or rosbenite.

I cannot agree with Oliver's suggestion that filters containing animal charcoal rich in phosphates should be used. Domestic filters give a false sense of security, and are rarely understood or kept in order, so that in time they become hot-beds of contamination, producing within themselves some of the very evils they are designed to prevent.
This condemnation of the domestic filter applies most of all to the charcoal variety.

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SUMMARY AND CONCLUSIONS.

The study of lead poisoning reveals the widespread and manifold uses to which lead and its compounds are put. Wherever lead is found the possibility of plumbism arises, but where it is present in the form of dust or fume the possibility becomes a probability.

The value of lead in Industry depends upon the extraordinarily adaptable qualities of the metal and its comparative abundance. The ancients were well aware of its merits and dangers.

Although the producer suffers as a rule, the consumer may be affected under certain circumstances.

Efforts to substitute harmless substances for lead have met with but partial success. In view of the sickness and mortality attributable to lead such efforts are worthy of every encouragement, but preventive measures have proved more practical in the past and are likely to remain so for the present. During the last two decades legislation has gone far to reduce the incidence and gravity of plumbism in Great Britain, but to be wholly successful legislation must be comprehensive and founded upon a thorough study of the subject.

To/

To this end trade processes, and the aetiology and pathology of plumbism must receive attention, as well as the actual symptoms and their treatment.

Lead is most dangerous when it occurs as fume or fine dust, and as such it may enter the body by way of the respiratory and alimentary systems, and to a smaller extent via the skin. Although more lead is likely to reach the stomach than the lung, lead in the latter situation is more potent of evil, for much of the lead which enters the stomach is not absorbed, whereas that which enters the lung will sooner or later pass within the tissues.

The presence of food in the stomach tends to check lead absorption, the presence of alcohol aids it.

As the result of experiment it has been stated that where the air breathed contains less than 5 millegrammes of lead per 10 cubic metres, serious symptoms will not occur, and that 2 millegrammes per 10 cubic metres is the smallest dose which will produce chronic plumbism.

The effect of lead upon living tissue falls most heavily on the blood and smaller blood vessels. To the resulting minute degenerations and haemorrhages, many of the leading symptoms seem traceable - the colic,/

colic, the neuritis, encephalopathy and nephritis. The "haemorrhage theory" explains most simply the pathology and symptomatology of lead poisoning, and it is supported by experimental, clinical and post-mortem evidence.

The attack upon the blood can be followed clinically and microscopically.

Very definite distinction must be drawn between the state of Lead Absorption (anaemia, blue line, constipation), and those symptoms which constitute Lead Poisoning in the legal sense - colic, paralysis and encephalopathy.

This Thesis has attempted to branch from the beaten track of Lead Poisoning and to investigate practically the effects of lead upon the renal and vascular systems, because it was felt that these were frequent and because existing information concerning them was vague. It seems certain, so far as these investigations go, that the long continued absorption of small quantities of lead, insufficient as a rule to produce actual poisoning, does bring about a definitely increased blood pressure in the majority of cases, and that ultimately those degenerative changes develop in the blood vessels which are commonly called arteriosclerosis. In a much smaller number/

number of cases we find changes in the kidneys, evidenced clinically by the persistent presence in the urine of small quantities of albumin, together with granular casts, epithelial cells and occasionally red blood corpuscles and leucocytes.

It would seem reasonable to divide the kidney changes into two classes - those developing after many years in association with hyperpiesis and arterial disease, and those developing within a few months, probably the result of the directly toxic effect of lead upon the secretory tissue and comparable to mercurial nephritis.

Hyperpiesis, arteriosclerosis and chronic nephritis together with certain "rheumatic" manifestations constitute the remote symptoms of plumbism: our knowledge of these would be advanced by the examination of lead workers on entry and by the keeping of medical history sheets on the lines suggested.

Women and young people are more susceptible to lead poisoning than grown men, and in women the graver symptoms are prone to occur together with serious disturbances of the reproductive functions.

Alcoholism and debilitating diseases accelerate the toxic action of lead.

Acute plumbism is rare, the symptoms are urgent and/

and relief is quickly sought. The chronic form of lead poisoning, as it commonly occurs, develops insidiously; the danger is not realised until the damage is done, and recovery may be protracted and incomplete. The commonest severe symptom of plumbism is colic, but the most serious symptoms are those related to the nervous system. Death from the effects of lead poisoning may occur years after the patient has given up lead work.

The treatment of lead poisoning follows definite lines - further absorption must be checked, elimination promoted, symptoms relieved and function restored. Of the measures described, the double electrical bath is the most useful single therapeutic and prophylactic device we have to-day.

The machinery of prevention is composed of four parts - The State, The Employer, The Employed and The Doctor. The duty of the State is to provide legislation, to collect information and to stimulate research. The employer is expected not only to carry out both the letter and the spirit of the law, but to keep in advance of it. It is his duty to use the least harmful substances and processes, to introduce dust-free and fume-free methods of manufacture, or when this is impossible to remove dangerous products

by/

by exhaust ventilation. His premises, together with the messing and lavatory accommodation provided for the workmen, should be of the most approved type compatible with commercial success, and he should remember that success itself is dependent largely upon the efficiency of his preventive methods.

The workman is expected to be loyal to himself and to his employer, to make the best use of the preventive means provided and to carry out intelligently those instructions which may be summed up in the word "cleanliness".

The rôle of the doctor is most important of all. He is at once the agent and adviser of the Government. He is expected to co-operate with the employer in doing all that is possible to prevent plumbism, and his vigilance and knowledge should inspire confidence among the workpeople and convince them that their interests are fairly and justly protected. Given an almost perfect legislative code, given reasonable manufacturers and intelligent operatives, the prevention of lead poisoning must remain at the last in the hands of the doctor.

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