[No 57.

SOUTH AUSTRALIA.

REPORT

OF THE

ROYAL COMMISSION ON PLUMBISM;

TOGETHER WITH

MINUTES OF EVIDENCE AND APPENDICES.

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White lead manufacture.

3. While in Sydney the Commission inspected the principal white lead manufactories from the standpoint of the measures adopted for the observance of industrial hygiene, and took evidence from the manager and medical men associated with the works in regard to the precautions adopted for the prevention of plumbism amongst employees in the industry. In Melbourne a visit was paid to lead-rolling works, where it was found that no hazard similar to that at Port Pirie existed. Evidence was taken in Adelaide from time to time between the visits of the Commission to Port Pirie and elsewhere. In all, 24 witnesses were examined, many of them at considerable length, and a number of them were recalled for further examination as the inquiry proceeded in order to satisfy the Commission in regard to various questions. The witnesses included 11 medical men experienced in the diagnosis and treatment of plumbism and its *sequelae*, including, as well as those previously mentioned, the local medical practitioners at Port Pirie and Dr. B. H. Morris, Inspector-General of Hospitals for South Australia and a medical referee under the Workmen's Compensation Act; also metallurgical experts, officers of health and industrial hygiene, smelter workers and others.

CHAPTER II.

DESCRIPTION OF PLANT AND METHODS OF TREATMENT.

Description of plant and treatment.

4. The evidence submitted on behalf of the Broken Hill Associated Smelters Proprietary, Limited, included particulars respecting the materials treated, a description of the treatment processes, and a comparison of the existing metallurgical practice with former methods as far back as 1897. At the present time the reduction of the lead ores into marketable form covers what are essentially three distinct processes:—(*a*) Blast roasting and sintering of the crude ore and fluxes at the Dwight & Lloyd and Huntington-Heberlein plants. (*b*) Smelting the sintered material in blast furnaces. (*c*) Refining the bullion obtained from the blast furnaces to convert the metal contents into marketable form as refined metals.

Blast-roasting plant.

The blast roasting and sintering plant consists of three sections, viz.:—(*a*) The "A" section comprises six Dwight & Lloyd straight line machines, each having 42 pallets 42in. wide by 24in. long These travel over a vacuum chamber 21ft. long. Each machine is equipped with an impeller-type fan, and the gases collected are delivered to cyclone dust collectors, from which they escape to the stack. The heat for ignition is supplied by coke-fired stoves of reverberatory type suspended over the pallets at one end of the vacuum chamber. (*b*) The "B" section consists of five Dwight & Lloyd machines similar in type and equipment to the "A" section. (*c*) The Huntington-Herberlein section consists of 15 sintering pots, each of 9½ tons capacity. The "A" section is operated as a pre-roasting unit and deals with 800 to 1,000 tons of charge per 24 hours: the other two sections are used as final roasting units.

Charge.

The charge for blast roasting includes:—Granular lead concentrates, slime lead concentrates, siliceous lead ore, lime sand, Risdon residues, and granulated slag. In treatment, the various components of the roasting charge are delivered from stock piles or railway trucks to a series of bins known as the mixing plant. From these bins the material is passed to the main charge-assembly belt, which delivers to the first of five conveyors arranged in series, and thereby is transported to storage hoppers. During the passage moisture is added by water sprays regulated to give a moisture content of about 7 per cent. From the storage hoppers the charge is fed to the machines by a conveyor belt delivering to an oscillating chute. After treatment the material falls from the end of the machine on to tray conveyors delivering to a belt conveyor, which transfers the pre-roasted material to an intermediate crushing station. There the sinter is passed through rolls, then on to belt conveyors, which return the products to either the "B" section of the Dwight & Lloyd plant or the Huntington-Heberlein pots for a final roast. The charge of the "B" machine is moistened to give a water content of about 5 per cent., and fed on to the machines from hoppers on lines similar to those described in connection with the "A" section. The product from "B" section falls directly into skips, in which it is transported to the blast furnace bins. The excess material from the pre-roasting section is treated in the Huntington-Heberlein pots, where the desulphurising is completed by air forced through the charge from below at a pressure ranging from 4ozs. at the commencement of treatment to 22ozs. at the end of the operation. After sintering the charge is tipped on to floors underneath the pots, where it is manually broken to 6in. gauge and loaded into skips for transfer to the blast furnace bins.

Huntington-Heberlein section.

Blast furnaces.

5. The blast furnace section consists of five large and two small blast furnaces. The large furnaces measure over 23ft. from the bottom of the crucible to the feed floor. The small furnaces are equal in height to the large, but are of a lesser area. The charge material for the blast furnace is collected by five steam or electrically operated aerial hoists, with spans of from 331ft. to 472ft., which deliver the various products into a series of bins above the feed floor and parallel to the blast furnaces. From these bins it is transferred to the furnaces in charge trucks handled by a hydraulically-operated mechanical traverser. The large furnaces are operated on current sintered material with about 11 per cent. of coke on sinter treated. Blast is supplied at a normal working pressure of 44ozs. The gases liberated in smelting pass through down-takes to the main flue, a structure 520ft. long, 15ft. wide, and 17ft. high, connecting with a 14ft. diameter stack, 202ft. high. About 50ft. from the junction of the flue and stack the furnace gases are withdrawn by an impeller-type fan, and delivered to the bag house. This consists of six brick chambers,

in which the bags for collecting fume are arranged in regular groups, and are mechanically shaken in rotation at regular intervals, the fume dropping into a hopper, from which it is withdrawn by an archimedean screw. The fume is subsequently burned to a clinker, and then returned to the blast furnace. The bullion is withdrawn from the furnace crucibles through syphons constructed of fire bricks and is moulded into bars. These, after cooling, are conveyed to the refinery in horse-drawn trucks. A scheme of mechanical bullion handling is being installed. The slag flows through a settler into a cast-iron launder, where it meets a stream of salt water, which separates it into granules. The launder discharges the granulated slag into an elevator delivering into storage bins, from which a proportion of it is railed to the blast roasting section and the remainder to the waste-slag dump. These smaller furnaces treat ordinary charge material, or are utilised in dealing with copper dross or antimony slag returned from the lead refinery. Slag for fluxing purposes in the blast furnaces is quarried from a portion of the material dumped in earlier smelting campaigns.

Refinery.

6. The refinery comprises eight sets of refining units, three large and five small, each set including :— One copper softening furnace, one antimony softening furnace, two desilverising kettles, one refining furnace, one market kettle. The charge capacity of the large sets is 50 tons, and of the smaller sets 37 tons, and the refining method in use is the well-known Parkes process. The furnaces are of the reverberatory type, and the zincing kettles are cast-iron vessels, hemispherical in section. The various units are so arranged as to ground level that the molten bullion gravitates from one receptacle to the next in series until the market kettle is reached. In addition to the lead refining sets, the following supplementary equipment is used to free from impurity the other valuable metal contents of the base bullion :—Two antimony dross furnaces, two gold alloy furnaces, four retort distillation furnaces, seven concentrating cupel furnaces, three fine silver cupel furnaces, one litharge-making furnace, one electrolytic gold parting plant.

Refining Methods

7. The bullion from the blast furnace is elevated to the level of the copper softening furnaces by a hydraulically-operated lift, and the bars are thrown by hand into the copper softeners through the charging doors where, after melting, the copper dross is removed from the surface of the molten metal by hand skimming. After the removal of the dross the bullion is run by means of cast-iron launders into the antimony-softening furnaces. In these the charge is maintained at a high temperature, and the skimmings, consisting of oxides of arsenic, antimony, and lead, rise to the surface and run off through a V-shaped notch in the end of the furnace. These skimmings, after cooling, are sent to the antimony-dross furnaces for re-treatment, while the bullion is run down a cast-iron launder into the desilverising kettles. When the bullion is tapped into the kettles a quantity of dross is formed, which is skimmed off and returned to the drossing furnaces. Following this, the charge is alternately strongly heated and cooled, zinc being added at each heating to recover the gold and silver contents of the bullion. During each zincing the molten bullion is stirred mechanically for a period of 30 minutes, then allowed to cool, and the alloy skimmed off. The handling of the skimmings is done by pneumatic lifts. The silver alloy is pressed, broken into small pieces, and delivered to the retort-furnace bins. The lead then goes to the final refinery furnaces, from which it is tapped into kettles and cast into market bars. The retort furnaces are producer-gas-fired regenerative furnaces, each accommodating four retorts for the treatment of zinc crusts. The zinc recovered from retorting is again used for desilverising, and the bullion and dross go to the cupellation furnaces. Of the 11 cupellation furnaces, seven are used for concentrating the retort bullion, three for running the concentrate to fine silver, and one for the manufacture of litharge. The commercial litharge goes to a special mill, where it is ground and then packed into tins for marketing.

Zinc Roasting.

8. The zinc roasting plant consists of two Skinner and six Barrier roasting furnaces, with the necessary equipment. Both types of furnaces are vertical. The Skinner furnace has an over-all height of about 36ft., and is divided into eight roasting-hearths. The material treated consists of zinc concentrates, both granular and slime, which are converted into calcines. When delivered from Broken Hill it is unloaded on to belt conveyors and delivered to storage bins, from which the material is transferred as required to the furnace charge bins. In the roasters the ore travels by turns from the centre to the circumference on alternate hearths, passing from one to the other through drop holes. The temperature of the lower hearths is maintained by coal or oil fires, while the upper hearths are cooled when necessary by opening the furnace doors or by blowing in cold air. The calcines are finally discharged through an automatic self-sealing door into a hollow cylinder for cooling. From this cylinder they fall into a push conveyor, which, in conjunction with another conveyor and elevator, delivers them to storage bins, from which the calcines are railed to the wharf for shipment to Tasmania. In their passage over the conveyor, and at the bins, the calcines are moistened by water sprays. The Barrier roasting-furnaces have six hearths, the alternate hearths being fixed and revolving. The charge and calcines are handled by methods similar to those for the Skinner furnaces. The gases from these furnaces are piped to the sulphuric-acid plant.

Acid plant.

9. The sulphuric acid plant is of the contact type, and the process consists essentially of purifying the gases from the roasters, forcing them through pre-heaters and converters, where the sulphur dioxide is converted into sulphur trioxide, cooling the latter, and absorbing it to form sulphuric acid.

Power plant.

10. The power required in the various sections of the works is supplied from a central plant in which the electrical equipment includes—(1) Two 3,000 K.W. turbo-alternators, each consisting of a Fraser

and Chalmers steam turbine of the Rateau type, directly coupled to a Vickers 575 volts, 3-phase, 50-cycle alternator, also smaller units. The main switchboard is in the engine-room immediately over the fireproof switch-room, which is located in the basement, and the motors throughout the works are controlled from the power plant.

11. Blast for the furnaces is supplied by two Fraser & Chalmers Rateau-type blowers and one Parsons turbo-blower, and compressed air is provided by two Bellis and Morcom vertical two-stage air compressors. Steam is supplied by six Babcock and Wilcox type boilers fitted with superheaters and chain-grate stokers. Induced draught for the boilers is supplied by a turbo-fan, and the flue gases pass through Greens' economisers before entering the stack. The accessory equipment includes feed-water pumps for supplying the boilers for condensing purposes, and for general, hydraulic, and fire services throughout the works.

Supplementary plant.

The supplementary plant includes—(*a*) Machine shops equipped to deal with the maintenance required in the various operating sections. (*b*) Brick and pottery works, where South Australian clays are made into the various specially-shaped fire bricks used in the construction of the different furnaces. (*c*) Material arriving by sea and products for shipment are handled over the company's own wharf situated within the works enclosure. To facilitate the handling of steamer cargo the wharf is equipped with two electrically-operated Priestman self-dumping cranes. (*d*) The various sections of the plant are served by branch railways of the same gauge as, and connected by a siding with, the Government railway system.

Tonnages treated.

12. The tonnage at present being treated approximates 7,500 weekly, of which about 5,000 tons is raw lead-bearing material, the balance fuel and fluxes (evidence of H. St. J. Somerset, q. 16). The output of market lead is from 120,000 tons to 130,000 tons per year, which represents the largest individual production of market lead of any smelter in the world. In addition to the smelting operations, about 1,250 tons per week of zinc concentrates delivered from Broken Hill are desulphurised and the calcines shipped to the Electrolytic Zinc Works, Risdon, Tasmania, for further treatment to recover the zinc in metallic form. The material handled in this section contains from 5½ to 6 per cent. lead (H. St. J. Somerset, q. 76A), and from the standpoint of hazard must be regarded as lead ore. After the extraction of the zinc at the Tasmanian works, the residues containing about 18 per cent. lead and 30ozs. silver per ton are shipped back to Port Pirie to recover these values. This material forms a regular percentage of the charge in smelting operations, the quantity dealt with approximating 600 tons per week (H. St. J. Somerset, qs. 89 and 902). There was no direct evidence enabling a comparison of the tonnages now being treated as compared with those handled during the earlier history of the smelters. The former manager, however, stated that in 1900 the blast furnaces in operation numbered 13, and that on the basis of the results then obtained 25 furnaces would be required to deal with the material now being smelted in six furnaces (W. Robertson, q. 687). It seems reasonable, therefore, to infer that the quantity of leady ores now handled is probably nearly double what was being smelted, say, prior to 1915, the year in which the present company took over the plant from the Broken Hill Proprietary Company. The same authority informed the Commission that the Hegeler furnaces formerly used to roast zinc ores were producing about 40 tons of calcines per day, which represents less than 25 per cent. of the output of zinc calcines from the Skinner and Barrier roasting furnaces now in commission (W. Robertson, q. 777). In addition to the changes in plant already referred to, there has been, with the evolution of the present metallurgical practice, an almost complete change in the blast roasting plant, as well as in the handling of materials, due to the installation of a large number of conveyor belts and other mechanical devices to replace manual labor for transporting various products within the works (W. Robertson, qs. 731-735).

CHAPTER III.

STATISTICAL EVIDENCE RELATING TO INDUSTRIAL DISEASE AMONGST SMELTER EMPLOYEES.

The General Health Position.

Statistics.

13. The fullest information at the disposal of the management of the Broken Hill Associated Smelters concerning the personnel employed at the Port Pirie Smelters, and the reported incidence of plumbism amongst them, was placed before the Commission in evidence by the General Superintendent. Tables embodying this information (marked A to P) are included in the printed evidence (*vide* q. 110 *et seq.*). Attention is drawn to the fact that these tables refer in the main to reported* cases of plumbism, many of which, as is pointed out subsequently, may not actually be cases of plumbism. In considering the tables it is necessary to have this in mind. Evidence as to the incidence of sickness other than industrial sickness, was tendered by the company's industrial hygiene officer and by the secretary of the Broken Hill Associated Smelters Sickness and Accident Fund (q. 581.) Further evidence as to the general health position at Port Pirie was obtained from the local health inspector (Mr. A. R. Leonard. q. 1066 *et seq.*) The tabulated statements deal only with the position from 1917 onwards, and as regards the incidence of plumbism amongst the smelter employees prior to that year there is no conclusive information. In 1910, the Chairman of the Central Board of Health (Dr. Ramsay Smith) conducted, on behalf of that body, an inquiry into the causes and occurrences of lead poisoning

*In the text of this report the word "reported" in relation to cases of plumbism means certified and compensated under the Workmen's Compensation Act.

at Port Pirie, and reported that in the absence of complete statistics from the evidence he estimated that during the three years 1907-1909 there had been from 150 to 200 cases of lead poisoning "among people working in the smelting works and those handling lead on the wharves, and painters." The witnesses ascribed the disease amongst the smelter employees chiefly to exposure to fumes on the top and bottom floors at the blast furnace plants ("Report into Cause and Occurrence of Lead Poisoning at Port Pirie," by W. Ramsay Smith, D.Sc., M.B., F.R.S.E.). To overcome this, late in 1909, the slag taps and pots were covered with hoods and these fumes carried away from the smelter buildings. This apparently improved the conditions, as from 1910 onwards to 1917 only occasional cases of lead poisoning were reported, and the hazard was considered to have been effectively limited, (W. Robertson., q. 753.)

14. In the absence of any statutory regulation making plumbism a notifiable disease, the statistical position is, at the present time, most obscure. The Commission, therefore, has had to rely mainly upon the evidence before it, given by the witnesses already mentioned. It has not been found possible, in consequence, to institute any very definite comparison between conditions in the smelters at Port Pirie and in the town of Port Pirie itself and other industries and towns in Australia and elsewhere; but the facts placed before the Commission are sufficiently in detail to permit of a general appreciation of the situation. Broadly, it may be stated:—(*a*) That there is no evidence of the state of general health of the inhabitants of Port Pirie being prejudicially affected owing to the existence in that town of the works of the Broken Hill Associated Smelters Proprietary, Limited. (*b*) That there is no evidence of harmful effects otherwise for the same reason. (*c*) That the health of the employees, apart from reported cases of plumbism, is at least equal to the general average maintaining in the State. (This last generalisation is based on a comparison of absenteeism due to sickness and accident as disclosed by the records of the Broken Hill Associated Smelters Sickness and Accident Fund, and the figures published by the Royal Commission on National Insurance, which, dealing with the members of Friendly Societies, may be presumed to have included a substantial portion of the industrial population of the State.)

Comparison of plumbism position in S.A.

15. Evidence was tendered by the General Superintendent, Mr. Somerset (q. 28), and his predecessor, Mr. Robertson (q. 746), was to the effect that working methods and conditions of hygiene at the works at Port Pirie compared more than favorably with the generality of similar plants in other parts of the world. Both these witnesses had had the opportunity (one in 1924 and one in 1919) of making a world tour of inspection, and the former stated that on the information supplied to him there was very little plumbism reported amongst lead workers in the United States of America and in Great Britain and Europe. In the absence of definite figures, however, the Commission cannot make any useful deductions. A report published by the United States Department of Labor, Bureau of Labor Statistics, in February, 1914, Bulletin No. 141, is descriptive of the investigations made by Dr. Alice Hamilton into the incidence of plumbism in lead works, principally smelters and refineries. Dr. Hamilton did not have the full information at her hands which a complete statistical system would produce, but by careful and full inquiry she was able to make certain summaries. In the first place are published figures showing the period of exposure and attack rate in 167 typical cases of plumbism in the industry. The details are as follows:—

Period of Employment.	No. of Cases.
Less than one month	18
One month and less than 2 months	19
Two months and less than 3 months	22
Three months and less than 4 months	33
Four months and less than 5 months	17
Five months and less than 6 months	12
Six months and less than 12 months	11
Total—Less than one year	132 or 80 per cent.

The figures furnished by the Broken Hill Associated Smelters Proprietary, Limited, show that of 429 cases reported from 1917 up to December 31st, 1924, 28 per cent. occurred within the first 12 months of employment. When these figures are segregated into nationality groups, it is found that the percentages of the totals in each group, calculated on the total cases in each group, are as follows:—

British	20	per cent.	of the total cases	"reported"
Greeks	47	"	"	"
Maltese	46	"	"	"
Italian	50	"	"	"
German	28	"	"	"
Scandinavian	Nil		"	"
Russian	Nil		"	"
Others	30	"	"	"

These figures show in the first instance that plumbism as reported does not affect the employees at the smelters at Port Pirie as readily as it appeared to affect certain typical lead workers in America in 1912.

They also show much greater susceptibility of Greeks, Maltese, and Italians to what has been reported as early plumbism. Two instances where Dr. Hamilton was able to get full information as to the type of plumbism occurring are recorded :—

(*a*) Of 175 cases reported—None severe, 41 moderate, 134 mild.

(*b*) Of 81 cases reported—Five severe, 17 moderate, 59 mild.

If those cases which have a period of disability of not more than 13 weeks are regarded as mild (there are no absolute standards in this connection), then the mild cases reported as occurring at Port Pirie constitute 47 per cent. of the whole, which is rather less than the percentage discovered by Dr. Hamilton. It must be remembered, however, that Dr. Hamilton, in her report, was dealing with the lead industry in the United States of America in 1912 and 1913, and that conditions at that time in the industry were, in all probability, widely different from those at the Port Pirie smelters since 1920.

Incidence of plumbism at Port Pirie, 1910-1925.

16. An outstanding fact emerging from the evidence is that from 1910 to 1917 there were no reported cases of plumbism at Port Pirie, notwithstanding that from the beginning of 1912 plumbism became a compensable industrial disease under the Workmen's Compensation Act. In 1917 only one case was reported ; in 1918, five ; in 1919, five ; in 1920, four ; and in 1921, three. In 1922 the number rose to 56. In 1923 it was 89, in 1924 it was 234, and for the first five months of the present year 126. The percentage of reported cases on the total of persons employed rose from nil to 5 per cent., and principally during 1923 and 1924. It was pointed out, however, at a late period in the proceedings of the Commission, that plumbism was not recognised as a compensable disease by the men until 1917, although cited as such by the Workmen's Compensation Act in 1912. Information from the Secretary of the Port Pirie Hospital showed that the following number of cases of plumbism were treated at that institution during the years 1910-1925 inclusive :—

1910	10
1911	9
1912	21
1913	58
1914	30
1915	22
1916	48
1917	31
1918	48
1919	13
1920	—
1921	—
1922	16
1923	19
1924	46
1925 (to end of May)	12

The years 1920-21, in which no cases were treated, represent the period during which the works were shut down. The above statement does not represent the total number of cases of plumbism occurring as, in all probability certain cases were treated privately, and the total would, therefore, be in excess of the figures quoted. These facts modify the reported percentage of increase, but there has been marked increase in the number of cases reported as occurring since 1923.

Influence of nationality.

17. A possible explanation lies in the great change which has taken place in the composition of the working force employed. At the beginning of 1922 the proportion of foreigners to persons of British origin was as one to eight, whereas at the end of 1924 it was as one to two. When this fact is noted and the figures as to the reported incidence of plumbism amongst the various nationality groups are considered, it appears that Greeks, Italians, and Maltese, in particular, are much more susceptible to the hazards of the industry than are persons of British or Northern European origin. The figures set out in the final two columns of Table L illustrate the reported attack rate during the period July, 1924, to May, 1925, viz. :—

Nationality.	July-Dec., 1924.	Jan.-May, 1925.
British born	3·010 per cent.	2·090 per cent.
Average of foreigners	9·133 "	10·577 "
Greeks	6·667 per cent.	12·414 per cent.
Maltese	25.000 "	18·072 "
Italians	9·028 "	1·351 "
Germans	4·167 "	16·667 " (very few employed)
Scandinavians	3·704 "	5·085 per cent.
Russians	13·793 "	Nil

18. Evidence subsequently submitted, however, by Professor H. G. Chapman and Drs. S. A. Smith and O. M. Moulden, after a personal study of local conditions, and after having conducted clinical examinations of a number of the persons reported to be suffering from plumbism, had the effect of disturbing very seriously the statistical evidence of the witnesses for the company. The company's tables deal with cases reported and considered under the Workmen's Compensation Act as cases of plumbism, and the attack rates and severity rates deducible from them cannot now be deemed to be at all conclusive. Of 29 men examined by Professor Chapman and Dr. Smith only seven were confirmed by them as undoubted cases of plumbism. Of 97 men examined by Dr. Moulden only 26 were confirmed by him as undoubted cases of plumbism. It is thus impossible for the Commission, in view of the conflicting nature of the medical evidence educed, to determine absolutely the extent and severity of the incidence of plumbism at the Port Pirie works. The important fact emerges that many cases formerly reported as cases of plumbism, may be disorders of an entirely different origin, viz., carbon-monoxide absorption, or may be diseases ordinarily existing in any community and in no way connected with the industry. Of those examined by them, Professor Chapman and Dr. Smith diagnosed two persons as suffering from carbon monoxide poisoning or its *sequelae*, and certain others displaying a train of nervous symptoms considered to be indicative of carbon-monoxide poisoning, but only to be determined finally after further observation and examination. Others again, represented as cases of plumbism, were considered to be suffering from appendicitis, myxœdema, cholecystitis, cardiac hypertrophy, &c. Dr. Owen Moulden, the medical expert for the company, concluded that of the 97 men examined by him no fewer than 53 were suffering from disability not arising from lead absorption, but, in his opinion, from carbon-monoxide inhalation. His conclusions were reached from a study of the symptoms and signs presented, and from investigations made in the works in places where these persons had been employed. He, too, diagnosed the complaints of several cases represented as plumbism as being definitely not so. He found various diseases not in any way referable to the nature of employment at the smelters. Professor Chapman, Dr. S. A. Smith, and Dr. Moulden concur in the view that continued research is necessary to reach finality as to the hazard or hazards presented by the works at Port Pirie. Only as a result of such research will it be possible to plan an effective medical campaign of prevention and to record statistically the facts of the situation. Carbon monoxide.

NOTES ON CERTAIN OF THE TABLES SUBMITTED.

Table B.—Numbers of Persons Employed during each Half-year, showing the Various Nationality Groups.

This table in the first two columns shows the steadily ascending proportion of foreigners employed, sufficient British-born applicants for employment have not been offering during the past few years, and foreigners necessarily had to be engaged. The principal increase amongst foreigners occurs in respect of Greeks, Maltese, and Italians.

Table C.—Persons Reported as Having Plumbism, 1917-1925.

This table shows clearly the remarkable increase in the reported cases of plumbism during the past three years, and particularly amongst the foreign element.

Table D.—Length of Service in Relation to Disability.

Of the total reported cases 46·15 per cent. occurred in persons having not more than two years' service. Of the cases reported amongst the various nationality groups percentages as under occurred in those having not more than two years' service:—

British	28·4 per cent.	Greek	80·55 per cent.
German	42·6 "	Maltese	81·89 "
Scandinavian	12·5 "	Italian	76·67 "
		Russian	12·5 per cent.

Table E.—Length of Disability in Relation to Department of Origin.

Owing to the interchange of workmen between various departments of the works, this table is not of substantial value.

Table F.—Length of Disability in Relation to Length of Service.

This table shows a general relation between length of service and length of disability. The chronic cases occur mainly in old employees of British origin. Mild cases predominate, being 47 per cent. of the whole.

Table G.—Length of Disability in Relation to Nationality.

This table does not assist to any conclusion of importance.

Table H.—Ages of Persons Affected.

The majority of persons affected come, as would be expected, in the age group 25-40 years. Of the older men those of British origin predominate. These are men of long service.

Table K.—Ages of Persons Affected in Relation to Length of Disability.

This table shows no useful comparison in the direction desired. It merely shows that industrial disease is proportional to the numbers of persons of the varying ages employed.

Table L.—Consolidated Table.

This table embodies information contained in several of the previous tables. It shows the general position at a glance as to—(*a*) Labor turnover; (*b*) average number of men employed; (*c*) the proportion as between British and foreign born labor; (*d*) the incidence of reported cases of plumbism each half-year and in each nationality group. The labor turnover is heavy, due to (*a*) men coming from and going to seasonal occupations, such as wharf work, farming, and shearing; (*b*) the replacement of foreigners by persons of British origin at every available opportunity.

Table M.—Department of Origin.

Vide remarks in regard to Table E.

Table N.—Length of Service in Relation to Nationality.

	Up to 4 Years' Service.	From 4 Years to 10 Years.	Over 10 Years.
Northern Europeans, including those of British origin	57·7 per cent.	90·4 per cent.	97·4 per cent.
Southern Europeans	42·3 per cent.	9·6 per cent.	2·6 per cent.

Table O.—Ages of Employees in Relation to Nationality.

If this table indicates anything of value it is that 82·29 per cent. of the employees are not more than 45 years of age, and that of the men above this age most of them are of British origin.

19. It is necessary in considering the foregoing summary to have regard to the following points:—(*a*) It has not been possible, on the information available, to prepare morbidity tables (Professor Chapman, q. 2085). (*b*) The fact that the majority of the Southern Europeans are of comparatively short service makes a full comparison difficult, but this does not invalidate a number of the conclusions. (*c*) During recent years foreigners have been employed in the production sections of the plant to a greater extent than persons of British origin, due to circumstances over which the company had no control, and to some extent this factor influences the statistics produced. The Commission holds the view, however, that the conclusions which are drawn from the table may be regarded as sufficiently well-founded for the purposes of the investigation.

CHAPTER IV.

SUMMARY OF MEDICAL EVIDENCE IN RELATION TO INDUSTRIAL DISEASE.

(A) Plumbism.

Toxicity of lead, dust, and fumes.

20. *Toxicity of Lead Dust and Fumes.*—The various compounds of lead show different degrees of toxicity according to their nature. In industrial processes the lead compounds which exhibit the greatest degree of toxicity are the basic carbonate or white lead, the oxides (red and orange lead and litharge), lead sulphate and oleate. A comparatively small number of cases of plumbism owe their origin to chromates and chlorides. (Legge & Goadby, "Lead Poisoning and Lead Absorption," 1912, p. 7). The poisonous nature of any lead compound from an industrial point of view is proportional to (*a*) the size of the particles, and (*b*) the solubility of the particles in the body fluids, such as saliva, mucus of the respiratory tract and the gastric and intestinal juices. The importance of the first factor, namely, size, is from the point of view of the ease with which particles may be inhaled or swallowed and absorbed. The work of the Broken Hill Technical Commission has demonstrated that lead sulphide is relatively less toxic than the oxides or carbonates. According to the evidence of Dr. M. R. Finlayson and the report of the above Commission, the average time of exposure which produced plumbism in workers at Broken Hill may be placed, approximately, at 20 years. (Prof. Chapman, q. 1723; Dr. Finlayson, q. 1467; Report of Technical Commission appointed to inquire into industrial disease at Broken Hill, 1922, p. 3). Sulphide of lead as galena is brought to Port Pirie in two forms, mainly (*a*) as concentrates, finely granular in form; and (*b*) as slimes, which are the result of a flotation process (H. St. J. Somerset, qs. 30 and 31). The slimes are much finer than the concentrates, and the physical condition is such that, in the absence of moisture, they exist as a very fine dust. In the course of roasting the sulphur is driven off, and ultimately, after treatment in the blast furnaces, crude metallic lead is produced. This bullion is then put through a refining process, and the ultimate product is refined lead. The treatments call for the use of high temperatures, and consequently a great deal of very finely divided lead as impure lead dust and also as lead fume is given off into the atmosphere. Owing to the fineness of this dust and fume, a high degree of toxicity is possible.

Causes of plumbism.

21. *Causes and Processes of Plumbism.*—There are three accepted channels through which lead may enter the body—(*a*) The respiratory tract by inhalation; (*b*) the gastro-intestinal tract by swallowing; and (*c*) the skin by prolonged contact. (Legge & Goadby, "Lead Poisoning and Lead Absorption," pp. 8 to

12. Dr. S. A. Smith, q. 1827.) Authorities seem to be universally of the opinion that the third of these channels is a negligible factor, and the balance of opinion of late years is to to the effect that the inhalation of lead dust and fume through the respiratory tract is the most important factor in causing poisoning by lead. At the same time, most authorities are agreed that a certain proportion of the lead may enter the system as a result of absorption from the stomach and intestines after it has been swallowed. The action of the gastric juices, however, renders insoluble the bulk of the lead swallowed, and it is excreted by the bowels. (Legge & Goadby, "Lead Poisoning and Lead Absorption," pp. 12 to 24.) When lead enters the body through respiratory passages it lodges in the alveoli or end divisions of the lungs, and the minute particles are then ingested by certain white blood corpuscles known as phagocytes. Any ingested lead which is absorbed through the stomach and intestines is also absorbed by phagocytes after lodgment in the minute ducts in the mucous lining of the tract. In both instances the lead thus enters the body and is carried to all parts of the body; but, where intestinal absorption occurs, a certain proportion probably enters the portal circulation and is carried to the liver, whence it is excreted by means of the bile. Where respiratory absorption occurs, no fibrosis or damage is caused in the lungs at the point of entry. Processes of plumbism.

22. *Susceptibility.*—Like many other substances, lead causes varying degrees of effect in different individuals. Some may be said to be relatively immune by nature to the effects of lead as a poison, while others are naturally susceptible, and show signs of plumbism very soon after exposure to a lead hazard. (Prof. Chapman, q. 1765. Legge & Goadby, "Lead Poisoning and Lead Absorption," pp. 27 and 28.) Legge & Goadby estimate that females are at least twice, and probably three times, as susceptible as males, and that young persons are twice as susceptible as adults. The Broken Hill Commission estimated that, approximately, 3 per cent. of male workers are susceptible. Such susceptibility may be classed as natural. Persons suffering from certain diseases, chiefly anaemia, show a predisposition to early poisoning by lead. In addition to the recognised state of susceptibility which exists in some people, there are others who, working in lead, will gradually establish a tolerance which will enable them to absorb larger doses without symptoms than they were able to absorb at the commencement of their employment. In these persons, however, a sudden increase in absorption or an inter-current disease may upset that balance of tolerance and precipitate symptoms of plumbism. Susceptibility.

23. *Lead Absorption.*—There are recognised, therefore, among lead workers two conditions—(*a*) lead absorption, and (*b*) lead poisoning. Many workers in lead exhibit signs of absorption without suffering from poisoning. Lead absorption is regarded by Professor Chapman as being a chemical term only, and the evidence of absorption is always the discovery of lead in the urine. (Prof. Chapman, q. 1760.) Leaving aside the question of susceptibility of individuals, normal persons working in lead processes usually show some effects of the intake of lead at an early stage, but they generally develop a tolerance or partial immunity more or less rapidly. This state may be subject to fluctuation according to variations in the rate of intake or the incidence of intercurrent disease. In effect, the state of tolerance is only relatively stable, and the balance depends upon uniform conditions of health, and intake of lead. The state of absorption may exist apparently indefinitely without developing into a state of lead poisoning (Prof. Chapman, q. 1758), although in some instances it may progress into definite poisoning. The situation is summed up by Sir Kenneth Goadby in phrases to the following effect:—Lead absorption is the ingestion or inhalation into the body of quantities of lead which are subminimal poisonous doses. These are sufficient only to produce changes in the body, which the body is able to deal with and repair. When the doses increase to cause damage which the repair system of the body is unable to cope with, plumbism occurs, and the whole of the lead then in the body may act as a toxic amount. (Report of Departmental Committee appointed to investigate the danger attendant on the use of lead compounds, Cmd. 632, evidence of Sir Kenneth Goadby, p. 467.) Signs of lead absorption are those evidenced by the majority of persons soon after first exposure to lead, viz., slight loss of health with a slight degree of anaemia, some loss of weight, and some loss of subcutaneous fat. Effects of lead absorption.

24. *Lead as a Cumulative Poison.*—Lead gradually banks up within the tissues of the body while absorption continues. Absorption may continue under uniform conditions for many years, and then the individual may suddenly show marked symptoms of poisoning. This event is usually precipitated by an attack of illness, or by alcoholic excess. Under these conditions the whole of the lead stored up in the body as before mentioned exerts a poisonous influence. In other words lead acts as a cumulative poison. (Legge and Goadby, "Lead Poisoning and Lead Absorption," p. 28.) Certain illnesses tend to precipitate attacks of plumbism where lead absorption is proceeding. The most common of these are disorders caused by chronic alcoholism, chronic constipation, disturbances of the alimentary tract, oral sepsis or diseased conditions of the mouth, with their train of *sequelae*. (Legge and Goadby, "Lead Poisoning and Lead Absorption," pp. 33 to 42.) Cumulation.

25. *Tolerance.*—Tolerance to the harmful effects of lead seems to be a natural chemical characteristic of certain individuals, but others, who show premonitory symptoms early in their industrial history, may gradually rid themselves of these symptoms, and acquire a degree of tolerance. (Legge and Goadby.) Such tolerance, however, may be easily upset by the conditions mentioned in paragraph 24. Tolerance.

Definition.

26. *Definition and Diagnosis of Plumbism.*—The difficulty of diagnosis of plumbism lies in the fact that definite standards for diagnosis do not exist (Dr. S. A. Smith, q. 1829). At the present time each examining medical officer must conceive his own clinical standards, and thus arises the difficulty in cases not presenting cardinal symptoms and signs of plumbism of determining the actual state of the patient. Where cardinal signs such as colic, paresis, and anaemia are present, no difficulty is experienced. Professor Chapman, in evidence, defined plumbism as "any condition induced by the introduction of lead into the body which may shorten or tend to shorten the duration of life or lessen the efficiency or mechanical energy of the body or diminish the comfort or wellbeing of the body" (q. 1721). The initial effects of the intake of

Diagnosis.

lead by industrial workers are usually manifested in them by some grade of anaemia, and some wasting of the fatty tissues. This syndrome does not constitute plumbism, but is evidence only of lead absorption and the signs mentioned pass away in the majority of persons with the establishment of tolerance. In cases of susceptibility, or of progression to lead poisoning, the signs mentioned become accentuated and associated with wasting of muscles, notably of the extensor groups of the forearm and leg. At the same time a degree of lack of mental energy becomes evident. Coincident with these signs abdominal colic appears. The presence of this colic is very definite, and if the patient is closely questioned it will not be confused with abdominal pains from other causes (Prof. Chapman, q. 1762; Dr. Smith, q. 2169). Attacks recur at intervals as short as half an hour apart, and the patient in describing an attack will characteristically place both hands over the lower abdomen. This colic is commonly ascribed to the effects of lead on the nerve endings in the intestinal wall (Legge and Goadby, "Lead Poisoning and Lead Absorption," pp. 110 to 122). Attendant on colic, as a general rule, is a history of constipation, but this may give rise to a false diarrhoea (Legge and Goadby, "Lead Poisoning and Lead Absorption," p. 115). A distinguishing feature regarding true lead colic in contradistinction to abdominal pains from other causes is the attendant slow pulse, also the fact that the pain is relieved by pressure.

Additional symptoms.

27. Additional more or less constant symptoms of plumbism are headache and the Burtonian blue line. The former is usually frontal in character, but it may be general. It is frequently the precursor of the cerebral type of poisoning. The true blue line is due to the deposition of lead in the form of sulphide in the gums, and is not definitely a sign of lead poisoning, but rather of lead absorption. It is not commonly found in persons with perfect teeth and gums, but in the presence of oral sepsis sulphuretted hydrogen is formed in the mouth, and converts lead salts into lead sulphide. This characteristically appears along the margins of the gums, especially where ulceration is present, as a blue line. In extreme cases it affects other parts of the mouth, and even the tongue has a blue discoloration. (Legge and Goadby, "Lead Poisoning and Lead Absorption," pp. 122 to 126.) Lead appears in the urine of all lead workers at an early period of absorption, and tends to diminish or disappear as the stage of tolerance is reached. At this stage the great bulk of elimination takes place by means of the bowels.

Types of plumbism.

28. Cases of plumbism may be divided into three main types, or, as some would classify, into four types (Dr. L. G. Tassie, q. 1212). These are—(*a*) The gastro-intestinal type, in which the predominant symptoms are colic and constipation. (*b*) The nervous type, or neuritic type, in which paresis and paralysis of the extensor muscles are the main manifestations. (*c*) The cerebral type, in which the tendency is towards fits, manias, and other encephalopathies. (*d*) The arterio-renal type, in which the chief signs are thickening of the arteries, and changes in the kidneys resembling Bright's disease. Apart from changes affecting the nervous and circulatory and renal systems, symptoms of plumbism are subjective.

Nervous signs.

29. Objective signs of plumbism as affecting the nervous system range from tremor, with weakness of the extensor muscles, through definite paralysis of these muscles, producing wrist-drop and foot-drop, to fits and definite mania as represented by class (*c*) in paragraph 28. These signs are associated with cramp and muscular pains, which are attributed to local action of lead on the nerves and muscles. A rapid absorption of lead in fairly large quantities tends to produce the gastro-intestinal type of case and these cases have been known to occur with fatal results in the absence of other marked symptoms. A less acute form brought about by a more prolonged intake of smaller daily doses of lead would tend, in the bulk of instances,

Chronic plumbism.

to the neuritic type. The chronic type of lead poisoning, which usually occurs after a period of some years of industrial history, is the arterio-renal type. This is brought about by prolonged action of lead on the blood vessels and kidneys, and results in a condition closely resembling Bright's disease. In mentioning the encephalopathic type, it may be stated that such cases are comparatively uncommon, and are the result as a rule of the absorption of large quantities of lead in a relatively short space of time. This type of poisoning is usually the result of chronic alcoholism. (Legge and Goadby, "Lead Poisoning and Lead Absorption," p. 157.)

The blood in plumbism.

30. *Examination of the Blood in Relation to the Diagnosis of Lead Poisoning.*—An aid to the diagnosis of lead poisoning is the examination of the blood. It may be here stated that no definite picture of blood is *per se* an indication of lead poisoning, but in conjunction with other systems, an examination comprising the red cells and haemoglobin estimations and the blood picture is of use. (Prof. Chapman, q. 1743; Dr. S. A. Smith, q. 1828; Dr. Yeatman, q. 1333; Dr. Tassie, q. 1218.) Lead acts on the red blood cells and causes them to become more fragile. This gives rise, through wear and tear, to a diminution in the numbers of red cells. This anaemia is stated by Legge and Goadby to be the earliest symptom of lead poisoning. (Legge and Goadby, "Lead Poisoning and Lead Absorption," p. 28.) The red cell count rarely falls as low

as 2,000,000 per c.mm. The estimation of a haemoglobin is regarded by some authorities as of more importance than the red cell count (Prof. Chapman, q. 1743). The loss of more than 20 per cent. of haemoglobin must be regarded as a sign of anaemia. Much discussion has eventuated as to the significance of the appearance of cells showing punctate basophilia in lead workers. The experience of experts in recent times is, mainly, that while such basophilic degeneration occurs in many classes of anaemia, certain classes of lead workers show it fairly constantly. At the same time it is to be regarded as a sign of lead absorption rather than of one of lead poisoning (Prof. Chapman, q. 1746).

Lead poisoning in various industries.

31. *Contrasts in Regard to Lead Poisoning in various Industries.*—Professor Chapman, in evidence, stated that basophilic degeneration was not found among miners at Broken Hill, even among those who were suffering from lead poisoning. This class of lead poisoning, it should be noted, is of a particularly chronic nature (Prof. Chapman, q. 1747). Dr. Matthew, medical officer in charge of the Commonwealth Health Laboratory, Port Pirie, in his evidence, indicated that the bulk of cases examined at Port Pirie showed basophilic degeneration. (Evidence of Dr. Matthew, q. 1124; see also Appendix.) The type of industrial lead poisoning which may occur in any given industry will be subject to variations and will depend upon the conditions of working and the rate of lead intake. Cases of lead poisoning found in Broken Hill were of two types and were not regarded as cases of typical industrial plumbism (Prof. Chapman, qs. 1724 to 1731). The first group gave a history of having suffered from repeated attacks of colic over 15 to 20 years and showed evidence of a definite paralysis of lead type, had lost weight, showed a typical earthy pallor, malnutrition, and complained of headaches, giddiness, and tremor.

Broken Hill.

Some of them also showed signs of Bright's disease. The second group gave the same history of repeated attacks of colic over many years, but no history of ever having had paralysis or pareses. They exhibited, like the first group, pallor with the earthy tint, malnutrition, loss of subcutaneous fat, and some of them complained of headaches, giddiness, tremor, muscular wasting, and loss of weight, and 50 per cent. of them had evidence of Bright's disease. Professor Chapman, in evidence (q. 1733), mentioned that cases occurring in potteries frequently manifest acute symptoms with encephalopathy.

White lead works in Sydney.

32. Interesting evidence of the incidence of lead poisoning was obtained from the factories of Berger's Limited, and the British Australian Lead Manufacturing Company, in Sydney, where white lead is manufactured. It is recognised that white lead, the basic carbonate of lead, in the form of dust is very toxic, and definite hazards exist at these works. In the case of Berger's Limited, only four cases of plumbism had occurred in seven years, and all these had recovered and returned to work (Dr. L. H. Rogers, q. 1556). At the British Australian Lead Manufacturing Works six definite cases and a doubtful case occurred in two years, all of whom recovered. In the subsequent two and a half years to date only two doubtful cases occurred (Dr. Freeman, q. 1651). These cases were all of an acute type and totally unlike the Broken Hill cases. Symptoms complained of were severe colic and constipation and in some cases paralysis. They apparently represent the results of a large dose of lead in a comparatively short time, and may be classed as acute.

Port Pirie

33. In Port Pirie medical evidence was given to the effect that typical cases were of a sub-acute type (Dr. Tassie, q. 1212; Dr. Yeatman, q. 1316). The prevailing symptoms were pallor, with the blue lead line in the gums, loss of weight, loss of appetite, with foul taste in the mouth, constipation and colic, loss of muscular tone with wasting, tenderness over the nerve trunks, sleeplessness, and pains in the joints. In these cases any one particular group of signs and symptoms may predominate and determine the case among one or more of three or four typical groups—anaemic, abdominal, neuritic, or cerebral. The cases described may be taken to represent the results of absorption of lead at a more rapid rate than those of the Broken Hill type, but less rapidly than the cases described as working in potteries and becoming acutely ill with cerebral symptoms. Thus it may be gathered that the type of plumbism case will vary between industry and industry, and will be determined by the working conditions relating to rate of intake of lead dust and fume.

Broken Hill Survey.

34. *Broken Hill Survey.*—The results of the work of the Technical Commission appointed to inquire into the occurrence of industrial diseases at Broken Hill are given in details in its report published in 1922. Clinical examinations were made of the urine of 209 men at work in the mines for some six months previous to the investigation, and lead was found in every instance. This indicated uniform absorption of lead by workers and, in connection with further experiments relating to dust estimation, formed the Commission's opinion that the concentration of absorbed lead to which Broken Hill workers are exposed is low. The Commission examined 6,538 men who had worked in the Broken Hill mines for varying periods. Of these, 61 were found to be suffering from lead poisoning. Of the 6,538 persons, 3,302 or 50·5 per cent. had worked for 10 years or less. Two, or ·06 per cent., of these were found to be suffering from lead poisoning. Of 1851 who had worked for over 10 and under 20 years, 23 or 1·2 per cent. had lead poisoning. Of 1,104 who had worked over 20 and less than 30 years, 30, or 2·7 per cent. were affected; and of 256 who had worked over 30 years, 6, or 2·3 per cent. were affected. These figures indicate that industrial lead poisoning in Broken Hill is a very slow process, and the cases are of a chronic type.

English works.

35. *Experience in English Lead Works.*—The incidence of lead poisoning in English factories and works is discussed under the annual reports of the Chief Inspectors of Factories and Workshops (England), 1914 to 1919 (Report for 1914, p. 81; Report for 1918, p. 66). In the report for 1919 (p. 61) Dr. Legge states that the sole causative agents in industrial plumbism are leady dust and fume, and that the sheet anchor of protection of the workers is locally applied exhaust ventilation.

(B) Carbon Monoxide.

Presence of Carbon Monoxide at the Smelters.

Carbon monoxide hazard.

36. As a result of personal inspections of the Broken Hill Associated Smelters plant and works processes by the Commission the conclusion was reached that there was a possibility of the health hazard at the works being influenced by the presence in the atmosphere at various points of carbon monoxide gas. Under examination, the General Superintendent stated that such gas was present inside the bag house and furnaces. He was not aware of the degree of saturation of the atmosphere by carbon monoxide necessary to cause injury to persons exposed (H. St. J. Somerset, q. 934). The possibility of carbon moonxide intoxication was put to several other witnesses. It had not come within the experience of the local medical practitioners. Professor H. G. Chapman, of Sydney University, and Dr. S. A. Smith, consulting physician of Sydney, in their evidence taken in Sydney, raised very definite suspicions in the minds of the Commissioners present as to the existence at the works of carbon monoxide, and the harmful effect it might be causing both independently of and concurrently with the lead hazard (Prof. Chapman, q. 1815; Dr. Smith, q. 1880). When these experts visited Port Pirie, at the request of the Commission, made an inspection of the plant, and examined a number of the men, they reached the definite conclusion that carbon monoxide was present in the atmosphere at several places, that it was inducing neurasthenia amongst a number of the employees, and that two out of the 29 employees examined, who had been certified as suffering from plumbism, were in fact suffering from chronic carbon monoxide intoxication (Prof. Chapman, q. 2037, *et seq.*; Dr. Smith, q. 2163). They recommended, therefore, that a systematic survey of the atmosphere should be made to ascertain where and to what extent carbon monoxide was present, and further that a blood survey should be undertaken amongst the employees liable to a carbon monoxide hazard, with a view to ascertaining to what extent, if any, carboxy haemoglobin was present in them (Prof. Chapman, q. 2150). The company had already made arrangements to carry out atmospheric analyses, apparatus for this purpose having been obtained from the management of the Broken Hill South S.M. Coy., Limited.

Investigation of carbon monoxide hazard.

37. In pursuance of its investigations the Commission, under the personal supervision of the Chairman and Mr. Commissioner Robinette, and with the assistance of local doctors and technicians, supplied by the Company at the request of the Commission, ascertained the carboxy haemoglobin contents of the blood of men working in various parts of the smelters. From 0 per cent. to 15 per cent. of saturation was ascertained, the Barrier Roaster Plant, Power Station, and Workshops giving the lowest figures and the Main Baghouse the highest. Details of the results obtained in the various departments of the works are set out in the following table:—

Top floor	In 3 hours' work, 4 to 11 per cent; in 7½ hours, 9 to 11 per cent.
Bottom floor	3½ hours, 2 to 8 per cent.; 8 hours 3 to 8 per cent.
Barrier Roaster	4 hours, nil.
Skinner Roaster	4 hours, 3 per cent.
Baghouse	7 hours, 8 to 9 per cent.; after 10 minutes inside a chamber of the baghouse, 15 per cent.
Refinery	2 hours, 3 per cent.; 7 hours, nil to 2 per cent.
H. & H. pots.....	3 hours, 1 to 12 per cent.; 7½ hours, 3 per cent. (Showed 12 per cent. in morning. There was a south wind blowing in afternoon).
Dwight & Lloyd "A" plant..	3 hours, 4 to 6 per cent.; 7 hours, 10 per cent.
Dwight & Lloyd "B" plant..	3 hours, 1 per cent.; 7½ hours, 5 per cent.
Power house	4 hours, nil.
Blacksmith's shop	4 hours, nil.
Sampling plant	4 hours, 4 per cent.
Coke heap	4 hours, 4 per cent. (Chairman's statement, q. 2134).

Carbon monoxide.

38. *Properties of Carbon Monoxide.*—Carbon monoxide is colorless and odorless. It is slightly lighter than air and readily diffuses to make a homogeneous mixture with air. The relative affinity of carbon monoxide and oxygen for the haemoglobin of the blood is 300 to 1.

Acute carbon monoxide poisoning.

39. *Types of Carbon Monoxide Poisoning.*—Carbon monoxide poisoning is of two types:—(*a*) Acute, and (*b*) chronic. Acute carbon monoxide poisoning is caused in a short space of time by exposure to atmosphere, containing as low as 0·15 per cent. of carbon monoxide by volume. This type is met with principally in coal mining and in industries which use large quantities of coal or coke. As for instance, steel making and metallurgical treatment plants operating blast furnaces and retorts. When the blood of a person is saturated to such an extent that it contains 30 per cent. or more of carboxy haemoglobin there is grave danger of acute carbon monoxide poisoning, and possibly death resulting.

40. *Chronic Carbon Monoxide Poisoning.*—Chronic carbon monoxide poisoning results from long continued exposure to small amounts of carbon monoxide. Text books on the subject state that when the atmosphere contains as little as ·01 per cent. by volume of carbon monoxide persons inhaling same intermittently over long periods are likely to develop chronic carbon monoxide poisoning. Professor Chapman holds the view that even a lesser density may induce the disease. The best medical opinion is that long continued exposure to low concentrations of carbon monoxide is much more serious in its consequences than short exposure to a very much greater concentration. Chronic carbon monoxide poisoning.

41. *Symptoms.*—A publication of the United States Bureau of Mines (Public Health Bulletin, No. 150), where a great amount of most important research work upon carbon monoxide has been carried out, contains the following table indicative of the symptoms produced by varying absorptions into the blood of carbon monoxide gas :— Symptoms.

Degree of Saturation (CO HB).	Symptoms Produced.
0%–10%	Nil.
0%–20%	Tightness across the forehead, possibly slight headache, dilatation of cutaneous blood vessels.
20%–30%	Headache, throbbing in temples.
30%–40%	Severe headache, weakness, dizziness, dimness of vision, nausea, vomiting, collapse.
40%–50%	Same as previous with more possibility of collapse and syncope, increased respiration and pulse.
50%–60%	Syncope, increased respiration and pulse, coma with intermittent convulsions.
60%–70%	Coma, intermittent convulsions, depressed heart action, possibly death.
70%–80%	Weak pulse, slowed respiration, respiratory failure, and death.

In connection with the co-operative work of the Bureau of Mines and the New York and New Jersey State Bridge and Tunnel Commissions in 1921, on the physiological effects of automobile exhaust gases, the following statement was formulated by Dr. Yandell Henderson in regard to the probable effects of a given concentration of carbon-monoxide gas in a given time :—

1. When the time of exposure in hours multiplied by the concentration of carbon monoxide in parts per 10,000 equals 3, there is no perceptible effect.
2. When the result is 6, there is just a perceptible effect.
3. When the result is 9, there will be headache and nausea.
4. When the result is 15 or more, the conditions are dangerous to life.
5. If the volume of breathing is increased by exercise (even by slow walking, and correspondingly more by physical work) the rate of absorption of carbon monoxide is increased proportionally.

42. *Tests of Carbon Monoxide Absorption.*—Colorimetric determinations of carbon monoxide absorption are readily made and the percentage of carbon haemoglobin in the blood is ascertained by reference to definite standards. The technique of the making of these determinations may be seen in the following publication :—" The Pyro-tannic Acid Method for the Quantitative Determination of Carbon Monoxide in Blood and Air," by R. R. Sayers, W. P. Yant, and G. W. Jones (Reprint No. 872, from the Public Health Reports, U.S.A., October 5th, 1923). Tests for absorption.

43. *The Action of Carbon Monoxide on the Body.*—The blood contains coloring matter known as haemoglobin. The oxygen necessary to the maintenance of life is taken from the air inhaled by the lungs and passing into the haemoblogin of the blood circulates throughout the body to perform its function of burning up of waste matter. One gramme of haemoglobin carries 1·34 c.c. of oxygen. Roughly speaking, in Australia, 100 c.c. of blood carries 20c.c. of oxygen. One gramme of haemoglobin, when saturated, carries 1·34 c.c. of carbon monoxide. One hundred cubic centimetres of blood will, therefore, carry, when saturated, 20 c.c. carbon monoxide. The exact amount varies with the weight of the individual, but the average of the blood of an adult person is 5,000 c.c., or, approximately, 9 pints. The blood of an average person, therefore, when saturated, carries 1,000 c.c. of carbon monoxide. The amount of carbon monoxide absorbed is proportional to the amount of air breathed and the percentage of carbon monoxide in that air. Experience shows that a person becomes acutely affected when his haemoglobin is 30 per cent. saturated, and it is known that the result is likely to be immediately, or within a few days fatal, when the blood is 60 per cent. saturated, that is to say, when the person has absorbed 600 c.c. of carbon monoxide. As the blood containing carbon monoxide passes through the capillary vessels to the veins it loses extremely little, if any, of the carbon monoxide. Thus the tissues are denied the oxygen necessary to them and damage to them ensues. The amount of damage which results is dependent not only upon the amount of carbon monoxide contained in the blood, but also upon the sensitiveness of the individual to the gas. The opinion is held by some authorities that the damage done by carbon monoxide is due simply to its interference with the oxygen carrying capacity of the blood. It is believed, however, that in addition to this, it has a specific poisonous effect Physiological aspect.

upon the human tissues. Some cases of carbon monoxide poisoning of an acute type recover without damage and disability. Others, however, reveal its effects after a period of delay, and in some persons changes are set up some days after the inhalation of the gas. Carbon monoxide has a selective effect upon certain nervous tissues in the brain, inducing degenerative changes. In this way tremor, rigidity of the muscles, as well as what are known as neurasthenic symptoms ensue. Exercises, high temperature and humidity, and low oxygen content of an atmosphere increase the degree of poisoning for any given concentration of carbon monoxide. Therefore, badly ventilated working places would increase the danger. Anything which lowers the physical fitness of the individual, such as illness, overwork, or excesses of any kind, exaggerates its effects.

Sequelae.

44. *Sequelae of Acute Carbon Monoxide Poisoning.*—The *sequelae* of acute carbon monoxide poisoning include headaches, muscular pains, long periods of unconsciousness, loss of strength and mental derangement, loss of memory, paralysis, and temporary blindness. Most persons affected completely recover in a day or two, but there are cases known where the *sequelae* have persisted for several months and, in a few instances, for years.

Plumbism complicated by carbon monoxide poisoning.

45. *Carbon Monoxide Poisoning and Plumbism.*—A study of the hazards of carbon monoxide at the Port Pirie smelters reveals the possibility of the existence in certain parts of the works of a health hazard. Where small quantities of carbon monoxide are intermittently absorbed by individuals there is a possible danger, if not of neurasthenia, at least of loss of tone. Loss of tone affects the appetite and digestion, and these in turn induce anaemia. Thus the individual may display steadily diminishing powers of resistance to disease and finally become incapacitated.

CHAPTER V.

ADMINISTRATIVE AND TRADE EVIDENCE, WORKING, AND LIVING CONDITIONS.

Working conditions at Smelters.

46. The present position respecting reported cases of plumbism among the Smelter employees suggests that the hygienic conditions at the Smelters have become worse than they were formerly. This view met with a strong denial from the General Superintendent for the Company, who contended that the reverse was the case, and gave particulars of a number of alterations made for the betterment of conditions as well as of a number of other projected improvements, either in course of installation or for which plans were being prepared (H. St. J. Somerset, q. 145 *et seq.*). In support of this view the industrial officer for hygiene at the Smelters, who was appointed in 1923, gave detailed statements of measures taken since that date to improve conditions, particularly in respect to the suppression of dust by the regular watering down of certain portions of the works, the moistening of leady material in storage or in course of treatment, and particulars of a number of other changes carried out for the purpose of reducing the hazard. Both these witnesses, as well as the former Superintendent of the Company, maintained that a large number of changes made in the plant and treatment processes, while introduced to obtain improved efficiency, had ameliorated working conditions and lessened the health risk (G. Dey, q. 660; W. Robertson, q. 738). A witness, who had been employed at the Smelters for 23 years, stated that the dust was much worse now than in 1921, referring particularly to that originating around the Skinner and Barrier Roaster furnaces, (J. Malyeha, q. 494-5). Another witness gave evidence regarding the escape of fumes from the baghouse connected with the blast furnaces, and the presence of a quantity of fumes in the blast roasting section, particularly when the Huntington-Heberlein pots were tipped (A. H. Hart, q. 174). These statements were not contested, but evidence was given regarding alterations in progress and proposed modifications in practice to minimise the dust and fumes as the places specified. The evidence regarding the extent of the health hazard of the different sections of the works was inconclusive, but its existence in all the operating departments was established. The secretary of the local branch of the Amalgamated Engineers' Union stated in evidence that out of five cases of plumbism amongst the members of his union since 1923, four of the men affected had been employed in repair work at the Dwight & Lloyd plant (H. R. Summerton, q. 1178). This is the only definite statement obtained as to the point of origin of any cases. From information obtained by the Commission, by personal inspection as well as from evidence, it is clear that the condition of most working places is affected to a considerable degree by the prevailing weather conditions, such as direction of wind, humidity, and the operations being carried out at the time. Consequently the hazard varies.

Working hours at the Smelters.

47. Working hours at the Smelters, as far as the operating departments are concerned, are governed by an award of the State Industrial Court made in September, 1923, which regulates the wages, hours, terms, and conditions of employment of the daily-paid staff of the Broken Hill Associated Smelters Proprietary, Limited, at its works at Port Pirie. Under clauses 5 and 6 of this award it is prescribed that 48 hours shall constitute a week's work, and that time worked in excess of this on Sundays and holidays or outside regular hours shall be paid for at overtime rates, viz., time and a half for shift workers, double time for day workers. The practice regarding shift workers engaged in the treatment of ores and manufacture of lead is for the men to work eight shifts in one week, seven the next week, and six the following week, or an average of seven shifts per week (H. St. J. Somerset, q. 801). Under a condition of employment established by the company in 1918 shift workers are allowed 14 days' holiday per annum, on full pay, provided that they have not lost more than 14 days without a certificate for sickness. Day workers are under the same terms allowed

12 days if they have not more than 12 days' lost time. Men who have not been employed for a full year are entitled to a holiday allowance in proportion to the time worked (G. Dey, q. 598). The company also maintains a holiday camp at Weeroona, on the opposite side of Spencer's Gulf to Port Pirie, where the company's employees and their families are accommodated at low rates.

Hours of working.

48. In Australia, as well as in other countries, where there is, as in the lead-smelting industry, an admitted health hazard, the practice for many years has been to limit the hours of employment either by legislation or the awards of Industrial Tribunals. This was done in New South Wales as far back as 1904, when the Court of Industrial Arbitration in an award regulating the industrial conditions in the painting trade adopted this course. The same principle has been applied in other industries, such as mining, throughout the Commonwealth. Certain medical witnesses were strongly of the opinion that a reduction in the number of shifts worked per week from seven to six would be in the interests of the health of the employees (Prof. Chapman, q. 1813; Dr. S. A. Smith, q. 1890). The Company's chief representative before the Commission was in agreement with this opinion (H. St. J. Somerset, q. 803).

Housing and Living Conditions at Port Pirie.

Evidence and inspection re housing conditions.

49. Realising the importance of the housing and living conditions of employees as a contributing factor in the matter of their general health, the Commission took evidence and made personal inspections with a view to ascertaining the facts of the position at Port Pirie. The General Superintendent of the Smelters stated that he had heard that a great number of the foreign-born workmen were in the habit of "batching" together (H. St. J. Somerset, q. 150). The evidence of A. R. Leonard, Health Inspector for the Corporation of Port Pirie (q. 1068 *et seq.*) was to the effect that a considerable number of the unmarried foreign-born workmen "batched" together in houses, slept upon the floors, and were not cleanly in their habits. They lived upon the cheapest quality food, desiring as it appeared to reserve their money for other purposes. They were not regular in their washing of clothes, nor in their personal ablutions. They preferred their meals on return from work without washing. They did not go in for healthy sport. This evidence was confirmed by Dr. C. Yeatman, Health Officer (q. 1308). Others among the foreign element, he stated, observed quite satisfactory standards of living, particularly those who lived with their families. Many of them were property owners. Joshua Retchford, Manager of the Broken Hill Associated Smelters' Co-operative Store, stated in evidence that the foreign-born workers, particularly new arrivals and unmarried men, were heavy purchasers of the cheaper lines of canned foods (q. 1380 *et seq.*). This would be anticipated in persons who "batched" as a means to minimise labor in the preparation of food.

50. The Commission, in company with the Health Inspector, made an inspection of typical areas in Port Pirie. It may be generally stated that this inspection confirmed the evidence given by Mr. Leonard. The average of the houses occupied by workmen of British origin and by foreign-born workmen in residence with their families was found to be of a satisfactory standard. It appears that under the Health Act, which is an old Act, the powers of the corporation and inspector are very limited (q. 1099 *et seq.*). The inspector cannot deal with authority with any building. He has to rely largely upon moral suasion in order to secure structural improvements, and it would be in the interests of public health if the Act were modernised. Evidence was tendered by J. H. Leahey, Assistant Town Clerk, that 319 of the employees at the Smelters owned their homes (*q.* 1897). This represented, approximately, 17 per cent. of the whole. The Commission understands that at the present time the housing in the town is barely adequate. New houses are being erected, but not in great numbers, and many people board or live in apartments. Consequently with any increase in the employment of married men there would be a serious house shortage.

Visit to Sydney and inspection of white lead manufactories.

51. The members of the Commission (with the exception of Mr. Commissioner Robinette) during their visit to New South Wales inspected the works of Lewis Berger & Sons (Australia), Limited, at Rhodes, and of the British Australian Lead Manufacturers Proprietary, Limited, at Cabarita. Both establishments are situated on the Parramatta River, near Sydney. Berger's works were erected in 1917, and about 100 men are employed in the lead corroding, paint manufacture, and varnish making departments. All these operations involve a definite health hazard, but this, from the evidence of the Company's officials, has been so effectively controlled that only four cases of definite plumbism have occurred, and no case of plumbism has been reported within the past two years. The loss of time among employees from occupational disease or accident was stated to be less than one day per annum, and from all causes less than eight days per annum, which is below the average for the Commonwealth, as recently given by the Federal Commission on National Insurance (Dr. Rogers, q. 1556). This favorable position and the low incidence of plumbism were ascribed to :—(*a*) The factory hygiene conditions being up to date. (*b*) The prevention of dust by the installation of dust collectors throughout the buildings, enclosing the crushing and elevating machinery, and the prevention of the accumulation of dust throughout the buildings. (*c*) The provision of washing facilities, and an allowance of time before meals to permit of employees washing. (*d*) The supply by the Company of clean overalls twice a week to prevent employees' ordinary clothing becoming contaminated with dust. (*e*) The provision of respirators for the use of employees where there is any hazard from dust. (*f*) The enforcement of personal hygiene. (*g*) A weekly medical inspection of the employees, with free medical examination of employees who complain of ill-health (C. M. Taylor, q. 1614). The medical officer for the works attributed the favorable results to co-operation between employer and employees, and gave it as

British experience in white lead industry.

his experience that this was the determining factor in industrial hygiene. At the British Australian Company's works operations are at present confined to the making of white lead mixed with oil. The plant has been in operation about four years, and an average of 27 employees are actually engaged in the lead processes. The reported cases of plumbism total nine, and the medical officer of the company stated that most of these occurred soon after the commencement of operations, when the precautionary measures now in force were not fully applied. The employees are supplied by the company with clean overalls daily, and other preventive measures are applied on the same lines as those described as being in force at Berger's works (evidence of Dr. Freeman and G. H. Podger, pp. 72-75).

CHAPTER VI.

MATTERS RELATIVE TO THE INQUIRY—PREVENTIVE MEASURES ADOPTED IN OTHER STATES AND COUNTRIES.

Prevention of plumbism in other States and countries.

52. Amongst the important matters subordinately connected with the inquiry was the question of the measures found to be effective for dealing with plumbism in other States and countries. Most of the countries where lead is extensively mined, smelted, or used in manufactures have laws and regulations governing the conduct of operations in lead metallurgical processes. In addition to making regulations aiming at the prevention of the disease, most of the countries where lead is produced or smelted in important quantities have in recent years made lead poisoning and its *sequelae* a compensable disease under Workmen's Compensation Acts. This course was adopted in Great Britain as far back as 1907, and in South Australia in 1912. From the reported results the general experience has been that the passing of compensation laws has usually been marked by an increase in the reported cases in any particular industry. This must obviously be attributed to the fact that when a compensation law is in force a workman suffering from a compensable disease has not the same motive for repressing mention of his illness. As a consequence, a number of cases are reported which, if not of a serious character, would probably have been repressed before the passing of a Compensation Act. Despite this fact, in Great Britain there is reported a continual diminution in the number of cases of lead poisoning and in the severity of the cases. This is attributed to enforced attention under statutory regulations to the suppression of dust, prevention of fume, and personal cleanliness on the part of employees. In this connection a witness, with long experience, stated that during the first two years after the introduction of statutory regulations in Great Britain the incidence of plumbism amongst employees in British white lead works was reduced to a fifth of the number previously reported (G. H. Podger, q. 1711). In 1900 one thousand cases of industrial poisoning by lead were recorded in England; in 1922 the number has fallen to 200, though more lead was used. ("Lead," Monographs on Industrial Chemistry, Smythe, p. 311).

Regulations in New South Wales and Tasmania.

53. At present two of the Australian States (New South Wales and Tasmania) have regulations aiming at the prevention of plumbism applying to smelters, while South Australia and Queensland possess the power under existing legislation to make such regulations. The precautions taken in the various States and other countries are indicated by the following summary:—

New South Wales.—Regulations under the Mines Inspection Act, 1901, provide for—(*a*) Prevention of dust and fumes:—Adequate provision must be made to prevent the emission of flue dust from smelter stacks. The outlets through which flue dust is removed from main flues must discharge into otherwise unoccupied space. The floors on to which the dust falls must be hard and impermeable, and provided with a curb raised above the surrounding surface so as to prevent the deposited dust or mud from being carried about. The dust must be wetted as soon as it is drawn from the flue. The accumulation of flue dust must not be allowed outside the flue unless within a securely closed receptacle. Respirators must be provided for men handling flue dust, and for any men in the vicinity of where it is being handled. Furnaces must be surrounded with a hood to catch the fumes from molten metal and slag. The tapping floors must be ventilated to allow the ready escape of fume. (*b*) Change house accommodation for workmen, &c.:—Properly lighted and warmed change houses and bath houses must be provided, and the latter supplied with hot and cold water. A workman engaged in smelting or otherwise handling lead ores must change his ordinary clothes for working clothes in the changing room before beginning work, and change clothes again on finishing work. (*c*) Records:—The manager of a works must keep a record of all cases of lead poisoning, whether certified or uncertified, and report them monthly to the Mines Department on a prescribed form. (New South Wales Mines Inspection Act, 1901, Rules and Regulations).

Tasmania.—The regulations of this State have been made under the Mines and Works Regulation Act, 1915, and are included under the heading of "General Rules for Smelters." The provisions require the prevention of dust and fume, &c., on smilar lines to those described as being in force in New South Wales.

South Australia.

South Australia.—The Mines and Works Inspection Act of 1920, by subsections 11 and 13 of schedule 2, gives the Governor in Council power to make regulations for:—The prevention

and laying of dust; the prevention of the escape of deleterious gases and fumes from any chemical or metallurgical process; the provision of changing and washing accommodation and the supply of pure drinking water.

Queensland.—The Mines Regulation Act (Consolidated) of 1911 gives similar powers to those contained in the South Australian Mines and Works Inspection Act. Queensland.

Great Britain.—The British regulations came into force in October, 1911, and May, 1912, and were made under the powers of the Factory and Workshop Act of 1901. Lead material is defined as material containing not less than 5 per cent. of lead. Under the regulations, smelters and works owners are required to make the following provisions:—Prevention of dust and fumes; all floors must be maintained in good condition and sprayed with water at least once a day; no lead material other than ingots of metal may be deposited or allowed to remain on any part of the floor not set apart for the purpose or be moved to a furnace (*a*) unless it is damp, or unless there is an efficient exhaust draught; or (*b*) the lead material is enclosed so as to prevent escape of dust; or (*c*) the persons moving the material wear respirators. The following operations must be carried on under efficient exhaust draught, or in such manner as to prevent the escape of gas vapor, fumes, or dust into any place in which work is carried on—(*a*) Melting lead or dirty scrap lead; (*b*) heating lead material so that vapor containing lead is given off; (*c*) cooling molten flake litharge; (*d*) feeding any furnace or retort; (*e*) manipulating any lead material in any furnace or retort; (*f*) removing lead material from any furnace or retort; (*g*) placing in any hopper or packing red or orange lead or flaked litharge. Overalls must be provided for workmen engaged in certain specified operations, and such overalls must be washed clean or removed at least once a week. Respirators must be provided where required, and those in use must be washed or renewed every day. Meal rooms, change rooms, and a place for the storage of overalls must be provided and maintained in good condition. Lavatory and bath accommodation must be provided. Every person employed in a lead process must be medically examined once in every calendar month and a health register must be kept. After suspension, owing to illness, no person may be re-employed in a lead process without obtaining a certificate from the examining surgeon appointed by the Chief Inspector of Factories. As regards employees engaged in lead processes, it is specified that clothing must be deposited in the dressing-rooms; that the employees must wash before eating, and that no person, except with the consent of the management, can interfere with the means provided for the removal of gas, fumes, or dust. Under the Act passed in 1920 dealing with the employment of women and young persons in lead processes the main regulations were added to by provisions enforcing (*a*) cleanliness of workrooms and tools, and (*b*) notification to the Government authorities of all cases of lead poisoning. ("Laws and Regulations relating to Lead Poisoning," by Gilbert Stone, p. 68.) Great Britain.

France.—A decree enacted in 1913 relating to a large number of lead-working operations, in addition to the smelting of lead ores, contained provisions applying to smelters similar to those included in the British regulations. ("Laws and Regulations relating to Lead Poisoning," p. 18.) France.

Germany.—The original German regulations were made in 1905, and cover the subjects dealt with by the British regulations. They also include provisions for the prevention of dust collecting within buildings in which lead processes are carried on. ("Laws and Regulations relating to Lead Poisoning," p. 19.) Germany.

Austria.—Regulations were adopted in 1901 similar in the main provisions to the German regulations. ("Laws and Regulations relating to Lead Poisoning," pp. 21, 183.") These were revised in 1923 and the latest regulations deal with the design of new works, including the lighting and ventilation of buildings, the prevention of dust, the collection of fumes, the supply of drinking water, persons who may be employed, hours of labor, and medical supervision of health of workmen. They also include a notice which describes the danger of lead poisoning and means for its prevention, a copy of which must be issued free of charge to every workman. (International Labor Office Publications, Legislative Series, 1923, I.) Austria.

United States.—The only State with definite legislation against lead poisoning is Missouri, the Health and Safety Act, 1913, of that State including provisions applicable to smelting works. ("Laws and Regulations relating to Lead Poisoning," pp. 212-215.) These follow generally the lines of the British regulations as far as dust, fumes, changing and washing accommodation are concerned. The Act also provides for all occupational or industrial diseases being notified to the State Board of Health, and prescribes penalties for any medical officer failing to comply with this section. In the State of New Jersey the Commissioner of Labor in 1914 circularised the lead and copper smelting companies of that State, drawing attention to the danger from dust and fumes in those industries and outlining regulations designed to reduce the hazard of the workmen employed in smelters. ("Laws and Regulations relating to Lead Poisoning," pp. 21, 183.) United States.

Medical certification at Port Pirie.

54. With regard to the practice concerning industrial disease amongst employees of the Broken Hill Associated Smelters at Port Pirie, under the Workmen's Compensation Act, 1911, a workman who believes himself to be suffering from industrial disease is required to obtain a certificate from a qualified medical practitioner to the effect that the subject is suffering from industrial disease. In the event of either the company or the man being dissatisfied with the diagnosis, the case is referred to a medical referee, whose decision is final. If a man is found to be suffering from a compensable disease compensation is paid weekly or fortnightly on production of a certificate to the effect that the subject is still incapacitated from work. It is also the practice to compound with men certified as suffering from plumbism by a lump sum payment on the basis of the estimated disability as assessed by the certifying practitioner or medical referee. In some cases the amount paid has been settled by arrangement between the company's representative and a union representative, and in others it has been referred to a magistrate for decision. For the purposes of record, it may be stated that persons seeking employment at the Broken Hill Associated Smelters must secure a certificate of fitness from a duly registered medical practitioner (H. St. J. Somerset, q. 920 *et seq.*).

CHAPTER VII.

GENERAL CONCLUSIONS.

Reduction of Hazard.

Methods of reducing hazard.

55. The Commission has given much attention to the best method for dealing with and, as far as possible, for preventing plumbism and other industrial disease. There is undoubted evidence that the evils disclosed are sufficiently grave to necessitate immediate action in the direction of the promulgation of regulations under the Mines and Works Inspection Act, thus enabling closer supervision by the Government department concerned. The need for preventive measures is based on two main points of view :—(1) From the humanitarian aspect of the effects on the health and wellbeing of the employee; and (2) from the aspect of the economic effect on the industry.

Dust and fume.

56. *Reduction of Hazard from Dust and Fume.*—The principal cause of industrial plumbism is the inhalation of lead in the form of fine dust. Certain authorities state that about 2 milligrammes or 0·002 grammes of lead is the lowest dose which, inhaled daily as dust and fume, may in the course of time set up chronic plumbism ("Memorandum on Industrial Lead Poisoning" form 324, 1921, Factory Department, Home Office, p. 12). Professor Chapman, in evidence, states that in his opinion a smaller dose would produce this effect (q. 1755). To prevent the liability it is imperative that, as far as possible, accumulations of dust should be prevented, and fumes and noxious gases to be collected, as near as possible, to the point of origin in order to preclude contamination of the atmosphere of working places. Dust should be collected, preferably, in moist condition, and disposed of in such a manner as to minimise danger to those engaged in handling it. Already the company has, as is shown in evidence by H. St. J. Somerset and G. Dey, had in progress a large programme of alterations and additions which will, in the opinion of the Commission, materially improve the working conditions and reduce the health hazard. Under this category come such items as—

(*a*) The extension of the water service to cover all places of storage for lead-bearing materials (G. Dey, q. 555).

(*b*) The building of a completely new set of mixing bins at the Dwight & Lloyd plant (H. St. J. Somerset, q. 2197 *et seq.*).

(*c*) The completion of the bag houses for the gases from both sections of the Dwight & Lloyd plant (H. St. J. Somerset, q. 268).

(*d*) The installation of the more powerful fans now on order (H. St. J. Somerset, q. 321) for delivering fumes into and for drawing them from the main blast furnace bag house.

In addition to these, other items which the Commission considers should receive urgent attention are—

(*aa*) The effective hooding of the discharge from "A" section of the Dwight & Lloyd plant, and of the crusher used to reduce material from the same section.

(*bb*) The improvement of service roads within the works area and their maintenance in such a condition as to prevent the dust from them affecting working places (q. 2383).

(*cc*) The cleaning of the floors, walls, and rafters of all buildings, and the keeping of them, as far as practicable, free from the accumulation of dust.

(*dd*) The enclosing of conveyor belts, and provision of arrangements for damping spillage and for its removal at regular intervals.

Zinc roasting plant.

57. These matters, with others not here specified, are covered by the detailed special regulations which the Commission recommend to be applied to the works under the powers contained in the Mines and Works Inspection Act, 1920. Among the places where conditions in respect of dust were bad was the Zinc Roasting Plant. Regarding this section, the Commission was informed by Mr. Commissioner Gepp that as General Manager of the Electrolytic Zinc Company, he had authorised the expenditure necessary to remodel portions of that plant in order to reduce the present hazard and make the conditions in conformity with the suggested regulations to apply to the industry; further, that the necessary alterations are

approaching completion (H. St. J. Somerset, q. 2200). Another source of origin of considerable dust, and fume laden steam has been the practice of tipping the sintered material from the Huntington-Heberlein pots as soon as the charge is cooked. The practice is now being considerably modified by reducing the tonnage treated in that section, and allowing as long as 16 hours for the charge to cool prior to tipping. This should effect substantial improvement in the conditions for the workmen engaged on the pots and in adjacent areas (H. St. J. Somerset, q. 331). H. & H. Pots.

58. In connection with the tapping of the lead bullion from the blast furnaces, the practice of running into small moulds causes the liberation of lead-bearing fume. A mechanical transport system which will handle this bullion on more efficient lines is being installed (H. St. J. Somerset, q. 283), and the Commission has been informed that, since its last inspection, this plant has been put into partial operation. Under the new arrangements the bullion will be tapped into covered ladels and handled by an electric crane instead of by manual labor. This should enable the bullion running spouts to be effectively hooded, and the fume to be carried off by efficient exhaust ventilation with a corresponding reduction in the hazard to the employees engaged around the blast furnaces. Bullion tapping.

59. While the terms of the reference of the Commission deal only with plumbism, the possible danger to the health of the smelter employees from carbon monoxide poisoning has been so far established that the Commission considers preventive measures should be observed in conjunction with those for dealing with plumbism. These should comprise the collection of all gases and fumes, as near as practicable, to the point of origin by means of efficient exhaust draught. The use of suitable respirators in doubtful atmospheres, a regular study of the conditions by gas surveys, &c., limitation of exposure, and the education of all concerned in the hazard. Carbon monoxide.

60. In respect to the regulations for the control of the working conditions at the smelters the Commission is unanimously of opinion that the enforcement of them should be vested in the State Mines Department, which administers the Mines and Works Inspection Act. Further, that an official of this department should be specially charged with the responsibility of seeing that they are observed and that adequate means are evolved for complying with the various provisions. The Commission is convinced that satisfactory results can only be secured by full co-operation between the employees, the management, and the supervising inspector; and it is considered that the appointment of a check inspector under the Mines and Works Inspection Act by the employees would be a material factor in assisting to achieve this object. The Commission also considers that from time to time the supervising inspector should arrange conferences between himself, a representative of the management, and the workmen's inspector in order to discuss details of the administration of the regulations and to devise further safeguards. State Mines Department.

Medical Services and Compensation.

61. The Commission cannot settle the vexed question raised by the medical evidence as to how much of the serious increase in the incidence of industrial disease amongst employees of the Broken Hill Associated Smelters Proprietary, Limited, at Port Pirie is due to plumbism or, as has been suggested, to carbon monoxide poisoning or some other concurrent disease that has not yet been accurately diagnosed. The Commission believes that carbon monoxide gas forms a portion of the industrial hazard at the smelters, and considers on this account that industrial carbon monoxide poisoning should be made a compensable disease under the Workmen's Compensation Act of 1911. The Commission realises chronic poisoning by this gas is at present regarded as an ill-defined state concerning the diagnosis of which many opinions exist, but anticipates that research work at present in progress throughout the world will result in the establishment of certain criteria which will obviate this difficulty. In the opinion of the Commission if carbon monoxide poisoning be made a compensable disease it is essential that a body such as the Federal Department of Health, should be asked to make an investigation with a view to establishing definite criteria of diagnosis of the disease for the help of medical practitioners. In dealing with the matter of plumbism, authorities state that certain persons are naturally susceptible to the effects of lead intake. Consideration has been given by the Commission to this aspect, and it is of the opinion that employees who are found to be susceptible should be removed from further exposure to the hazard, or withdrawn from employment in the Smelters. The Commission regard it as equitable that provision for compensation of these susceptibles, if withdrawn, should be made, and that the basis for compensation should, if possible, be settled by discussion between the interested Unions and the representatives of the company. Complex nature of hazard.

62. The local medical practitioners, in evidence, expressed the desire that they as individuals should be relieved from the responsibility of assessing the incapacity caused by plumbism under the Workmen's Compensation Act (Dr. Tassie, q. 1219). It is considered that different methods should be introduced and a recommendation is included covering this matter. A majority of the Commission are of the opinion that the health of the employees at the smelters would be further safeguarded by regular medical inspection at periods varying according to the hazard in various operations. This practice is almost universally adopted in other States and countries with similar industries, and medical witnesses before the Commission expressed the opinion that such inspection would be an important factor in preventing industrial disease by warning the cases showing early symptoms (Dr. Tassie, q. 1227; Dr. Yeatman, q. 1346; and Dr. Assessment of incapacity.

Morris, q. 1412). In view of the opposition of the men certified as suffering from plumbism to examination by the Commission's medical experts, as well as from the statement of the employees' representative (Mr. Commissioner Robinette) that a large majority, if not all, of the employees at the smelters would object to any arrangement for inspection by a company's medical officer, the other members of the Commission consider that no useful purpose would be served by making a definite recommendation on the subject. It is, therefore, suggested that the matter should be considered in conference by representatives of the management and of the employees' unions with a view to arriving at some acceptable arrangement. From September, 1920, to March, 1921, the Broken Hill Associated Smelters Proprietary, Limited, had attached to their staff a highly qualified medical officer, but co-operation of the men necessary to ensure results was not obtained, and the works since that date, except for the provision of a first-aid station, have been without a staff medical service.

Dental.

63. Practically all the medical witnesses expressed the opinion that the proper care of the mouth and teeth were an important factor in preventing lead poisoning (Dr. Tassie, qs. 1229-31; Dr. Yeatman, q. 1369; Dr. Morris, q. 1414; Dr. Rogers, q. 1575; Dr. Freeman, q. 1675). On this matter the Commission unanimously adopted the following resolution :—" That in the opinion of this Commission the care of the teeth amongst the smelter employees is an important factor in preventing lead poisoning, and that in view of this facilities for dental treatment should be made available at Port Pirie for all smelter employees at the lowest possible rates."

Personal hygiene.

64. Care on the part of the employees is a necessary condition in the prevention of plumbism, and personal hygiene is a matter of utmost importance with those who are employed among lead risks. Attention should be directed to the following points :—Personal cleanliness and changing of clothes after work; abstention from eating except in places set apart for the purpose; the wearing of overalls and respirators when engaged in certain specific hazardous jobs; care of the teeth and gums; abstention by the employees from the making of cigarettes and the cutting or rolling of tobacco when engaged in lead processes. A number of these matters are dealt with in detail in the proposed regulations, and personal compliance with the provisions set out will limit the occupational health risk.

Housing.

65. With regard to housing, in the opinion of the Commission it is desirable that as far as possible married men should be encouraged to work in such an important key industry as the smelters, and the housing position is one that would require early attention were any considerable number of additional families located in the town. The Commission considers it very desirable that the Government, the company, and the employees should, in co-operation, face the question of housing. From the provision of sufficient homes of a good standard, under a scheme which would be based preferably upon the idea of personal ownership rather than rental, substantial public good would accrue.

Importance of co-operation.

66. The Commission again wishes to emphasise the fact that in order to achieve the best results in the elimination of industrial disease at the Smelters, complete co-operation between the company, the unions representing the employees, and the Mines Department representing the Government, is necessary. On the part of all concerned full and minute attention must be paid to details of dust prevention and other matters dealt with in the proposed regulations. On the part of the company there must be a continuance of efforts directed toward improving the conditions of work, and also toward the education of employees concerning the hazards of the occupation and the best means of avoiding harm from them. On the part of the men and the company there must be careful observance of regulations framed for the purpose of preserving the health of the employees.

Authorities Consulted.

In the course of its investigations the Commission has had to consult a large number of works of reference and periodical publications, and from these sources has obtained much valuable information. The most important are listed among the appendices.

CHAPTER VIII.

FINDINGS AND RECOMMENDATIONS.

Cause of plumbism.

67. According to the terms of reference the Commission has been instructed to inquire into the cause or causes of the disease known as plumbism, the increase thereof among the employees of the Broken Hill Associated Smelters, Proprietary, Limited, at Port Pirie, and the best means for the prevention or alleviation thereof. The Commission finds :—

(1) The cause of plumbism is the taking into the body of lead-bearing dust or fume. This process occurs mainly by means of absorption into the body through the respiratory tract, and in a less degree through the alimentary tract by ingestion. The lead in the body is eliminated by the natural excretory apparatus of the body, but when the rate of absorption exceeds the rate of elimination, an accumulation of lead in the system ensues, resulting in damage to body parts, chiefly blood vessels and nerves, and resulting in lead poisoning or plumbism. As previously mentioned in paragraph 61 and elsewhere, the Commission is of the opinion that carbon monoxide gas exists as a hazard at the Smelters, and that, therefore, plumbism as known at Port Pirie presents in certain cases a complex in which the symptoms of carbon monoxide poisoning and of lead poisoning run concurrently in varying proportions.

(2) As before stated, a very marked increase in the number of reported cases of plumbism among the employees at the Broken Hill Associated Smelters at Port Pirie has occurred within the last four years. The actual increase in the number of cases diagnosed as and treated for plumbism in Port Pirie, however, is not so great as it would appear, owing to the fact that during the years 1911-17 inclusive advantage was not taken of the fact that plumbism was a compensable disease. It has been shown that in some of those years upwards of 50 cases have been treated in the local hospital, and that a total of 219 cases was treated. Notwithstanding this fact, the numbers of cases compensated for 1923 and 1924 show a very large increase over previous years. From the evidence submitted to the Commission and the results of inspections of the works, the Commission is of the opinion that the principal causes of this increase in reported cases may be stated as follows:— Cause of increase.

(*a*) The increased tonnage of lead-bearing material being handled for treatment in a comparatively limited area.

(*b*) The change in the physical character of the ores and concentrates treated, owing to the inclusion in the deliveries from supplying companies of a greater proportion of fine slime products and a possible increase in the dust created in the smelting operations.

(*c*) The change in the composition of the working force at the Smelters due to the increased number of Southern Europeans employed, amongst whom the incidence of industrial disease is greater. There is no definite evidence that this class of foreigners is more susceptible by nature, but there appears to be an increased liability to industrial disease among them, which may be attributed to (i) deficient knowledge of the English language, which causes their employment mainly on laboring work in the operating departments, where the greatest hazard exists, and prevents full understanding of the nature of this hazard and the means of prevention; (ii) a lower standard of living amongst a certain proportion of them than exists amongst British-born and Northern European workmen; (iii) recent arrival in Australia, as is the case with a large proportion of the employees, with the attendant changes of climate, occupation, and diet, reduces for a time their physical tone and renders them temporarily at least more susceptible.

A contributing factor to the increase may be that modern methods of medical diagnosis are the means of determining cases as plumbism which would formerly have been designated chronic gastritis and other diseases (Dr. Tassie, q. 1199. Dr. Yeatman, q. 1313).

(3) As a result of careful investigation, the Commission finds that three essential principles must be observed in defining the best means of alleviating or preventing industrial plumbism, namely, the prevention of the escape of fumes; the reduction to a minimum of dust; and the education of the personnel in the avoidance of the hazard. Means of prevention.

The Commission, therefore, respectfully submits the following recommendations:—

FOR THE SUPERVISION OF OPERATIONS AT THE SMELTERS.

1. That, for inspection purposes, the Broken Hill Associated Smelters at Port Pirie, apart from boiler inspection, be brought solely under the Mines and Works Inspection Act, 1920, and that the following regulations under this Act be made:— Proposed regulations.

Definitions.

1. In these regulations, unless some other meaning is clearly intended,

"Lead process" means any process for the treatment of lead material for the recovery of lead products and by-products:

"Lead materials" means materials containing not less than 2½ per cent. of lead:

"Owner" means the owner of the mine or works:

"Agent" means the agent of the mine or works:

"Manager" means the manager of the mine or works:

"Prescribed medical authority" means the medical authority appointed for the purpose of certification for compensation for industrial diseases among the employees of the Broken Hill Associated Smelters Proprietary, Limited, at Port Pirie:

"Inspector" means an inspector appointed under the Mines and Works Inspection Act, 1920.

Warning Notice.

2. In any place where any lead process is carried on so as to cause dust, or fume, or gas in the atmosphere, the owner, agent, or manager shall exhibit to the satisfaction of an inspector notices in the following terms:—

Warning Notice.

Persons working in or about these works may take dust or fumes or gas into their bodies.
Danger to health may arise from the inhalation of—

(*a*) lead dust in suspension in the atmosphere:

(*b*) fumes given off by molten lead:

(*c*) carbon monoxide gas.

Early treatment prevents permanent injury to health from any of these causes. Persons suspecting themselves to be affected in any degree by lead or suffering from headache, presistent loss of appetite, constipation of the bowels, frequent nausea and vomiting, weakness in the arms or legs, dizziness, pallor of the skin, lassitude or a foul mouth or foetid breath should present themselves for medical examination.

This notice is exhibited in accordance with the regulations made under the Mines and Works Inspection Act, 1920.

(Sgd.) .....
Manager.

Posting of Regulations.

3. The owner, agent, or manager shall cause—

(*a*) legible copies of these regulations to be exhibited in conspicuous places throughout the mine or works to the satisfaction of an inspector:

(*b*) a copy of these regulations to be handed to each person who is employed at the mine or works at the time of coming into force of these regulations, and to each new employee before commencing work, and shall keep an official record showing that each employee has been supplied with a copy of these regulations as aforesaid.

Notification of Industrial Disease.

4. When in the opinion of the prescribed medical authority, after examination, any person employed at the mine or works is suffering from any disease resulting from his employment, a report shall be made by such medical authority in the prescribed form under the Workmen's Compensation Act, 1911, to an inspector.

Storage of Lead Materials.

5. The owner, agent, or manager shall cause all lead materials to be stored in such places as an inspector directs, and whilst so stored such lead materials shall be maintained in such a condition as to prevent dust arising therefrom.

Handling and Manipulation of Lead Materials.

6. The owner, agent, or manager shall cause all lead materials in process of transit from one place to another precedent to and during the process of treatment and/or being manipulated in any furnace, retort, mill, or chamber, as far as practicable, to be handled and/or manipulated in such manner as to prevent dust, fumes, and/or gas being liberated in the atmosphere of working places.

Flue Dust.

7. (1) The owner, agent, or manager shall make adequate provision to prevent, as far as practicable, the emission of flue dust from smelter stacks. If an inspector considers any alteration or any additional appliances are necessary for these purposes, he may, by written notice, require the owner, agent, or manager to make or supply the same, and in such notice a reasonable time shall be specified within which such required alterations or additions shall be made. If the owner, agent, or manager objects to any requirements of an inspector in this direction, he may, within the time specified in the notice, show cause in writing to the Chief Inspector of Mines, appointed under the Mines and Works Inspection Act, 1920, who may confirm, vary, or veto the notice of an inspector. No owner, agent, or manager shall fail to comply with the directions of an inspector unless such directions have been vetoed or varied by the Chief Inspector of Mines. When the Chief Inspector of Mines varies the direction of an inspector, no owner, agent, or manager shall fail to comply with such varied directions.

Flue Dust—How to be Dealt with.

(2) (*a*) The owner, agent, or manager shall not allow the ports by which flue dust is removed from main flues to open into the tapping floors, but the outlets shall be on the other side of the flues into a space otherwise unoccupied.

(*b*) The owner, agent, or manager shall cause the floors to which the dust falls when first hoed out to be smooth and impermeable, and to be provided with a kerb raised above the surrounding surface so that the deposit of dust and mud may not be stepped on and carried about; the floors shall be perfectly clean except when in actual use.

(*c*) Workmen employed to cleanse flues and to gather and transport flue dust shall change clothes before going on shift and when leaving work.

(*d*) The owner, agent, or manager shall not allow any person to be so employed unless such person uses a suitable respirator to cover his nose and mouth, or to engage in work where other persons are so employed unless such person uses a respirator.

(*e*) The owner, agent, or manager shall cause the flue dust to be carefully wetted as soon as it is drawn from the flue, and shall not permit the accumulation of wet flue dust except within a securely closed receptacle; and shall not permit any accumulation of dry flue dust outside the flues.

Ventilation of Tapping Floor.

(3) (*a*) The owner, agent, or manager shall cause all tapping floors to be ventilated to the satisfaction of an inspector.

(*b*) The owner, agent, or manager shall cause all noxious fumes and/or gases being discharged to atmosphere to be discharged at such height from the ground level as an inspector may direct.

Persons Entering Furnaces, Etc.

8. The owner, agent, or manager shall not allow any person to enter into any furnace, melting pot, retort, condensing chamber, or flue until it has been ventilated, provided that where it is not practicable to ventilate same, suitable respirators shall be supplied by the owner and shall be used by the persons employed.

Persons Employed in Flues.

9. The owner, agent, or manager shall not allow any person to remain in any flue not under efficient exhaust draught or in any condensing chamber for more than three hours without an interval of at least half an hour.

Provision for Standpipes and Hoses.

10. The owner, agent, or manager shall provide standpipes and hoses or other suitable contrivances on feed floors, tapping floors, and at every other place where dust is raised, so that dust may be conveniently laid by sprinkling water.

Ventilation.

11. The owner, agent, or manager shall cause all buildings in which lead processes are carried on to be adequately and constantly ventilated and the floors, walls, and rafters of all buildings to be as far as practicable kept free from accumulations of dust.

Maintenance of Roads.

12. The owner, agent, or manager shall maintain, as far as practicable, the service roads within the mine or works area in such a condition as to prevent dust arising.

Provision of Overalls.

13. The owner, agent, or manager shall provide suitable overalls for the use of all persons employed in any of the following processes, which overalls when required for use shall always be clean and free from dust, and when in use shall be worn in such a manner as to protect the underclothes and the body from dust :—

(*a*) Cleaning any flue (unless damp) or condensing chamber :

(*b*) Demolishing any furnace, melting pot, retort, condensing chamber, or flue, unless either damp or under sufficient exhaust draught :

(*c*) Doing repairs inside any furnace, melting pot, retort, condensing chamber, or flue with material which has formed part of any such structure unless damp :

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

(*e*) Placing in any hopper or chute or packing red or orange lead or litharge.

Respirators.

14. The owner, agent, or manager shall provide suitable respirators for the use of all persons employed in any process named in Regulation 13, and also in other places and on such other occasions as an inspector, after consultation with representatives of the owner and the employees, may direct.

Meal Rooms, Etc.

15. The owner, agent, or manager shall provide and maintain for the use of all persons employed in any lead process and so that such places shall not be exposed to dust or fumes from any manufacturing process—

(*a*) A suitable meal room or rooms situated with due regard to the maintenance of cleanliness and hygiene, and adjacent thereto suitable arrangements for the washing of hands and face prior to taking food and with either warm water laid on or with a supply of hot water always at hand ; also boiling water for tea-making as required.

(*b*) A suitable place or places for the storage of overalls provided in pursuance of Regulation 13, which place or places shall be separate from those required by paragraph (*a*) of this regulation.

(*c*) In or adjacent to such meal rooms suitable individual locker accommodation (and the doors supplied with hasp and staple) to enable storage of food, soap, and towel.

Change Houses, Washing, and Bathing Places adjacent to or in connection with Change Houses.

16. The owner shall provide and maintain in a cleanly state and in good repair for the use of all persons regularly employed in any lead process—

(*a*) Adequate and suitable change house accommodation. Such change houses shall be properly warmed and ventilated with provision to carry off the steam and vapor from the showers and wash basins, and with provision for drying working clothes. The floors shall have smooth and impermeable surfaces so that they can be readily cleaned.

(*b*) Adequate lavatory accommodation with either—

(I.) a trough with a smooth impervious surface fitted with a waste pipe, without plug, and of such length as to allow at least 2ft. for every five persons regularly employed at one time, and having a constant supply of warm water from taps or jets above the trough at intervals of not more than 2ft ; or

(II.) at least one lavatory basin for every five persons regularly employed at one time fitted with a waste pipe and plug and having a constant supply of hot and cold water or warm water laid on.

(*c*) Sufficient and suitable shower bath accommodation with an ample supply of hot and cold water laid on.

Drinking Water.

17. The owner, agent, or manager shall provide an ample supply of sweet and wholesome drinking water, which shall at all times be freely and easily available to all persons employed. It shall be stored in such a manner as to prevent contamination by dust.

Duties of Persons Employed.

18. (1) Every person employed in any lead process shall deposit in the place or places provided in pursuance of Regulation 16 all clothing put off during working hours.

(2) Every person for whose use an overall is provided, in pursuance of Regulation 13, shall wear the overall when employed in any process named in that Regulation, and shall remove it before partaking of food or leaving the premises, and deposit it in the place provided in Regulation 15.

(3) Every person for whose use a respirator is provided, in pursuance of Regulation 11, shall wear the respirator in the process for which it is provided.

(4) Every person employed in any lead process or in any place where any lead process is being carried on shall, before partaking of food, wash his face and hands.

(5) No person employed shall introduce, keep, prepare, or partake of any food or drink except a non-alcoholic drink in any place in which any lead process is carried on.

(6) No person employed shall make cigarettes or cut or roll tobacco in any place where any lead process is being carried on.

Interference with Equipment.

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

Penalties.

20. Any person who commits a breach of any of these regulations shall be guilty of an offence, and shall, if no other penalty is prescribed, be liable to a penalty not exceeding for the first offence £20 and for a subsequent offence £100.

2. That an official of the Mines Department be specially charged with the responsibility of seeing that the regulations under the Mines and Works Inspection Act, 1920, as recommended, are observed, and that adequate means are devised for complying with them.

3. That a workmen's check inspector be appointed, and that should there be any doubt as to power to appoint such workmen's inspector at the Broken Hill Associated Smelters, Port Pirie, under section 12 of the Mines and Works Inspection Act, the Act be amended to enable the appointment of such an inspector by the workmen with the same powers as are defined in the Act.

4. That from time to time the supervising inspector under the Mines and Works Inspection Act arrange conferences between himself, the representative of the management, and the workmen's check inspector in order to discuss details of the administration of the regulations and to devise further safeguards.

II.—Medical Certification and Compensation for Industrial Disease.

Medical certification and compensation.

5. That a special Workmen's Compensation Act be passed having application only to industrial hazard at the Broken Hill Associated Smelters, Port Pirie.

(*a*) That under this Special Act provision be made for the appointment by the Government of a Medical Board, consisting of three duly qualified medical practitioners, one of whom to be nominated by the management, one by the employees' unions, and the third as chairman, who would be the local officer of health for the time being located at Port Pirie, to be nominated by the Government.

(*b*) That the appointments to this board be for the duration of two years and renewable for like periods.

(*c*) That this board exclusively exercise the duties of certifying surgeon and referee as provided in the Workmen's Compensation Act of 1911 in respect of workmen disabled by any disease mentioned in Schedule 3 of the principal Act or in the special Act recommended as applying to the Broken Hill Associated Smelters, Port Pirie.

(*d*) That the board have power to determine the period of incapacity of any workman in the degree of his disability in respect to earning full wages at the work at which he was previously employed.

(*e*) That the decision of the board in respect to determining such period of incapacity and degree of disability shall be final.

(*f*) That the board be paid from consolidated revenue, the fees to be based on those paid to the Medical Board constituted under the Workmen's Compensation (Broken Hill-Lead Poisoning) Act, 1922.

(*g*) That any workman who is in receipt of compensation for disablement by industrial disease should, unless the board declare in writing that it is unnecessary for him so to do, submit himself for treatment by a qualified medical practitioner selected by himself, either as a hospital patient or otherwise, as the board may determine. The board should have

discretion to require any such workman to submit himself to treatment by an approved medical practitioner provided and paid for by the employer. The employer should at the direction of the board provide and pay a qualified medical practitioner to give such treatment.

(*h*) That if any such workman refuse to submit himself for any such treatment or obstruct same his right to compensation should be suspended or cancelled.

(*k*) That each payment for compensation should be made only on the production of a fresh certificate from the board.

(*l*) That notwithstanding section 14, subsection 2, of the Workmen's Compensation Act, 1911, there should be no bar to a medical practitioner who has acted in his professional capacity in connection with any case of specified industrial disease, or who has treated a person so suffering, from acting as a member of the board, and dealing with such case, provided that he has been duly appointed a member of the board.

(*m*) That it be obligatory for any medical practitioner attending any workman believed to be suffering from industrial disease contracted at the Broken Hill Associated Smelters to give notice to the board.

(*n*) That the board have power to require any workman so notified as suffering or suspected to be suffering from industrial disease to present himself to the board for the purpose of being medically examined. Any person failing to comply with this provision should forfeit his right to compensation.

(*o*) That it be made obligatory for the board to furnish to such workman a certificate of the result of the examination, stating whether he is or is not suffering from any of the specified industrial diseases, and to supply the employer with a copy of such certificate.

(*p*) That the board be given power to certify that any workman previously certified as suffering from plumbism who has recovered therefrom and who, in the opinion of the board, is susceptible to further attack, should be removed from further exposure to the hazard or withdrawn from employment in the Broken Hill Associated Smelters.

(*q*) That provision for compensation of workmen so certified as susceptible be made, and that the representatives of employers and employees' unions meet in conference and endeavor to arrive at a satisfactory basis of compensation.

Carbon monoxide.

6. That carbon monoxide poisoning be made a compensable disease under the Workmen's Compensation Act, 1911 (*vide* para. 61).

III.—GENERAL.

Hours of work.

7. That, as the medical evidence was unanimously to the effect that in such an industry as that of the Broken Hill Associated Smelters, Port Pirie, a respite once a week is desirable in the health interest of the employees, the working time should, save under exceptional circumstances, be six shifts per week, instead of the average of seven shifts per week as at present on production work.

8. That a body such as the Federal Department of Health be asked to make an investigation with a view to establishing criteria of diagnosis for plumbism and carbon monoxide poisoning for the help of medical practitioners.

The Commission is of opinion that with the completion of the programme of construction, alteration, and improvement on which the company has been engaged for some time, and of the further work in the same direction covered by the Commission's recommendations, and provided that the Commission's recommendations as a whole be adopted, and that the various suggestions by the Commission contained in this report also be put into operation, as far as proves practicable, there will be a marked and satisfactory improvement in the position at Port Pirie.

We have the honor to be,
Sir,
Your Excellency's obedient servants,

KEITH R. MOORE, Chairman.
J. L. PEARSON.
HERBERT W. GEPP.
W. ROBINETTE, (subject to dissent).

J. SINCOCK, Secretary.

Parliament House, Adelaide, July 14th, 1925.

DISSENT.

I dissent from the Commission's report, and in doing so have no desire to reflect on the collective judgment of the majority of the Commission. My principal reasons for dissenting are—

(1) *Compulsory Medical Examination.*—Although the Commission does not in its report make a definite recommendation in regard to compulsory medical examination, nevertheless the report may have a far-reaching effect in that direction. I object to any form of medical examination, whether voluntary or compulsory, believing that it would not tend to reduce the industrial hazard as it is claimed to do. Before any move is made in that regard, I am of the opinion that the company should exhaust every effort to eliminate dust and fumes, which, according to medical evidence, are the principal causes of the prevalent industrial diseases at the Smelters. The weight of medical evidence would appear to be in favor of medical supervision of workers at the Smelters, but on reviewing the situation it will be found that no good purpose would be served by it. It is apparent from the evidence given before the Commission, and from its inspections of the works, that before any attempt at medical examination of the men at the Smelters is made it is imperative that the hazard should be attacked at its base, and the only successful method of accomplishing that is the adoption of scientific methods to eliminate the dust and fumes. Compulsion of any kind is repugnant to Australian sentiment, and I am confident that any attempt at compulsory examination of men working at the Smelters would foment a serious industrial upheaval.

It would be grossly unfair to compel workmen periodically to submit themselves to a medical examination without some scheme being provided for adequate compensation of those men found to be in the first stages of, or susceptible to, an industrial disease. Even then such a provision would not tend to industrial peace. No doubt the effect of having compulsory medical examination would lessen the number of cases of industrial diseases to be compensated by the company, by reason of the fact that it would place a weapon in the employers' hands to be unfairly used against the workers, in that workmen found to be suffering from, or susceptible to, industrial diseases would be dismissed from their employment. As a matter of fact the company have already commenced upon a campaign of "weeding out" those men who have been suffering from plumbism, and have been medically certified as fit to return to work. Mr. Somerset, General Superintendent for the Company, admitted in evidence (q. 1290) that 29 such men had been refused re-employment; but the records kept by the Australian Workers' Union would show a greater number than that admitted by Mr. Somerset. It is reasonable, then, to assume that the company would be more ruthless if in a position to know the state of health of their employees individually. I am, therefore, of the opinion that compulsory medical examination would only serve the interests of the employer. In view of the above facts it cannot be honestly claimed that compulsory medical examination would play even a small part in preventing industrial diseases at the Smelters. As I have pointed out, it would reduce the number of cases of industrial diseases at the Smelters, but industrial disease would still be prevalent even to a greater extent in the community. Men whose health was partially impaired by industrial diseases would be thrown into other avenues of employment, and it would eventually be found that compulsory medical examination had been responsible for the effects of industrial diseases being prevalent among a greater number of workers in the State than would have been the case without compulsory medical examination.

(2) *Medical Certification and Compensation for Industrial Diseases.*—Whilst I am not in full accord with the creation of a new Workmen's Compensation Act applying to Port Pirie, or the appointment of a Medical Board there, I consider some alteration is necessary; but whether a special Act or an amendment of the existing Act is preferable I consider should be a matter for Cabinet to determine. I wish it to be clearly understood that I oppose the creation of any board except the personnel consists of duly qualified medical men in *bona fide* general practice at Port Pirie, and provided that no doctor retained by either the company or the employees' unions, or the employees as a body, should be permitted to sit on the board. I object to the board proposed by the Commission exclusively exercising the duties of medical referee as provided in the Workmen's Compensation Act of 1911, *vide* paragraph (c) of Recommendation 5. I suggest that provision should be made in the proposed new Act for either party to appeal against the decision of the board to a referee as at present constituted in the principal Act. I object to the board's decision being final, as proposed in Recommendation 5, paragraph (e). I suggest that the powers of the referee as constituted in the principal Act should be amended to provide that he be empowered to determine the period of incapacity of any workman or the degree of his disability in respect to earning full wages at the works at which he has previously employed should either party appeal from the board's decision in those regards. My reason for making the above suggestion is that the confidence of the parties concerned under the Act would not be shaken if they have an avenue of appeal from the board's decision. I further

suggest that the duty of the board should be to examine any workmen who believes himself to be suffering from an industrial disease, without his first having obtained a certificate from a medical man that he is suffering from such a disease.

After reviewing the evidence given before the Commission, and as a result of the inspections of the Smelters at Port Pirie, I am not convinced that the company are doing all that is in their power to reduce the health hazard, particularly in regard to the removal of accumulated dust in the buildings at the works.

(3) *Professor Chapman and Dr. Smith's Appointment, Evidence, and Methods of Examination.*—I feel it is my bounden duty to comment upon the irregular manner of the appointment of Professor Chapman and Dr. S. A. Smith, of Sydney, and the reprehensible methods adopted by them in order that men working at the Smelters would submit themselves for medical examination, also upon the grossly unfair manner under which the examinations were conducted. Owing to unforseen circumstances, I was unable to accompany the Commission to Sydney, where it was decided to secure the services of Professor Chapman and Dr. Smith at a remuneration of £21 per day each. Those two gentlemen proceeded to Port Pirie before the Commission had returned from Sydney to Adelaide. I did not receive notification of the decision until after they had arrived in Port Pirie, and had commenced their investigations, though a telegram was sent to me on the day prior to their arrival. When the Commission met on June 3rd I learnt from correspondence that notices had been served upon beneficiaries under the Workmen's Compensation Act, requesting them to appear before Professor Chapman and Dr. Smith, and that summonses had been issued by the Secretary to the Commission for service upon men working at the Smelters who were not beneficiaries, commanding them to appear before Professor Chapman and Dr. Smith for no other purpose, apparently, than to be medically examined. I telegraphed from Adelaide to Professor Chapman protesting against his action, and also took up the matter with the Chairman of the Commission, and eventually these summonses were withdrawn. The examination of the beneficiaries continued despite my protest. The action of the Commission in sanctioning the issue of those summonses was illegal and most unfair, as a number of the men had been previously examined by doctors appointed by the company. Moreover, the examination of the beneficiaries proceeded in the presence of the company's medical adviser (Dr. O. M. Moulden), but the beneficiaries' medical advisers were not present, nor were they consulted as to the clinical record of the respective beneficiaries. It appears to me to be singular that Professor Chapman did not see fit at least to consult the beneficiaries' medical attendants. Undoubtedly he was aware that the beneficiaries' own doctors could have given him more detailed and complete information than Dr. Moulden could. Despite the fact of Professor Chapman having carried out similar investigations in Broken Hill, when the men's interests were safeguarded by union representatives being present at the examination, yet on this occasion Professor Chapman did not arrange for the men's representative to be present. His action in that respect alone stamped his investigations with suspicion.

Another instance of the utter disregard of the beneficiaries' interests in connection with these examinations was that the names and addresses were supplied by the company and no effort was made by Professor Chapman or Dr. Smith to have the lists, as supplied, verified by officials of the unions to which the men belonged. There was no evidence that the men examined by Professor Chapman and Dr. Smith, assisted by Dr. Moulden (the company's medical adviser) were beneficiaries. The company, under such conditions, could easily have supplied the names and addresses of men free from a compensable disease. I consider these examinations, under the conditions I have outlined, were, to say the least, a grave blunder, and they will certainly shake the confidence of the public in the Commission's report. When Professor Chapman was giving evidence I endeavored to clear away the suspicion which his action had created, but I regret that my efforts were futile. I am of the opinion that the appointment of Professor Chapman and Dr. Smith, and the enormous expense attached thereto, was a waste of public money. There are medical men in this State who are, in my opinion, equally competent as those two gentlemen. I refer, among others, to Drs. B. H. Morris and Angas Johnson, who have had vast experience in the diagnosis of industrial diseases, particularly plumbism. It is unfortunate that the Commission did not take into consideration the qualifications of these doctors before recommending to the Government the appointment of Professor Chapman and Dr. Smith. Whilst I am most anxious to meet the grave effects of industrial diseases amongst the employees of the Broken Hill Associated Smelters, Port Pirie, and fully appreciate the commercial importance of the lead industry to Australia, I believe that the industry is in a sound financial position, and able to make the provision necessary to ensure healthy working conditions.

I contend that the recommendation of the Commission under the heading "Medical Certification and Compensation for Industrial Disease" does not come within the scope of the terms of reference under which the Commission was appointed.

W. ROBINETTE.

Parliament House, Adelaide, July 14th, 1925.

INDEX TO WITNESSES.

INDEX TO APPENDICES.

smelter at St. Louis, and the Federal smelter at the same place; also the Perth Amboy smelter near New York City. In England the only smelter I saw treating lead-bearing material was at Swansea Vale, and it is classed as a zinc-producing plant mainly. In Belgium I visted the Hoboken smelter, treating lead concentrates similar to those treated here, although not necessarily obtained from the same place, and also other purchased lead ores. I also visited the Pennaroya smelter in Spain, the smelter of the Burma Lead Mines in Burma, and various small metallurgical plants and some power stations in Norway.

25. Can you give us an indication of the annual output of lead in the United States, which, I understand, is one of the main producers in the world?—No.

26. It has the largest production in the world?—Yes.

27. The annual production in the world is about one million tons?—Yes. I cannot give the exact figure.

28. How, in your opinion, does the Port Pirie smelter compare with foreign plants from the point of view of up-to-date treatment methods?—I consider the treatment of zincy-lead ores in Port Pirie is at least equal to that in any other smelter I saw.

29. Can you give us a general plan and flow sheet of the works?—I am having a special plan prepared that brings every item of building construction on the works right up to date. That will not be ready for a day or so, but in the meantime, to assist the Commission, I have a plan of the works' layout which is practically correct now. In all major points it is all right.

30. I would like a little information in regard to your processes in detail, so that later the Commission may have on record the processes in sequence in dealing with the evidence of other witnesses and in considering their whole problem. I should like an indication of your raw materials in so far as their analysis or assay value is concerned, starting with lead concentrates. You might particularly specify the main constituents, including such elements as lead, arsenic, antimony, and any others you might think are pertinent to the metallurgical general position?—I might say that on the copies of the flow-sheet given to members of the Commission the other day the assays indicated in the lead concentrates there were the averages for a period when the lead was somewhat lower than it is now. The figure now would be about 62 per cent. of lead in the granular concentrate. The granular lead concentrates form the major part of the concentrate material that is being sent to the smelters. They can be taken to contain on the average about 62 per cent. of lead, 16 per cent. of sulphur, .2 per cent. of arsenic, and .15 per cent. of antimony. They are the main constituents. Zinc is about 9 per cent. on the average.

31. Have you any other form of concentrate?—We call that granular lead concentrate. We also have slime concentrate, which carries somewhat less lead, its average being around 56 per cent. The zinc would be about 13 per cent., the sulphur 17 per cent., the arsenic about .08 per cent., and the antimony about .2 per cent. These are approximate figures.

32. What silver is contained in those two concentrates?—Approximately 25oz. in the lead concentrate, and about 40oz. in the slime concentrates. It depends entirely on the amounts of each that come from different mines in a given period.

33. What is the approximate silver figure per annum?—Roughly we make 140,000oz. a week, which equals about seven to eight million ounces a year.

34. You have lime sand and limestone as fluxes?—Yes. We do not use any limestone at present, but the use of lime sand is a regular part of the roaster charge. That does not contain any lead.

35. Where is it obtained?—From Wardang Island, in the Gulf, about a hundred miles away.

36. Do you use crushed ironstone?—Not at present. We have not used it for some years.

37. What about siliceous ore?—That is the oxidized ore that comes from Broken Hill. We use about 200 tons a week.

38. What is the assay of that?—It varies greatly, but contains on an average about 20 per cent. of lead.

39. What silver and what sulphur?—About 15oz. of silver. Sulphur varies tremendously, but could be taken as around 5 per cent. The arsenic and antimony are very light—.03 per cent. of arsenic and .04 per cent. of antimony.

40. Is any other raw material used, either in the roasting plant, blast furnace, or elsewhere?—Yes; we have the residues that come from Risdon after the zinc has been extracted from the roasted zinc concentrates.

41. What is the assay of that?—About 18 per cent. of lead.

42. The granulated slag which you return all the time to your blast furnaces would go very low in lead?—Yes, about 2½ per cent. to 3 per cent. in lead.

43. What do you do with this raw material? I presume you can divide it into main sections, and we can then touch on the analyses and products as we come to those particular products, so that the Commission can be fully posted in the process?—The first section is the ore unloading and handling section, which deals with the delivery of all ores and materials to the Dwight and Lloyd storage bins or to the reserve heaps in various parts of the plant. A part of its functions is, of course, the reloading of material from these reserve heaps as and when required.

44. You keep certain quantities of raw materials in stock all the time to draw on as required?—Yes, there are approximately three months' supply of all materials necessary to carry on the smelters on hand at all times.

45. At this point will you tell the Commission briefly the general process of lead smelting and refining until you reach the finished products of lead and antimonial lead and bar silver?—Yes; the ore when it is unloaded to the storage bins at the Dwight and Lloyd plant is fed, together with the calculated amount of the various fluxes and materials necessary, to a main collecting belt, which delivers it well mixed to the super hoppers over the Dwight and Lloyd machines.

46. Will you rather describe the process, more or less, on the metallurgical side?—When the concentrates reach Port Pirie they are finely divided and carry the lead in the form of sulphide of lead. It is not practicable to extract the lead and the silver from those concentrates until such time as the sulphur has been practically all driven off and the material agglomerated or sintered. When the material after passing through the roasting and sintering plant is put into the above condition it is delivered to the blast furnace, together with coke and necessary fluxes, and smelted so that it produces two products—a bullion that contains the greater part of the lead that was in the original concentrates and also practically all the silver. This bullion also contains small quantities of sulphur, antimony, arsenic, copper, and zinc. The second product is slag that contains the waste matters which were in the original concentrates and ores, and also the fluxes that were added to enable the roasting operations to be successfully carried out. The slag also contains small quantities of lead and silver. This slag leaving the furnaces is granulated in water and sent to the waste dump. The bullion containing the impurities set out above is sent to the refinery. The first operation in the refinery is the elimination of the sulphides of lead, zinc, and copper that were originally dissolved in the bullion and carried out of the blast furnaces with it. This is done by charging the bullion bars into a reverberatory furnace, where the bullion is raised to a temperature which is sufficient to keep it well melted, and at this temperature it rejects the sulphides that were originally dissolved in it. These sulphides in the form of a dross lying on the top of the molten bullion are removed by the furnacemen by means of paddles, drawn from the furnace and delivered to small pots that are wheeled out, drained of any metallic lead that may have been included in the skimming, and dumped in a pile for return to the blast furnaces for retreatment. The temperature at which this operation is carried out is in the neighborhood of 700 degrees centigrade. At certain stages, however, the copper-drossing

furnace is practically cold. The bullion, after drossing in the furnace mentioned above, is delivered to another reverberatory furnace called the antimony softening furnace, situated at a slightly lower level. Here it is heated to a temperature of about 900 degrees centigrade and air is allowed to pass over the surface of the molten bullion. This air oxidises the antimony and arsenic in the bullion and also some of the lead, and the compounds formed run off the surface of the bullion in the form of slag through a small running notch at the end of the furnace and are caught in small pots on wheels. These are wheeled out, and the antimony slag, as it is called, is dumped for treatment in another small reverberatory furnace. The time of operation necessary in the antimony softening furnace to properly soften one charge of bullion is about 12 hours. At the end of that time the bullion is run down into desilvering kettles for the removal of small quantities of gold and the silver. These kettles are set in such a way that the greater part of the kettle is below the level of the working floor, and they sit in a combustion chamber, by means of which the temperature of the lead is kept up to the working point. There would be about 55oz. of silver to the ton in the bullion. The removal of the very small quantity of gold in the bullion is the first step at this stage, and it is done by adding a small quantity, about 170lbs., of zinc to the molten bullion in the kettle. The amount of zinc added depends entirely on the size of the charge that goes into the kettle. This zinc is melted by raising the temperature of the bullion in the kettle, and when it is thoroughly melted it is stirred into the bullion by means of a mechanical stirrer, this operation going on approximately for 40 minutes. At the end of that time the fire is drawn out from beneath the kettle, and the contents are allowed to cool back nearly to the solidification point of lead. The bullion then rejects the zinc in the form of an alloy of zinc, silver, and lead. That contains also the small amount of gold present in the bullion and some of the copper contents. After the removal of the crust containing the gold the kettle is again heated and further quantities of zinc are put into it, the routine followed being the same as in the case of the gold. This further zinc removes the greater part of the silver contents of the bullion. The temperatures would be around about 500deg. centigrade. A third zincing is necessary to remove the whole of the silver, and this is done in precisely the same way as before mentioned. The bullion has now been freed of the impurities it contained and of its silver and gold, but in the process of desilverising certain amount of zinc becomes alloyed with the lead, approximately .6 per cent., and in order to remove this the bullion is syphoned down into a reverberatory furnace called a refining furnace, situated on a lower level. Here the bullion is heated to a temperature of about 950deg. centigrade, and air passed over the surface of the molten bullion. This oxidises the small amount of zinc that the bullion contains, and also oxidises a considerable quantity of lead at the same time. The drosses formed by the oxidisation of zinc and the lead are removed by the furnaceman by the aid of a paddle, drawn from the end of the furnace and tipped into small pots on wheels. These pots are wheeled to a platform outside the refinery and tipped. The lead is now pure, containing about 99.989 per cent. lead. It is run from the refining furnace to a receiving kettle and moulded into market bars by means of a syphon operated by the men in the moulding ring. The market lead is taken out from the refinery by contractors in small hand-drawn trucks and stacked on the wharf for shipment as required. Going back to the desilverising section, the zinc crusts containing the silver and gold are sent to receiving bins, and in the case of the silver crusts, go to a small kettle, where the major part of the lead is melted out and separated from the true zinc-lead-silver alloy that the crusts contain. The alloy is taken over from this kettle and sent to the retorting furnaces, where it is charged into plumbago retorts that carry about 12cwts. to 13cwts. of crusts. These retorts are set in a furnace in such a way that the neck of the retort protrudes slightly from the outer wall of the furnace, and the body of the retort is so placed that the firing gases, which are producer gases, can circulate around the retort and heated up to the necessary temperature to distil the zinc from the lead and silver. The distilled zinc is caught in a condenser that fits tightly over the plumbago retorts. In the upper part of the further end of the condenser there is a small vent-hole to allow the escape of a certain quantity of gas, so that the internal pressure in the condenser will not cause it to separate from the retort bottle and allow the escape of gas at this point. At this vent-hole during the operation of the retort there is always a small flame burning. This is metallic zinc vapor burning to zinc oxide. The distillation of a charge of crusts in one of these retorts takes about eight hours. When the process is finished the condenser is drawn away from the front and the operator ladles out from the retort bottle the lead and silver alloy that remains there after the zinc has been distilled. He moulds this alloy into small bars, and it is sent from there to the silver yard, where it is further treated. The temperature of the gas retort ranges up to 1,250deg. centigrade. The lead-silver alloy first of all goes into the silver yard and is fed to cupels, which are really small reverberatory furnaces. Here it is heated to about 950deg. centigrade, and the air blown by means of a light blast over the surface of the molten metal. This air oxidises the lead, forming litharge, which melts and runs off the surface of the bath and is granulated in a tub of water. As the lead oxidises and runs from the cupel the level of the bath of molten metal, of course, decreases, and further lead-silver alloy is fed in to keep it up to the necessary level. This process is carried on until ultimately the cupel is full of silver. The temperature at that point would be 1,050deg. centigrade in the cupels. When the cupel is finally full of silver, the silver is dipped by means of ladles and poured into bars of about 1,000oz. each.

47. You have an electrolytic refinery which operates at intervals. What does that do?—Reverting now to the zinc-silver-lead crusts that contain the small amount of gold originally in the bullion, these are treated by melting them in a reverberatory furnace called the gold alloy furnace, where the zinc is oxidised and fluxed off by the addition of litharge to the charge. A certain amount of the copper that was in the gold crusts goes out with the slag produced. This slag is skimmed off and sent back to the blast furnaces for retreatment. The lead-silver-gold alloy, after removal of the zinc, is tapped from the furnace into a kettle and zinced for removal of the silver and gold, which then follow the same course as the silver alloy in regards to retorting and cupelling. The ultimate product is a silver bar that contains small quantities of gold. This is cast into anode bars and refined electrolytically for separation of the gold and silver in a small electrolytic refinery which operates for a short period about twice a year.

48. How much gold is won by this smelter annually?—The amount varies tremendously, because the major part of the gold we get comes from purchased ores, but it would not be more than 2,000oz. a year. Going back to the retreatment of the refinery by-product. The by-products from the refinery operation are returned to the blast furnace department, mostly, for further treatment. The first by-product produced is the copper dross. This is returned to the blast furnace department and smelted in a small blast furnace, together with refinery furnace dross and certain other fluxes, producing a lead bullion and a matte containing copper, silver, lead, zinc, a sulphide, a complex sulphide, of the metals that it and small quantities of arsenic and antimony. The matte is contains, such as lead, copper, iron, zinc, which are the main metals. The bullion coming from this furnace goes back to the refinery and is refined in the ordinary way. The matte is tapped into pots, sent out to the dump, hand broken, and

stored, and ultimately shipped to the copper refinery at Port Kembla, New South Wales. The second by-product produced in the refinery is the antimony slag. This is remelted in small reverberatory smelters known as antimony dross furnaces in the refinery building and a certain amount of coal is added to it. These furnaces operate at a temperature of about 700deg. to 750deg. centigrade. This process reduces some of the lead in the slag, and the furnace ultimately produces a lead bullion known as hard lead, because it contains sufficient antimony to make it much harder than ordinary lead, and a slag that contains the greater part of the antimony that was originally in the antimony slag, and also lead and arsenic, the antimony and arsenic being combined with the lead in the slag. The hard lead produced by the furnaces goes back to the antimony softeners for retreatment, and the slag goes to the blast furnace department. The temperature of the blast furnace would be about 1,200deg. centigrade in the crucible of the furnace. Once in every six months a campaign is run, in which this antimony slag is reduced to antimonial metal, containing about 12 per cent. of antimony and 88 per cent. of lead. The arsenic that was in the antimony slag before its reduction in the blast-furnace is eliminated by the addition of metallic iron to the charge. This metallic iron combines with the arsenic, forming the speiss, which is separated from the matte when cold and thrown over the dump. The third by-product in the refinery is what is known as refiner skimming. These refiner skimmings are mainly oxide of lead, but contain an appreciable quantity of oxide of zinc and a small quantity of antimony. This dross is returned to the blast furnace department and smelted, either in conjunction with the ordinary charge or in the matting furnace in conjunction with the copper dross referred to before.

49. You have dealt with the metallurgical side practically completely. In the roasting department what happens when the raw materials are mixed and delivered into the roasting grates?—In order that the Commission may more thoroughly understand the process of roasting, I will explain briefly what a Dwight & Lloyd machine consists of. The machine is, in effect, an endless belt composed of separate pallettes, each one of which is really a small section of grate that runs between guides and makes a tight joint with those pallettes on either side of it, when it is traversing the operating part of the furnace. The palettes, coming to the beginning of the operating section, pass under a chute that delivers to them the charge that is to be roasted. Having got that charge, they pass under a levelling plate, which sets the depth of the charge at this point at about 3½in. After levelling, the pallette, in its low progress forward, passes under an ignition stove, which is delivering red-hot gases to the surface of the charge. Just at this point the under-side of the pallette makes contact with a suction chamber that runs in two sections right along to the end of the operating section of the Dwight & Lloyd machine. These suction chambers being connected with a fan, that is pulling about 14,000ft. of free air per minute, draw the air down through the charge, and, of course, as the pallette comes to the point where the fiery gases are available they are drawn by the suction of the fan down through the charge and ignite the surface, starting the sulphides of lead, zinc, and iron to oxidise, and generating so much heat that as the belt travels forward over the remainder of the suction box the temperature caused by the oxidation of the sulphide is such that the whole depth of the charge has been partially roasted by the time the end of the operating section is reached. The travel of the charge over the suction-boxes on the first section of the Dwight & Lloyd machines is from 28in. to 32in. a minute.

50. I want the Commission to be informed as to what happens in that charge from the chemical standpoint and the change in the chemical form of the lead?—In the operation of roasting the charge, which originally contained around 11 per cent. of sulphur, and which in addition contains most of its lead and zinc as sulphides of lead and zinc, is roasted during its progress over the machine to such an extent that when it is finally discharged from the end of the machine it contains about 7 per cent. of sulphur and the lead and zinc sulphides originally present are partly or wholly oxidised. The charge at this point contains about 43 per cent. of lead. The gases that are drawn by the fan from the roasting charge contain the sulphur that has been eliminated from the charge during roasting, and these are sent by the fan to what are known as Cyclone dust catchers. These cyclones take out the mechanical dust that is carried by the gases, but do not take out all of the fumes. After passing through the Cyclone the gases are at present discharged directly into the air through chimney stacks.

51. In regard to the chemical reaction occurring in the Dwight and Lloyd machine, the preparation of the Dwight and Lloyd mixture is done by means of bins, feeding belt conveyors and cross conveyors, is it not?—Yes.

52. Will you very briefly describe the arrangement and the condition of the material in each case, whether fine, whether dry, and whether coarse?—**The preparation of the charge for** the Dwight and Lloyd machine is done from a series of bins, called the mixing bins. These are a number of small bins set side by side, that contain a few hours supply of each of the materials requisite for the roaster charge. Granular concentrates, slime concentrates, lime sand, siliceous ore, granulated slag and Risdon residues are stored at this point. From each of these bins, a small belt runs out above a general collecting belt, and by regulation of the doors at any individual point the quantity of material delivered from these bins per minute can be accurately guaged. Each door is therefore set at the requisite point and all the bins that are delivering material for the charge are delivering simultaneously on to the collecting belt. This belt discharges its contents on to another belt which in turn discharges to a further belt, the reason for these continued discharges being that it is essential that the material should be as thoroughly mixed as possible before it reaches the super hoppers of the Dwight and Lloyd machine. Reverting to the materials going to make up the charge, I would say that the lead concentrates are granular in form, consisting of sulphides of lead and zinc with small quantities of gangue, and come to the bin in a damp condition, and in the process of discharging from the bin they make no dust. The slime concentrates are in a very much finer state of division than the granular concentrates and carry as a rule more moisture. In fact they usually carry so much moisture that they occasion considerable trouble in ensuring their regular discharge from the storage bin. The Risdon residues are in very much the same category as the slime concentrates. The lead content of these, however, is in the form of sulphate. The granulated slag discharges wet from the bin to the collecting belt. The lime sand contains not more than 2 or 3 per cent. of moisture and the siliceous ore about 4 per cent of moisture as a rule.

53. There are no dry materials fed on to that belt at all?—That is so, they are all moist.

54. These materials go up a belt and are mixed by passing from one belt to another. Is there any other mixer of any sort?—Yes, there are two mixers situated at the discharge end of two of the belts that catch the charge as it is being dropped from one belt to the other and give it a mixing.

55. I understand this material is then fed into hoppers and from the hoppers on to the first machine, the A machine Dwight and Lloyd?—Yes.

56. It then passes along, and the sulphur is partly burned out and the sinter made?—Yes.

57. What do you do with it as it discharges over the end of this grate?—**The sinter from the first section of the Dwight & Lloyd machine drops from the discharging end of the machine to a hooded hopper and from there falls on a tray conveyor that places the material on to an inclined belt leading to a cracker where the material is broken down to about**

1¼in. size. From there it travels by belt conveyor to a set of rollers which are operated as and when required and the metal reduced to such a state that about 84 per cent of it will pass a ¼in. mesh.

The Commission adjourned.

Wednesday, April 29th, 1925, at 10.30 a.m.

[At Congregational Hall, Port Pirie.]

Present—

Dr. K. R. Moore (chairman).
Mr. J. L. Pearson.
Mr. H. W. Gepp.
Mr. W. Robinette.

HENRY ST. JOHN SOMERSET, General Superintendent, Broken Hill Associated Smelters, Port Pirie, was recalled and further examined:

58. *By Mr. Gepp*—When we adjourned yesterday afternoon you were describing the way in which the material is delivered from the A machine on the Dwight & Lloyd plant, and the method of treatment of this material prior to delivery to the next operation. Is that material dry or wet on its delivery from the A machine and through the process of treatment to the B machine?—On the A machines a little before the point of discharge there is a water spray from which water is played on to the surface of the roasted sinter. The water is regulated so that the sinter shall be wetted as far as practicable before it drops through the hopper on to the tray conveyor underneath.

59. What is the purpose of having the A and the B machine series?—Because the material cannot be efficiently roasted and sintered in the one operation on a Dwight and Lloyd machine.

60. What are the specific specifications for the final product from the Dwight & Lloyd plant?—It must be as strong as practicable and as low in sulphur as it is possible for us to get it. It usually assays about 1.9 per cent. of sulphur.

61. What do you mean by "as strong as possible"?—The sinter must be strong in order that it shall not break up too much between the point of discharge on the final Dwight and Lloyd machine and the blast furnace tops.

62. Why is it necessary to get the sulphur down so low as under 2 per cent?—Because if the sulphur is not got down to a point somewhere around 2 per cent. there is metallurgical trouble in the blast furnaces, and the loss of lead carried away in the slag is greater than if the sulphur is reduced to the figure I have given.

63. What is the operation on the B machines?—The sinter that is made on the A machines is called pre-roast. This is crushed for delivery to the B machine section, so that 84 per cent. of it approximately will pass through a quarter-inch mesh. In this condition it is delivered mostly to the super hoppers of the second section of Dwight & Lloyd machines—the B section—but part of it goes to a bin that supplies the Huntington-Heberlein sections. That part which goes to the Huntington-Heberlein section is much more coarsely crushed. Further, our practice on the second section of the Dwight & Lloyd machine is such that we are now beginning to crush the greater part of the pre-roast much more coarsely than was the custom a few months ago. The material once delivered into the super hoppers of the B Dwight & Lloyd machines is delievred to the machines in precisely the same way as is done in the A section. At this point it is quite damp. As a matter of fact, it is usually damp right through from the crushing machines to the feed on the B section. If it is not damp enough further water is added at the B section. I might explain to the Commission here that both in the A and B sections it is impracticable to produce good results unless the feed is well damped before going on to the machine. Once it is fed to the B machine the operation is precisely similar to that on the A machines. When the material is delivered over the discharge end of the B machines it is much stronger and more compact than it was when leaving the A machines. It contains about 44 per cent. of lead and about 2 per cent. of sulphur. It falls from the B machines into skips that are placed below, and these skips and the discharge sections of the machines are covered over by hoods that are carried back above the suction chamber on the machine, and air is in this way drawn up from around the skips and in through the roasting charge again. This serves to eliminate dust at this point. Once the skip is full of sintered material it is pushed out by hand to a point underneath the aerial hoist, and from there it is lifted and delivered to the blast furnace bin.

64. You have one more roasting operation, I understand, called the Huntington-Heberlein process, in which you treat some of your pre-roast material from your A machines. Why should you do this and not do it on your B machines?—Until comparatively recently it was necessary to produce a considerable proportion of Huntington-Heberlein sinter as compared with Dwight & Lloyd sinter in order to ensure that the blast furnace operation would run smoothly. This is so because the Huntington-Heberlein sinter is much stronger and coarser than the Dwight & Lloyd sinter, particularly when the Dwight & Lloyd sinter is below standard quality. If the proportion of Huntington-Heberlein sinter in that case is reduced to a low figure very considerable trouble develops in the blast furnace tops. Latterly, however, the Dwight & Lloyd work has been modified, with the result that the sinter is stronger and better than it used to be, and this has enabled us to reduce considerably the amount of pre-roast going to the Huntington-Heberlein pots. The method of operating the Huntington-Heberlein pot is, shortly, this:—The pot itself is a bowl that holds from 8 tons to 10 tons of charge. It is equipped near the bottom with a false bottom, consisting of a perforated steel plate. Underneath this steel plate there is an opening that connects with the blast main that delivers the air necessary for the sintering operation. When the pot is ready to charge, a certain amount of red-hot coke is drawn in trucks from a stove and delivered into the Huntington-Heberlein pot, where it rests on the perforated false bottom. On top of this hot coke the moistened pre-roast material is directly tipped, and the pot gradually filled up, the blast in the meantime having been turned in through the bottom of the pot. The roasting then goes on, the blast being regulated as occasion demands until the pot is completely sintered right through. The fumes from the pot while it is under operation are carried away by a hood that sits down over the pot, and are drawn by the stack draught and delivered directly to atmosphere. When the sintering operation is completed the pot is tipped, and the material, which is largely a solid cake, is hand-broken, loaded to skips, and delivered to the blast furnace bins. Its analysis is practically identical with that of the Dwight & Lloyd sinter, but physically it is much coarser.

65. In your answer to question No. 46 yesterday you said that the material, after passing through the roasting and sintering plant, is put into a certain condition; that is, the sulphur eliminated and the material agglomerated or sintered, it is delivered to the blast furnace, together with coke and necessary fluxes, and smelted so that it produces two products, namely, a bullion and a slag. You have explained to the Commission that the roasting operation is for these two purposes, namely, sulphur elimination and preparation of an agglomerated or sintered material. Will you now tell us in brief the operations on the blast furnace on the same lines as you have given us the operations on the roasting plant?—The bins that contain the material necessary to the blast furnace operation are situated above the feed-floor level, and along under the discharge openings of the bins a railway track runs on which the charge cars travel. These charge cars take the material from each bin in quantities that are set by the blast furnace superintendent, that is to say, each charge car takes a portion of Dwight and Lloyd sinter, a portion of Huntington-Heberlein sinter, some return blast furnace slag in lumpy form, the coke that is necessary for the smelting operation, and on occasions

some of the by-products that are returned for smelting from various sections of the plant. The truck passing from one bin to the other receives its full charge, and is then transferred automatically to the opposite side of the feed-floor and at the end of the feed-floor. It travels from there along a railway track that runs over the tops of the blast furnaces and about 7ft. above them. When the truck arrives over the furnace to which the charge is to be delivered, it is disconnected from the hauling-rope and allowed to stand over the furnace. The feeder then releases a catch, and the truck is so made that half the charge delivers into the front of the furnace and half to the back.

66. What is a blast furnace, purely from a layman's standpoint?—A blast furnace is essentially a rectangular column sitting on a crucible. This column is built so that the lower portion is made up of hollow cast-iron boxes through which water is circulated when the furnace is in operation. These boxes are known as water-jackets. Above the boxes the column is built of firebricks up to the level of the feed floor. Through the jackets near the bottom of the furnace there are certain openings cast, through which the blast necessary for the smelting goes. These openings are known as tuyere openings. On the feed-floor level there is a hood fixed to take away the fumes and gases from the furnace when it is in operation. This hood is set down along the centre line of the top of the furnace, and is, in effect, a box with one side open, that side being the one that is pointing downwards into the furnace, and is in connection with the charge when the furnace is operating. From the ends of the box, flues lead away into the main smelter flues and the fumes are drawn off in this way. When the furnace is ready to operate, the crucible on which the furnace sits is filled with molten lead. A wood fire is started above this, coke is put on the top of the fire, blast furnace slag and coke again on top of that, and then the regular furnace charges. The blast is turned on, being increased gradually from a few ounces pressure up to about 44oz. when the furnace is operating normally. The action of the blast is to burn the coke and to supply heat necessary for smelting the charge. It also is regulated in such a way that the atmosphere in the furnace is kept on the reducing side. This is necessary in order that the oxide of lead that goes into the furnace in the sinter can be wholly reduced to the metallic form, and so separated from the waste matters that the sinter contains. As the material melts it runs down through and among the partly molten charge, and collects in the lower part of the furnace, where the metallic lead separates out from the slag. The metallic lead, having the greater specific gravity, collects in the crucible of the furnace, and flows out through an inverted syphon that makes connection with the bottom of the crucible. The slag, on the other hand, accumulates above the level of the molten lead in the crucible, and is periodically drawn off through tapping holes in the ends of the furnace. As it runs out of the furnace it falls first into the bowl of a slag-pot, and from there overflows into a launder, in which there are strong water jets. These water jets chill the slag very rapidly, breaking it into small granules, and in this form it is swept away by the water into a pit, from which a bucket elevator lifts it to storage bins, and from these storage bins it is drawn off periodically into railway trucks, which are taken by a locomotive, and the slag is dumped over the waste dump. The purpose of the slag-pot situated immediately under the tapping-hole of the furnace is to catch any metallic lead that might otherwise escape with the slag.

67. You have a product you call litharge. What is it?—It is an oxide of lead, and is used in glass work, pottery work, and largely in the rubber trade.

68. Is it a product that you make specially at the works?—Litharge is the result of a special process. It is not connected with the production of market lead.

69. Where do you get the raw material for the litharge plant from?—The litharge is made from the pure lead which is produced in the refinery.

70. Will you describe briefly the litharge plant from the point of view of mechanics?—Litharge is made in a cupel similar to the cupels in which the silver-lead alloy is cupelled. The lead bars are melted in the cupel hearth, and when the hearth is full of metal an air blast is played on to the surface of the molten lead. This converts the lead to oxide, and this oxide, being in molten form, runs out through a small notch into pots set to receive it. When the pot is full of litharge, which by this time is solidified, it is wheeled out and delivered to the litharge mill. In this mill the material is fed to a pulverising plant, which is entirely closed, the feeding being done through a small opening that is opened as required for the delivery of the lump litharge. In this mill the litharge is crushed to a fine powder, and taken by an air blast and delivered into a storage bin, the top of which is also covered. From this storage bin it is delivered into kegs that are set on a shaking table. The purpose of this shaking table is to settle the litharge down as closely as possible in the keg, and enable the requisite quantity to be put into it. When the kegs are filled they are taken from the shaking table by the man in charge, and delivered to a small table in another part of the room, and there the kegs are lidded. When they are lidded they are wheeled out into another room, where the painting and the marking of the kegs are done.

71. Reverting for a moment to the question of roasting and blast furnace operations, I understand that you came to Port Pirie in 1917. In those days a certain amount of the sulphide ore was treated in Ropp furnaces, was it not?—Yes.

72. Afterwards it was sintered by what means?—The function of the Ropp furnaces, which were long mechanical furnaces, in those days was to pre-roast the ore for the Huntington-Heberlein section of the sintering plant. That is to say, they were doing part of the work that is now done by the A section of the Dwight & Lloyd plant. The material, when it was delivered from the Ropps, was entirely different from the material that now comes from the A section of the Dwight and Lloyd plant. It was not sintered at all. It was partially roasted, and was in a dusty condition. From the Ropp furnaces it was delivered while still hot to the Huntington-Heberlein pots, and the operation carried on in the usual way after that.

73. You consider that the elimination of the Ropp furnaces and the installation of the Dwight & Lloyd A machines constitute a definite improvement from the metallurgical and health standpoints?—Absolutely. The material coming from the Ropps to the Huntington-Heberlein pots made a very poor sinter. Instead of the material coming out in a solid lump, as it now mostly does, it then contained a large quantity of unsintered dusty material that had passed unchanged through the operation. The conditions in those days at that particular plant were much worse than they are now. The Ropps furnaces no longer exist. They were pulled down recently.

74. But portion of the Huntington-Heberlein plant does still exist?—Most of it does.

75. You have another operation at Pirie in connection of the roasting of zinc concentrates and the manufacture of sulphuric acid?—Yes.

76. What is the analysis of the zinc concentrates that are roasted here?—They contain, approximately, 47 per cent. of zinc, 6 per cent. of lead, and 29 per cent. of sulphur.

76A. What, approximately, is the analysis of the product which, I understand, is called calcine?—It carries around 53 per cent. of zinc, 5½ per cent. of lead, and about 5½ per cent. of sulphur.

77. Where does this product go?—The calcine is delivered from the furnace bin to stock piles on the wharf front, and from there it is loaded mechanically into ships for transport to the Electrolytic Refining Company's works at Risdon, Tasmania.

78. An acid plant is worked in conjunction with the roasting plant?—The function of the acid plant is to take the gases that are formed when roasting the zinc concentrates, and convert the sulphur di-oxide in them to sulphuric acid.

79. Where does this acid go?—It is then sent by railway in