1922.
(SECOND SESSION.)

NEW SOUTH WALES.

Legislative Council.

DEPARTMENT OF LABOUR AND INDUSTRY.

FURTHER REPORTS

OF THE

TECHNICAL COMMISSION OF INQUIRY

APPOINTED TO INVESTIGATE

The Occurrence of Industrial Diseases in and about the Metalliferous Mines at Broken Hill.

Ordered by the Council to be printed, 4 July, 1922.

SYDNEY: JOHN SPENCE, ACTING GOVERNMENT PRINTER.

1922.

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Conclusions Concerning Conditions at Broken Hill.

SINCE it began its work in December, 1919, the Technical Commission has completed its inquiry into the state of health of 6,538 mine workers employed in or about the mines at Broken Hill. A record has been made of the results of a full medical examination of each person, during which he has given a history of his past and present health. A photograph has been taken with X-rays to show the condition of his lungs and other organs within the chest. An account has been obtained of the various occupations followed by each man from the time of his starting to work on leaving school until the date of the medical inspection. When needed, the results obtained by the medical inspection, the radiographic examination, and the industrial history, have been supplemented by chemical and bacteriological tests, and by inquiries into such records of employment as might be available.

As directed in its terms of appointment, the Technical Commission has completed the medical examinations of all persons in the employment of the Companies working at Broken Hill, and has made medical inspections of all persons entering into the employment of these Companies who were not on the pay roll of the Companies in May, 1919. Every man at work in or about the mines along the lode at Broken Hill has been the subject of a medical inspection, which has included such a medical examination as is required by the Workmen's Compensation (Broken Hill) Act, 1920. Each man holds a certificate from the Technical Commission. In the case of those men defined as "mine workers" under the Workmen's Compensation (Broken Hill) Act, 1920, the certificate is to the effect that the mine worker is free from pneumoconiosis and from tuberculosis; but in other cases, the certificate states that the man is a fit person to work in or about the mines of Broken Hill. Copies of these certificates have been furnished to the manager of each Company conducting operations along the line of lode at Broken Hill. Each manager has reported that he holds a medical certificate from the Technical Commission in respect to every person employed by the Company in or about its mines or treatment works at Broken Hill. Every person desirous of entering into the employment of these Companies has been medically examined before starting to work. When persons who have not been "mine workers" as defined by the Workmen's Compensation (Broken Hill) Act, 1920, have been found affected with some ailment which would be aggravated by the conditions of work present at Broken Hill, or with some physical defect rendering their occupations more hazardous to themselves, or likely to endanger the safety of others, the Commission has refused a certificate of fitness for employment in the mines.

As already reported, a condition of pneumoconiosis may arise in the lungs of mine workers as the result of the inhalation of particles of dust. This disease is found almost entirely among those mine workers, commonly known as miners, who are engaged, *inter alia*, in drilling holes in rock. Chemical analyses of the lungs removed from dead miners have shown the presence of lead, zinc, manganese and silicon, whenever the man has worked over ten years in the mines at Broken Hill. The presence of this associated group of substances shows that the miners take into their lungs dust derived from the ore body at Broken Hill. The form of pneumoconiosis found among the miners at Broken Hill is characterised by changes along the air passages and beneath the pleural covering of the lungs, and by the scanty affection of those parts directly concerned with the respiratory exchanges. This form of pneumoconiosis differs from those found among miners at Bendigo, Cobar, and Kalgoorlie, and among rockchoppers in Hawkesbury sandstone. Owing to the different involvement of the parts of the lungs, the radioscopic appearance of the chest is not the same as that of a person affected with pneumoconiosis due to quartz. Further, the impairment to breathing leading to a lessened capacity for work is absent in the early stages of the disease. Two stages of the disease can be recognised among the miners at Broken Hill. These could be distinguished by the radioscopic appearance of the chest. In the first stage there is less affection of the lungs than in the second stage. Clinical signs of the disease are absent in the first stage, in which there is no impairment to the general health. In the second stage clinical signs may be found, but not invariably, on medical examination, while there may also be present some impairment of the general health and capacity for work. These conditions of pneumoconiosis, however, render the miner more liable to contract pulmonary tuberculosis. Tuberculosis of the lungs may supervene either on the first stage or on the second stage of pneumoconiosis. After the infection with tuberculosis, the general health fails; impairment of working capacity develops; and clinical signs of pneumoconiosis, complicated with tuberculosis, are present on medical examination. Tuberculosis of the lungs is also found among mine workers at Broken Hill apart from any pneumoconiosis. It affects both surface and underground workers, but is more prevalent among underground workers.

The Commission has found 113 mine workers at Broken Hill affected with the first stage of pneumoconiosis; 51 with the second stage of pneumoconiosis; 102 with pneumoconiosis complicated with pulmonary tuberculosis; and 107 with uncomplicated tuberculosis. The Commission has examined 2,618 miners. Among these miners 1,595 had worked as miners at Broken Hill only; and 1,023 had worked as miners at Broken Hill and elsewhere.

TABLE I.—Practical Miners.

Period as Practical Miners:—		Per cent.
10 years and under	996	38·0
20 years and over 10 years	894	34·2
30 years and over 20 years	526	20·1
Over 30 years	202	7·7
	2,618	

	Broken Hill only.	Not Broken Hill only.
10 years and under	689	307
20 years and over 10 years	582	312
30 years and over 20 years	285	241
Over 30 years	39	163
	1,595	1,023

Among

Among 689 miners who had worked with drills for ten years and under at Broken Hill only, 6, or 0·9 per cent., suffered from the first stage of pneumoconiosis; none from the second stage of pneumoconiosis; and 1, or 0·1 per cent., from pneumoconiosis complicated with pulmonary tuberculosis: in all, 7, or 1·0 per cent., were affected with some degree of pneumoconiosis.

Among 582 miners who had worked with drills at Broken Hill only for over ten years but less than twenty years, 15, or 2·6 per cent., suffered from the first stage of pneumoconiosis; 4, or 0·7 per cent., from the second stage of pneumoconiosis; 13, or 2·2 per cent., from pneumoconiosis complicated with pulmonary tuberculosis: in all, 32, or 5·5 per cent., were affected with some degree of pneumoconiosis.

Among 285 miners who had worked with drills at Broken Hill only for over twenty years but less than thirty years, 21, or 7·4 per cent., suffered from the first stage of pneumoconiosis; 9, or 3·2 per cent., from the second stage of pneumoconiosis; 14, or 4·9 per cent., from pneumoconiosis complicated with pulmonary tuberculosis; in all, 44, or 15·4 per cent., were affected with some degree of pneumoconiosis.

Among 39 miners who had worked with drills at Broken Hill only for over thirty years, 1, or 2·6 per cent., suffered from the first stage of pneumoconiosis; none from the second stage of pneumoconiosis; 4, or 10·3 per cent., from pneumoconiosis complicated with pulmonary tuberculosis: in all, 5, or 12·8 per cent, were affected with some degree of pneumoconiosis.

Among 307 miners who had worked with drills at Broken Hill and elsewhere for ten years and under, 5, or 1·6 per cent, suffered from the first stage of pneumoconiosis; 1, or 0·3 per cent., from the second stage of pneumoconiosis; 5, or 1·6 per cent., from pneumoconiosis complicated with pulmonary tuberculosis: in all, 11, or 3·6 per cent., were affected with some degree of pneumoconiosis.

Among 312 miners who had worked with drills at Broken Hill and elsewhere for over ten years but less than 20 years, 18, or 5·8 per cent., suffered from the first stage of pneumoconiosis; 12, or 3·8 per cent., from the second stage of pneumoconiosis; 19, or 6·1 per cent., from pneumoconiosis complicated with pulmonary tuberculosis: in all, 49, or 15·7 per cent., were affected with some degree of pneumoconiosis.

Among 241 miners who had worked with drills at Broken Hill and elsewhere for over twenty years but less than thirty years, 19, or 7·9 per cent., suffered from the first stage of pneumoconiosis; 16, or 6·6 per cent., from the second stage of pneumoconiosis; 29, or 12·0 per cent., from pneumoconiosis complicated with pulmonary tuberculosis: in all, 64, or 26·5 per cent., were affected with some degree of pneumoconiosis.

Among 163 miners who had worked at Broken Hill and elsewhere for over thirty years, 18, or 11·0 per cent., suffered from the first stage of pneumoconiosis; 7, or 4·3 per cent, from the second stage of pneumoconiosis; 17, or 10·4 per cent., from pneumoniosis complicated with pulmonary tuberculosis: in all, 42, or 25·8 per cent., were affected with some degree of pneumoconiosis.

In addition, 12 who had not worked as miners suffered from some degree of pneumoconiosis; 10 were affected with the first stage of pneumoconiosis; 2 with the second stage of pneumoconiosis; and none with pneumoconiosis complicated with pulmonary tuberculosis.

TABLE II.—Practical Miners.

Period as Practical Miner.	Broken Hill only.		Not Broken Hill only.	
Pneumoconiosis—Stage 1.		per cent.		per cent.
10 years and under	6 out of 689	·9	5 out of 307	1·6
20 years and over 10 years	15 ,, 582	2·6	18 ,, 312	5·8
30 years and over 20 years	21 ,, 285	7·4	19 ,, 241	7·9
Over 30 years	1 ,, 39	2·6	18 ,, 163	11·0
Pneumoconiosis—Stage 2.				
10 years and under	Nil out of 689	...	1 out of 307	·3
20 years and over 10 years	4 ,, 582	·7	12 ,, 312	3·8
30 years and over 20 years	9 ,, 285	3·2	16 ,, 241	6·6
Over 30 years	Nil ,, 39	...	7 ,, 163	4·3
Pneumoconiosis—Stage 3.				
10 years and under	1 out of 689	·1	5 out of 307	1·6
20 years and over 10 years	13 ,, 582	2·2	19 ,, 312	6·1
30 years and over 20 years	14 ,, 285	4·9	29 ,, 241	12·0
Over 30 years	4 ,, 39	10·3	17 ,, 163	10·4
Persons affected with Pneumoconiosis.				
10 years and under	7 out of 689	1·0	11 out of 307	3·6
20 years and over 10 years	32 ,, 582	5·5	49 ,, 312	15·7
30 years and over 20 years	44 ,, 285	15·4	64 ,, 241	26·5
Over 30 years	5 ,, 39	12·8	42 ,, 163	25·8

Uncomplicated pulmonary tuberculosis was found present in 107 mine workers. Of these, 49 had been employed underground only; 31 both underground and on the surface; and 27 on the surface only.

The Commission has had the opportunity of observing the progress of these diseases among those persons examined by it prior to 30th June, 1920. It found that of those 90 persons affected with the first stage of pneumoconiosis 12, or 13·3 per cent., had become infected with pulmonary tuberculosis, and 1 had died from this infection; that of 44 persons affected with the second stage of pneumoconiosis 7, or 15·9 per cent., had become infected with tuberculosis and 1 had died from this infection; and that of 59 persons affected with pneumoconiosis complicated with pulmonary tuberculosis 20, or 33·9 per cent., had died; 27, or 45·8 per cent., showed an advancement of the disease; while 12 or 20·3 per cent., revealed no change in their condition.

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The Commission draws attention to the fact that 18 persons still residing in or about Broken Hill, who were found affected with pneumoconiosis, had contracted pulmonary tuberculosis, while only one person who had left the town had become infected with tuberculosis. These facts support the recommendation of the Commission that persons affected with pneumoconiosis should leave Broken Hill and take up an occupation elsewhere, preferably in an agricultural or pastoral area.

Among the 65 persons affected with uncomplicated pulmonary tuberculosis 7, or 10·8 per cent., had died; 25, or 38·4 per cent, showed an advancement of the disease; while 33, or 50·7 per cent., revealed no change in their condition.

The Commission invites a comparison of these observations with those on persons suffering from pneumoconiosis complicated with pulmonary tuberculosis. This comparison shows that pneumoconiosis complicated with pulmonary tuberculosis advances more rapidly, and is a more rapidly fatal affection than uncomplicated pulmonary tuberculosis.

Chemical analyses of the urine of 209 men who had been at work on the mines for some six months previous to the examination has revealed in every case the presence of lead. These men were not selected in any way, but were taken consecutively on certain mines from different occupations, namely, miners and other underground workers, mill-hands, and surface workers other than mill-hands. The Commission concludes that men working in or about the Broken Hill mines are, without exception, exposed to the action of lead circulating in the blood. The chemical analyses of the dust present during the various operations in the mines and the minute quantities of lead found in the urine, and in the lungs and kidneys, show that the concentration of lead in the blood to which workers in and about the mines at Broken Hill are exposed is low.

The Commission has carried out complete examinations of 6,862 persons, among whom 6,538 had worked in the Broken Hill mines. In these examinations the previous history of illness of each individual was taken, and departures of any kind from normal health were noted.

From a consideration of these facts, a group of men was made, in each of whom there existed a history of lead poisoning, or symptoms and signs of ill-health, such as general weakness, loss of full working capacity, loss of weight, unhealthy appearance as revealed particularly by pallor and wasting of the subcutaneous tissues, or any symptoms or signs of diseases of the heart, the arteries, the kidneys, nervous system, the muscles and joints, and the digestive organs.

The condition of each individual in this group was then considered, and it was found that a number of men presented, on examination by the Commission at any time, such signs or symptoms as might possibly have been caused by intoxication with lead. Each of these was summoned for re-examination during the last few weeks of the Commission's work in Broken Hill in 1921. Some were not able to present themselves for re-examination on account of ill health; in such of those cases who lived in Broken Hill, examinations have been carried out in their homes where possible. Other men were not able to present themselves for re-examination because of their removal from the Broken Hill district. In such cases examinations have been made where possible by a member of the staff of the Commission during journeys to and from Broken Hill.

The Commission finds that 61 men were suffering from the effects of lead poisoning at the time of their examination.

Two thousand four hundred and ninety-one persons, or 38·1 per cent. of those examined gave no history of any colic weakness, or past ill health of any description whatever, and presented no evidence of any kind of departure from normal health, although they had been exposed to the action of lead during the whole period of their employment at Broken Hill.

Three thousand and eighteen, or 46·1 per cent. of those examined gave histories of some past illness, or presented evidence of some affection due to a cause other than plumbism, *e.g.*, persons suffering from pulmonary tuberculosis, persons with hernias, persons with deformities of the limbs due to accidents, and healthy persons with a history of a past attack of enteric fever, diphtheria, influenza, &c. The only individuals in this group suffering from disease are those in whom the causation of their disease could be readily ascertained by the Commission.

Four hundred and forty-three or 6·7 per cent. of those examined gave no definite histories of attacks of colic or of palsies. Neither did they complain of persistent headache or vertigo, nor had they suffered from fits. They presented evidence of an altered state of the heart, kidneys, or blood vessels. The group includes a number of persons whom the Commission decided to be affected with pneumoconiosis. It contains those suffering from albuminuria following an acute fever and from physiological albuminuria It also includes those affected with endocarditis.

Five hundred and twenty-five persons or 8 per cent. of those examined gave a history of past attacks of colic, or some other form of ill health attributed by them to the effects of lead, either occurring within a few years, or at some longer interval after their commencement of employment in or about the mines at Broken Hill, but medical examination did not reveal any impairment of health or signs of disease which could be attributed to intoxication by lead.

Sixty-one persons gave a history of having suffered from the effects of lead and presented evidence on medical examination of injury to their health.

(*a*) In 31 persons there was present some degree of lead palsy. In 30 of these, a history of recurrent attacks of lead colic was obtained, combined in 22 instances with a history of paralysis or weakness of the limbs. In one instance no colic had been experienced, but signs and symptoms of a nervous affection had been present. Chronic constipation and persistent headache were common symptoms, each occurring in 22 instances. Vertigo was found on 20 occasions. A history of fits was relatively uncommon, occurring in only 5 men. Fourteen men complained of pains in the joints and muscles.

On clinical examination, every one of these 31 men showed definite signs of paresis, and wasting of muscles. The extensor muscles of the forearm were affected in 26 men. In 11 these were the only muscles affected, while in 15 paresis was also present in the brachial peroneal or leg extensor muscles. Paresis and wasting of the small muscles of the hand (Aran Duchenne type) was found in two men. In three men paresis and wasting of the brachial muscles was found, in two of whom the brachial muscles alone were affected. The knee jerks were exaggerated in 15 instances, and tremor was present in 19 individuals.

In addition to these signs of affection of the nervous system, an unhealthy appearance revealed by the cachectic pallor of the skin, and wasting of the subcutaneous tissues was present in 28 instances. Three men who did not present these signs of pallor and bad nutrition were of the ages of 37, 39, and 41 years, and in each of these, the history of the first onset of lead-poisoning was recent, viz., in 1915, in one case, and 1919 in the other two cases. Signs of disease of the arteries, heart, and kidneys, as indicated by the presence of increased systolic blood pressure with, or without, albuminuria, and affection of the heart muscle and valves, and albuminuria combined with signs of heart disease were present in 18 instances.

Among these 31 men, no signs of any other diseases which could produce such localised palsies were discovered.

(*b*) Of the remaining 30 men, all gave a history of colic; two had suffered in the past from paralysis or weakness of the muscles; 22 had constant headache; 18 had chronic constipation; 11 suffered from giddiness; 1 had suffered from fits; 14 from pains in the joints and muscles.

On medical examination they all showed cachectic pallor, and wasting, together with tremor in 13 instances; exaggeration of the knee jerks in 5 individuals, and the signs of disease of the arteries, heart, or kidneys in 13 instances.

TABLE III.

		Group A.	Group B.
Total		31	30
History	Colic	30	30
	Palsy	22	2
	Chronic constipation	22	18
	Persistent headache	22	22
	Vertigo	20	11
	Fits	5	1
	Pains in muscles and joints	14	14
Signs of	Paresis and wasting—		
	Antebrachial only	11	0
	Antebrachial combined with others	15	0
	Brachial	3	0
	Aran Duchenne	2	0
	Exaggerated knee jerks	15	5
	Tremor	19	13
	Unhealthy appearance	28	30
	Pallor	28	30
	Arterio-renal disease	18	13

These findings are in accordance with the observations of other investigators of the effects of lead absorption. Following exposure to lead, a varying number of persons show forms of ill-health or diseases dependent upon the amount of lead absorbed day by day, and the susceptibility of each individual.

Of the 6,538 persons who had been employed in and about the mines at Broken Hill, and had been exposed continuously to the action of lead, 3,302 or 50·5 per cent. had worked for ten years and under; 1,851 or 28·3 per cent. for over ten years and under twenty years; 1,104 or 16·9 per cent. for over twenty years and under thirty years; and 256 or 3·9 per cent. for over thirty years. Twenty-five persons failed to supply a satisfactory industrial history.

Of the 3,302 persons who had worked for ten years and under, 2 or ·06 per cent. were found to show the effects of poisoning by lead. Of the 1,851 who had worked for over ten years and under twenty years, 23 or 1·2 per cent. were affected. Of the 1,104 who had worked for over twenty and under thirty years, 30 or 2·7 per cent. were affected; and of 256 who had worked for over thirty years, 6 or 2·3 per cent. were affected.

Of the 61 persons found to be suffering from the effects of poisoning by lead, 27 had worked only underground. Of these, 25 were miners, one was a trucker, and one was a mullocker. Of the 660 miners who had worked only underground at Broken Hill for ten years and under, 1 or ·15 per cent. was suffering from poisoning by lead. Of the 412 miners who had worked only underground at Broken Hill for over ten years and under twenty years, 11 or 2·6 per cent. were affected. Of the 271 miners who had worked only underground at Broken Hill for over twenty years and under thirty years, 10 or 3·7 per cent. were affected. Of the 67 miners who had worked only underground at Broken Hill for over thirty years, 3 or 4·5 per cent. suffered from lead-poisoning. Of the 190 truckers and 63 mullockers who had worked only underground, one trucker and one mullocker have been found affected by plumbism.

Of the 823 general labourers who had worked only on the surface, 5 were found to be suffering from lead-poisoning, 2 of whom had worked for over ten and under twenty years, and 3 for over twenty years but under thirty years.

Of the 774 mill hands who had worked only on the surface, one who had worked for twenty-six years was affected with plumbism.

Of the 726 persons who had worked both on the surface and underground for a total period of ten years and under, none were affected with plumbism. Of the 751 men who had worked both on the surface and underground for a total period of over ten years and under twenty years, 9 or 1·2 per cent. were affected. Of the 462 men who had worked on the surface and underground for a total period of over twenty and under thirty years, 16 or 3·4 per cent. were affected; and of the 96 who had worked both on the surface and underground for over thirty years, 3 or 3·1 per cent. were affected. Among the 28 men affected with plumbism who had worked both on the surface and underground, all but 3 had a long service underground (ranging from twelve to twenty-nine years), with a short period on the surface (ranging from one to six years). The three exceptions had worked—

6 years underground and 11 years on the surface.
7 " " 17 " "
10 " " 19 " "

TABLE IV.—Persons affected with Plumbism. Total Work at Broken Hill.

10 years and under	2 out of	3,302 =	·06 per cent.
20 years and over 10 years	23 ,,	1,851 =	1·2 ,,
30 years and over 20 years	30 ,,	1,104 =	2·7 ,,
Over 30 years	6 ,,	256 =	2·3 ,,

Underground Only.—Practical Miners.

10 years and under	1 out of	660 =	·15 per cent.
20 years and over 10 years	11 ,,	412 =	2·6 ,,
30 years and over 20 years	10 ,,	271 =	3·7 ,,
Over 30 years	3 ,,	67 =	4·5 ,,

Surface and Underground Practical Miners.

Total work at Broken Hill.

10 years and under	0 out of	726 =	·0 per cent.
20 years and over 10 years	9 ,,	751 =	1·2 ,,
30 years and over 20 years	16 ,,	462 =	3·4 ,,
Over 30 years	3 ,,	96 =	3·1 ,,

Since poisoning by lead at Broken Hill is the result of inhalation of dust, it is of interest to note that miners who inhale dust in quantities sufficient to produce pneumoconiosis are more liable to suffer from plumbism than men in other occupations in and about the mines.

The Commission recommends that the 61 persons who have been found by it affected with disease as a result of poisoning by lead be excluded from the industry. As their illness has arisen from the nature of their occupation it recommends that they receive compensation. It suggests that the amount of this compensation be varied according as the disablement is temporary or permanent, partial or total. An amendment of the Workmen's Compensation Act, 1916, will be necessary to provide compensation to all these persons since a workman who has been out of employment over twelve months is unable to obtain compensation. The Commission recommends that employment for 1,250 shifts along the line of lode at Broken Hill forms the basis of association with the industry for the purpose of obtaining compensation for poisoning by lead previous to 31st May, 1919.

Since the absorption of lead is caused by the inhalation of dust containing lead, all steps taken to diminish the presence of dust in the air breathed will lessen the amount of lead taken into the body. The Commission holds that the conditions of mining set out for the industry in an earlier report will diminish the number of persons affected by lead, since lead-poisoning has been more prevalent among underground workers, especially miners. These conditions of mining lessen the amount of dust in the air which is breathed by the miner.

As lead is absorbed as a consequence of the inhalation of minute quantities of dust, the Commission is of opinion that the effect of the poisoning due to lead in this industry should be prevented by removing susceptible persons from exposure to the action of lead. It recommends that poisoning by lead in the county of Yancowinna be made a disease notifiable to a medical authority; that it be made necessary for all persons affected with or suspecting themselves to be affected with lead-poisoning to report themselves to the medical authority, and to submit to examinations by the medical authority; and that a liability be placed on medical practitioners to notify to the medical authority the names of all persons found or suspected by them to be suffering from lead-poisoning arising in the county of Yancowinna.

The Commission suggests that the medical authority be a board of three medical practitioners, one nominated by the mine workers, one nominated by the mining companies, and the third a medical practitioner appointed by the Governor in Council, on the nomination of the Minister for Labour and Industry, and preferably a medical officer of the Public Service. The medical authority will determine whether the person who has been affected by lead will remain in the industry, or be excluded from further exposure to lead. If persons are withdrawn from the industry as soon as the medical authority is of opinion that they are so susceptible to the action of lead as to render it possible that they may suffer from some degree of permanent disablement if they continue in the industry, the Commission is satisfied by its observations on the effects of lead among mine workers at Broken Hill that no permanent injury will arise among the mine workers of Broken Hill. The medical authority should be vested with discretion in respect to the withdrawal of men temporarily affected with lead poisoning.

Under the Workmen's Compensation Act, 1916, compensation is due to all mine workers temporarily affected with lead-poisoning. The Commission recommends that compensation be paid weekly to all men who are certified by the medical authority to be suffering from any ailment causing some degree of temporary partial disablement and due to lead. This weekly compensation will continue until the medical authority certifies that the mine worker is fit to return to work in and about the mines at Broken Hill and until the mine worker is taken back into employment. When the mining companies do not continue the employment of a person who has been paid compensation for temporary disablement due to lead-poisoning, the Commission recommends that the companies pay a sum of money in compensation for exclusion from the industry to permit him to proceed elsewhere and obtain a new occupation. The companies should possess power of dismissing a mine worker who had previously received temporary compensation, for misconduct or gross neglect of duty.

When the medical authority authorises the exclusion of a mineworker he should receive compensation according as his disablement is temporary or permanent, partial or total. In the case of those persons who have been long engaged in work in or about the mines at Broken Hill, and who may develop chronic lead-poisoning as a result of further exposure to the action of lead, the Commission recommends that compensation be increased according to the number of shifts worked for varying companies. Such a grouping as has been employed by the Commission, over ten years but under twenty years, over twenty years but under thirty years, over thirty years, would be satisfactory.

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The Technical Commission is of opinion that the amount of dust present in the air of the mines is so reduced that the quantity of dust taken into the lungs is no longer sufficient to give rise to pneumoconiosis, provided the operations of mining are conducted in such a manner—

(1) That the firing of explosives takes place at the end of shift;

(2) That a water blast is used after firing explosives except in an open stope with an air current moving through it with a speed of 20 feet a minute or more and in a square-set stope with through ventilation;

(3) That an interval of thirty minutes elapse after firing explosives before work, such as shovelling ore, boring and charging holes, or timbering be resumed in a working place; and

(4) That the boring of holes with drills is undertaken with the precautions enumerated hereinafter.

Owing to the system of ventilation, it would appear that, as far as practicable, firing explosives should take place at the end of each shift. It will be recognised that occasionally in bad ground or to put in timber or in a development end it may be urgently necessary to fire without waiting for the end of the shift. Further, it may be advantageous to break up a large mass of ore which delays further operations with a small quantity of explosive. As the Commission considers that such firing should only take place after due consideration, it recommends that no firing should be allowed except at the end of shift unless special permission in writing be given for each firing by the officer in charge of each working place. The permit should state the reason for departing from the general rule, and a duplicate copy of the permit should be lodged the same day at the office of the underground manager.

The use of a water blast lessens the amount of suspended dust after firing when the air current is not sufficient to sweep dust away rapidly. It is applied after the explosion for different periods of time according to the working place. The use of a water blast quickly lessens the amount of dust in the air after firing in dead-end stopes and in open stopes with an air current of less than 20 feet per minute. The Commission recommends that these water blasts should be used after firing except in such stopes as are mentioned above. The number of water blasts to be used and the amount of water to be atomised depend on the size and situation of the working place. The water blast should be applied in such a way that finely divided water in the form of a fog is distributed throughout the whole working place affected by the dust produced at the explosion.

When ore is being filled into trucks after an explosion dust is produced. To diminish the amount of dust the ore should be kept thoroughly wet with water from a hose. A single watering is not sufficient, and water should be applied with the hose from time to time.

It has been found that a period of thirty minutes is necessary after firing (with the use of the water blast when needful) to secure satisfactory conditions in the air in respect to the amount of dust. The Commission recommends that no work be commenced in a working place until thirty minutes has passed since firing explosives in that place. This recommendation is not intended to prohibit an inspection of the result of an explosion or the entrance of a mine worker to start a water blast, or the firing of another set of holes during this period of thirty minutes. No continuous work as barring down, shovelling ore, or timbering should be resumed until thirty minutes have elapsed.

Rock drilling can be carried out in a satisfactory manner in respect to dust either with reciprocating or hammer drills. Whatever the nature of the drill, axial feed or external jet, the proper application of water will yield satisfactory results. The precautions, which are necessary, are that the face to be drilled is thoroughly wetted before drilling commences; that the face to be drilled be thoroughly wetted from time to time during drilling; that water is applied in a continuous steam in quantity not less than one gallon per minute; that water must be applied to the collar of the hole before the air is admitted to the drill; and that the water must be applied in or about the hole to prevent the issue of dust. With axial water feed drills the water must be delivered at the point of the drill before the drill is started. These precautions are covered by general rule 55 of the Mines Inspection Act, but the Commission is of opinion that many mine-workers are not sufficiently conscientious in their application. If sufficient care is used, boring is practically free from dust.

The Commission is satisfied from its tests that mining in dead-end stopes, open stopes, and square set stopes can be carried out without danger to mine-workers from pneumoconiosis if it be conducted in the manner indicated.

The Commission has devoted much attention to the problem of the removal of dust while winzes are being sunk. Owing to the differences in the locations of winzes in the mines, it has been difficult to establish uniform conditions in winzes. The Commission recommends that firing explosives in winzes be restricted to the end of shift; that an interval of thirty minutes elapse after firing explosives before work is resumed, provided that a water blast be applied to play down the winze from the top to the bottom for a sufficient period to lay the dust; that an interval of one hour elapse before work is resumed when a water blast is not used after firing explosives in the manner mentioned above, provided there is a ventilation current of air within the winze of a velocity of more than 40 feet a minute; that an interval of two hours elapse before work is resumed when a water blast is not used, after firing explosives as mentioned above, provided that the ventilation current of air within the winze has a velocity of less than 40 feet a minute; that axial water-feed drills be used wherever possible; that drilling be carried out with the precautions mentioned in respect to drilling in other situations; and that additional ventilation for men at work be provided within a winze by some mechanical means whenever the ventilation current of air within the winze has a velocity of less than 40 feet a minute, the extra ventilation being so arranged as to increase the supply of air at the bottom of the winze.

In respect to the conditions of mining recommended by the Commission to be followed in order to prevent the occurrence of pneumoconiosis, it proposed that some official, as for example the Inspector of the Department of Mines, be charged with the responsibility of determining that mining is being carried out in conformity with these recommendations of the Commission, and that adequate means be devised for enforcing compliance with them.

The Commission has investigated the ventilation of the mines at Broken Hill in respect to its effect on the temperature and humidity of the mine workings, on the removal of fumes produced by explosives, and on the removal of dust produced in the various operations of mining. It has not had an

opportunity

opportunity of examining the whole of the mines, but has become familiar with the conditions of the British Mine, Central Mine, North Mine, South Mine, and Zinc Corporation Mine. The conditions in these mines do not differ greatly from those in the mines not at work while the Commission was making its observations at Broken Hill.

In all the mines examined, the supply of air was ample for all respiratory purposes, and sufficient to prevent any accumulation of expired carbon dioxide; the supply of air was also sufficient to ensure satisfactory conditions of humidity and temperature in the working places in the mines.

The Commission is of opinion that the general systems of ventilation operating in the mines examined by it during the twelve months in which these mines were at work and during which the Commission was making its observations are satisfactory.

In general, the mines are ventilated from the lower levels, the air passing gradually to the higher levels, to which some additional supplies of fresh air may be led, while the air is ultimately drawn into the up-cast shaft from one of the upper levels. Dependent on the external temperature, the air at the down-cast shaft in the lower levels has a temperature varying from 60° F. to 70° F., with a water content of 2 to 3 grains per cubic foot. The temperature of the air rises as it passes along drives and cross cuts to the working places, where the temperature varies from 70° F. to 80° F., with a water content from 5 to 6 grains per cubic foot. As the air travels through the workings its water content rises to 7 or 9 grains per cubic foot. In the upper levels, in which very few men were working during the period in which the Commission was making its observations, the temperature rises over 80° F., and may reach 87° F. in the neighbourhood of the up-cast shaft. The water content of the air did not, however, increase in the dry, practically unused, upper levels. In the working places the humidity of the air was over 90 per cent. saturation, with water vapour. The temperature of a working place in any level is inversely proportional to the amount of air passing through it. Places in which the cubical content was low, and the current of air of low speed, possessed higher temperatures than stopes of large cubical content. In places where the humidity was 90 per cent. saturation with water vapour and over, the Commission found no impairment of the working efficiency of men at temperatures below 80° F. (dry bulb). Above this temperature miners removed part of their clothing while at work. Test measurements of the amount of work performed by mullockers working at a temperature of 83° F. (dry bulb) and over 90 per cent. saturation with water vapour with little clothing showed no diminution from the amount of work performed by the same men clothed at 70° F. (dry bulb) and over 90 per cent. saturation with water vapour; but the Commission is of opinion that continuous heavy work at this temperature would be harmful to health. The Commission wishes to emphasise the economic advantage of working at lower temperatures. While it may not be possible to eliminate working places with temperatures of over 80° F. and with a humidity of 90 per cent. saturation with water vapour during the extension of the area in which mining is conducted, every effort should be made to provide, as early as possible, through ventilation in sufficient quantity to lower the temperature below 80° F. (dry bulb).

The Commission finds that the gases generated by the use of explosives circulate with the air currents from the workings in the lower levels upwards through the workings of the higher levels. Its recommendations that, except under urgent circumstances as already specified, firing of explosives be restricted to the end of the shift, and that no person enter into working places for thirty minutes after firing explosives, ensure that a sufficient interval of time will exist during which the ventilation air current will sweep out these gases from the mines. The Commission has found no evidence of any injury to health among underground workers produced by the fumes arising from explosives. Temporary disablement arising among miners as a result of the inhalation of fumes from burning explosives may, however, occur from time to time.

The Commission regards the ventilation of the mines as the most important factor in the removal of dust. It has been found that, wherever the velocity of the air current in a working place exceeds 20 feet a minute the amount of dust suspended in the air is not sufficient to give rise to pneumoconiosis. It recommends that the workings of the mines be laid out to ensure, as far as possible, a velocity of 20 feet a minute within them. In large stopes this velocity is not attainable. Dependent on the dilution of the concentration of dust by the large volume of air, the Commission finds that the passage of 5,000 cubic feet a minute past any working place is sufficient to prevent the accumulation of dust in the air during the conduct of mining operations. These air currents are not sufficient to prevent the accumulation of dust in the immediate neighbourhood of drilling operations not adequately supplied with water, nor in close proximity to heaps of dry ore being shovelled about. As already mentioned, water must be used to assist in keeping down dust in these operations. The Commission suggests that by a judicious use of stoppages, brattices and doors, the air-currents in the workings of the mines can be distributed with the desired velocity, except during extension operations and in dead ends.

The Commission finally recommends that systematic sampling of the dust conditions of various working places be continued, and that records be kept of the results of these tests, together with readings of the temperature, humidity, and cooling power of the air.

From these records it will be possible to obtain information as a result of which variations and improvements in the working conditions may be introduced at the direction of the mining inspector or other official placed in control of mining conditions.

HENRY G. CHAPMAN.
S. A. SMITH.

31st May, 1922.

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Interim Report *re* Distribution of Dust.

THE Technical Commission of Inquiry has almost completed its study of the distribution of dust in the air of the mines at Broken Hill. In the course of its investigation it has observed the conditions under which the amount of dust in the air of the mines is reduced to a minimum during certain of the operations of mining. As it seems possible that there will be shortly an extension of the mining undertaken at Broken Hill, it appears to be desirable to furnish you with an interim report on these matters. A brief summary of the results of some of the tests is added to this report.

The Technical Commission has been led to the opinion that the amount of dust present in the air of the mines during the hours at which mine workers are engaged below the surface is so reduced that the quantity of dust taken into the lungs is no longer sufficient to give rise to pneumoconiosis, provided :—

(1) That the firing of explosives takes place at the end of shift except as mentioned hereinafter ;

(2) That a water blast is used after firing explosives, except in an open stope with an air current moving through it with a speed of 20 feet a minute or more and in a square-set stope with through ventilation ;

(3) That an interval of thirty minutes elapse after firing explosives before work, such as shovelling ore, boring and charging holes, or timbering be resumed in a working place ; and

(4) That the boring of holes with drills is undertaken with the precautions enumerated hereinafter.

Owing to the system of ventilation, it would appear that, as far as practicable, firing explosives should take place at the end of each shift. It will be recognised that occasionally in bad ground, or to put in timber, or in a development end, it may be urgently necessary to fire without waiting for the end of the shift. Further, it may be advantageous to break up a large mass of ore which delays further operations with a small quantity of explosive. As the Commission considers that such firing should only take place after due consideration, it recommends that no firing should be allowed except at the end of shift unless special permission in writing be given for each firing by the officer in charge of each working place. The permit should state the reason for departing from the general rule, and a duplicate copy of the permit should be lodged the same day at the office of the underground manager.

The use of a water blast lessens the amount of suspended dust after firing when the air current is not sufficient to sweep dust away rapidly. It is applied after the explosion for different periods of time, according to the working place. The use of a water blast quickly lessens the amount of dust in the air after firing in dead-end stopes and in open stopes with an air current of less than 20 feet per minute The Commission recommends that these water blasts should be used after firing, except in such stopes as are mentioned above. The number of water blasts to be used and the amount of water to be atomised depend on the size and situation of the working place. The water blast should be applied in such a way that finely divided water in the form of a fog is distributed throughout the whole working place affected by the dust produced at the explosion.

When ore is being filled into trucks after an explosion dust is produced. To diminish the amount of dust the ore kept should be kept thoroughly wet with water from a hose. A single watering is not sufficient, and water should be applied with the hose from time to time.

It has been found that a period of 30 minutes is necessary after firing (with the use of the water blast when needful) to ensue satisfactory conditions in the air in respect to the amount of dust. The Commission recommends that no work be commenced in a working place until thirty minutes has passed since firing explosives in that place. This recommendation is not intended to prohibit an inspection of the result of an explosion, or the entrance of a mine worker to start a water blast, or the firing of another set of holes during this period of thirty minutes. No continuous work, as barring down, shovelling ore, or timbering, should be resumed until thirty minutes have elapsed.

Rock drilling can be carried out in a satisfactory manner in respect to dust either with reciprocating or hammer drills. Whatever the nature of the drill, axial feed or external jet, the proper application of water will yield satisfactory results.

The precautions which are necessary are that the face to be drilled is thoroughly wetted before drilling commences ; that water is applied in a continuous stream in quantity not less than 1 gallon per minute ; that water must be applied to the collar of the hole before the air is admitted ; and that the water must be applied in or about the hole to prevent the issue of dust. With axial water feed drills the water must be delivered at the point of the drill before the drill is started. These precautions are covered by general rule 55 of the Mines Inspection Act, but the Commission is of opinion that many mine workers are not sufficiently conscientious in their application. If sufficient care is used, boring is practically free from dust.

The Commission is satisfied from its tests that mining in dead-end stopes, open stopes, and square-set stopes can be carried out without danger to mine workers from pneumoconiosis if it be conducted in the manner indicated.

HENRY G. CHAPMAN.
S. A. SMITH.
W. A. EDWARDS.

3rd November, 1921.

SUMMARY

SUMMARY of Results of Tests.

Place.	Class of Work.	Remarks.	Dust mgm. per c. metre.
Dead-end stope	Firing	With water blast	5·1
,,	Filling ore		1·0
,,		Entering air	1·2
,,		,,	0·8
,,	Drilling		1·0
,,	Filling ore		2·0
,,	,,		1·1
,,	Drilling		5·5
,,	Firing with water blast	One hour later	1·27
,,	,,	Two hours later	0·82
,,	,,	One hour later	0·75
,,	Firing with water blast and two men shovelling.	Two hours later	1·0
Open stope	Drilling		0·6
,,	Filling ore		2·2
,,	,,		0·3
,,	,,		0·4
Overhead square set	,,		1·0
,, ,,	,,		0·7
,, ,,	Firing with water blast	10/40 min.	1·7
,, ,,	,, ,,	30/100 min.	1·66
,, ,,	Firing without water blast	10/40 min.	2·82
,, ,,	,, ,,	30/90 min.	2·8
,, ,,	Filling ore		0·66
Downcast air			0·02
Upcast air			Nil.
,,			Nil.
Square set dead-end	Filling ore		0·8
,, ,,	,,		1·0
,, ,,	Drilling		2·94
,, ,,	,,		7·04
,, ,,	,,		2·08
,, ,,	,,		3·12
,, ,,	Filling ore		1·36
,, ,,	,,		1·6
,, ,,	Drilling		4·01
,, ,,	,,		4·6
,, ,,	,,	Axial waterfeed	1·00
,, ,,	,,	,,	1·9
,, ,,	Firing with water blast	30/60 min.	1·3
,, ,,	,,	60/90 min.	1·3
Open stope	Drilling		2·48
,,	,,		0·47
,,	,,		1·08
,,	,,		1·15
,,	,,		0·84
,,	,,		4·4
,,	Firing with water blast	5/35 min.	3·1
,,	,, ,,	35/65 min.	5·4
,,	,, ,,	65/125 min.	1·29
,,	,, ,,	7/37 min.	40·0
,,	,, ,,	37/97 min.	1·07
,,	,, ,,	5/35 min.	3·00
,,	,, ,,	35/95 min.	0·53
,,	,, ,,	7/37 min.	38·4
,,	,, ,,	37/97 min.	2·2
Dead-end (with slight through current)	Firing without water blast	5/35 min.	49·0
,, ,, ,,	,, ,,	35/65 min.	1·7
,, ,, ,,	,, ,,	8/38 min.	138·0
,, ,, ,,	,, ,,	38/68 min.	1·63
,, ,, ,,	,, ,,	68/128 min.	1·00
Same dead-end without through current	Firing without water blast	2/100 min.	69·0
,, ,, ,,	,, ,,	100/145 min.	15·0
,, ,, ,,	Firing with water blast	3/35 min.	24·0
,, ,, ,,	,, ,,	16/76 min.	5·0

Sydney: John Spence, Acting Government Printer—1922.