SILICOSIS IN GREAT BRITAIN

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Introduction

The aim of this paper is to bring within review the industries and processes in which the workers are exposed to the inhalation of silica dust. Throughout, the use of the word " silica " has been confined to the dioxide of silicon, SiO_2, as it occurs free in nature in the form of quartz, flint, chert, etc. Although materials are dealt with which contain free silica mixed with other substances either naturally, as in granite, or artificially, as in earthenware, no substance is regarded as coming within the scope of this paper in which the silica is wholly united with other elements in chemical combination. It is necessary to make this limited application of the word " silica " quite clearly understood, because the compounds known as silicates will, sooner or later, have to be studied systematically as the causes of pulmonary disease in industry. There is abundant evidence already that the silicates cannot be regarded as a single group showing a uniform effect on the pulmonary tissues and producing the same results of disablement and death of those affected. There is also sufficient evidence to show that the action of the silicates is different from that recognised as typical of the action of free silica.

One of the problems raised by bringing together facts such as are grouped in this paper is that relating to the action on the lungs of mixed dusts. While it appears to be true that free silica tends to produce its characteristic effects whether inhaled alone or in admixture with other dusts, it seems equally true that its action is influenced to a greater or less extent by such dusts. When the accompanying dusts happen to be silicates which are capable themselves of producing effects, the resulting changes in the lung tissues, the influence on function and the reaction to infections become extremely complicated.

The need for close investigation of all the possible circumstances in which these dusts produce destruction of function is emphasised by observation of the cases of disablement and death which are brought to light at the present time, more or less by hazard.

The principal facts regarding the action of silica are generally accepted, but we are still far from being able to explain the apparently unequal results of exposure to the inhalation of even unmixed silica dust. To gain a better understanding of this problem it is necessary to place side by side as much of the evidence as can be brought together, from all sources where the problem exists.

The scope of this paper is confined almost entirely to matters which have come to the notice of the writer as Medical Inspector of Factories in the Factory Department of the Home Office. In the sections on mining, material has been supplied and guidance given by Dr. S. W. Fisher, H.M. Medical Inspector of Mines, whose help is gratefully acknowledged.

A number of dust-counts have been included in this paper. These have been made during various investigations within the last eight years. The instrument used for collecting the samples was Owens' jet dust-counter, and for counting, a microscope giving a magnification of from 900 to 1,000 diameters was used. In all cases, unless otherwise stated, all particles over about half a micron in size are included in the total count. In most cases an estimate is given of the proportion of the total number of the particles which appeared to consist of the dust under investigation, as distinguished from soot particles which constitute the greatest difficulty in accurate counting in most of these cases. The technique employed is similar to that described in the *Annual Report of the Chief Inspector of Factories, 1922* [1].

Each industry or process has been dealt with as far as possible under the following heads: definition; distribution geographically; employed persons; operations and processes at which silica dust is liable to be inhaled; special character of the silica dust and reference to other dusts and other modifying conditions as to the form and concentration of dust in the atmosphere; evidence of silicosis being produced; methods of prevention and special legislation; compensation.

The industries and processes include (1) refractory materials; (2) grinding of metals; (3) sandstone; (4) granite; (5) slate; (6) coal mining; (7) tin mining; (8) pottery; (9) sand blasting; (10) silica milling; (11) scouring powders; (12) flint crushing; (13) flint knapping; (14) millstone dressing.

References to the literature and official papers are given at the end of each section.

General Bibliography

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[1] Cf. General Bibliography, No. (7).

(7) " Investigation into the Dust Content of the Atmosphere of Workplaces in the Grinding of Metals and Cleaning of Castings. " By E. L. MIDDLETON, M.D., D.P.H. *Annual Report of the Chief Inspector of Factories for 1922.* His Majesty's Stationery Office, 1923.

REFRACTORIES INDUSTRY

For the purposes of legislation it has been necessary to define this industry, so far as the use of silica is concerned, in its limited sense. For this purpose the term " refractory materials " refers to materials used in the construction of furnaces, flues, crucibles, etc., on account of their resistance to heat, when they are subjected to the cutting action of flue gases, the influence of slags, and of sudden changes in temperature[1]; and in the making of moulds in which metals are cast. They contain over 80 per cent. of silica.

The refractory materials in the raw state consist of silica rock of high silica content, usually from 92 to 98 per cent. They include ganister, quartzite, siliceous sandstone, quartz-schist or conglomeratic quartzite [2]. Natural sand, flint and chert also may be used.

Distribution

These materials are widely distributed throughout this country. The chief sources of supply are Yorkshire, Derbyshire, Cheshire, North and South Wales, Durham and the south of Scotland, that is to say, in the coal measure districts. In the majority of cases the materials are manufactured near the spot where they occur in the quarries and mines.

Employed Persons

About 3,000 persons are employed at present in the industry, of which about 5 per cent. are women.

Processes

Various processes, from the quarrying or mining of the raw material to the handling of the finished product, may give rise to dust.

The raw material may be in the form of natural sand, as from the pocket clays of Derbyshire and deposits in the south of England. In getting out this material from the quarries or sandpits, the exposure to silica dust, though by no means absent, is relatively slight, for two reasons: (*a*) the grains of sand are of too large a size

[1] Cf. Bibliography, No. (1).
[2] Cf. Bibliography, No. (2).

to be inhaled; (*b*) there is always moisture present, from about 5 to 15 per cent., which fixes the finest particles. In addition to the action of the moisture, aggregation is assisted by the presence of a pellicle of kaolinitic material—of considerable importance from the health point of view since even when the material has been dried, crushed and made up into bricks, there remains a tendency for the minute particles to adhere so as to form aggregates too large to be inhaled. This protection, however, is only partial, and counts of atmospheric dust taken with Owens' dust-counter, for example, at making silica bricks and setting bricks in the kiln, show 1,000 to 3,000 particles per c.c. of air.

Quarrying and mining of solid rock involves definite exposure to silica dust, even when the surface of the rock is wet. Drilling, blasting and breaking with hammers, are always attended by the liberation of much fine dust. In these processes the action of the wind in removing the dust from the breathing point of the worker is one of the most important safeguards. The processes of crushing, grinding and sieving, which are usually carried on in more or less open sheds; mixing the materials into a plastic form for the manufacture of bricks and the subsequent manipulation by hand in moving the bricks to and from the drying floors, are attended by evolution of dust. Setting the dried bricks in the kilns is one of the most dangerous processes in the industry, and it is extremely difficult to solve the problem of dust suppression, since the use of moisture or exhaust draught is practically impossible. The use of a respirator for this process, if a suitable one could be devised, standardised to protect even to 50 per cent. efficiency, would be a useful measure, possibly with alternation of occupation, though this is a specially skilled job with ordinary kilns. The solution of the problem probably lies in the use of kilns which do not have to be entered and in which no skill is required.

Evidence of Silicosis being Produced

From 26 February 1911 to 18 December 1916, 36 deaths of ganister workers in the Stocksbridge district of Yorkshire showed 24 deaths due to phthisis and "ganister" disease; other respiratory diseases accounted for 5 deaths.

The Reports of the Medical Board of the Refractories Industries (Silicosis) Scheme show cases of silicosis or silicosis with tuberculosis certified from the time of appointment of the Medical Board in May 1925 to the end of 1928, as follows:

TABLE I

Period	Without impairment of capacity	With impairment	Total disablement	Death	Suspended for tuberculosis only
1 May 1925 to 31 December 1926	6	55	10	15	2
1 January 1927 to 31 December 1927	4	27	6	20	4
1 January 1928 to 31 December 1928	4	25	6	18	2

Records of 18 post-mortem examinations of the fatal cases in 1928 show that 9 were certified due to silicosis and 9 to silicosis with tuberculosis.

Of the former group the average age was 59 years and the average period of employment in the refractories industries was 22.6 years. In the latter group the average age was 49½ years and the average period of employment 17.6 years.

A complete description of the pathology of a ganister miner's lung, affected by silicosis with tuberculosis, is given in the *Annual Report of the Chief Inspector of Factories, 1900*, pages 487 to 494, with illustrations and chemical analysis of the ash. The amount of inorganic ash found in two samples formed 3.20 and 3.01 per cent. of the weight of dried lung. Silica, present as SiO_2, was 24 and 36 per cent. respectively of the inorganic ash, the remainder being chiefly iron, aluminium and calcium.

Prevention

Reference has already been made to the subject of prevention in this industry. For mining and quarrying with pneumatic drills, water supplied through the hollow drilled steel is a partial remedy. Suction with collection in a specially constructed bag filter is applicable. At crushing, grinding and other processes with the use of machinery, efficient exhaust draught combined with the use of water or steam spray, is nearly always possible. Moving materials on drying floors and to and from kilns is very difficult to control and calls for constant vigilance and cleanliness.

Refractory Materials Regulations have been in force since April 1919. They provide for suppression of dust on the lines indicated.

Compensation

The first scheme of compensation for silicosis was made for the refractory industry in 1919, under the Workmen's Compensation (Silicosis) Act, 1918, and came into operation on 1 February 1919. From that date until the end of 1928 awards of compensation have been made in 423 cases, including 121 cases of death. The present scheme, made under the Workmen's Compensation (Silicosis) Acts, 1918 and 1924, came into force on 1 May 1925. It provides for a Medical Board for the purposes of certification and periodic medical examinations.

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Grinding of Metals

In relation to silicosis the processes concerned in the grinding of metals are confined to those in which grindstones composed of natural or artificial sandstone are used.

The grinding of metals may properly be said to include, in addition to the actual grinding, those processes incidental to it which are carried on at the factory where the grinding takes place; these are: (1) racing, (2) hacking, and (3) rodding or scaring of the grindstones.

Distribution

The principal divisions of the industry and the chief centres at which they are carried on are as follows: (*a*) steel knives and forks, scissors, razors, surgical instruments—Sheffield; (*b*) saws, knives for plantation work, metal cutting and woodworking, reaper sections, chisels, augers, screwdrivers and similar tools—Sheffield, Birmingham and Glasgow; (*c*) scythes, sickles and shears—Sheffield and Worcestershire; (*d*) edge tools—Birmingham district and Sheffield; (*e*) files—principally Sheffield, also other engineering centres; (*f*) textile machinery and components—throughout Lancashire and Yorkshire, also in Cheshire, Scotland and Belfast; (*g*) stoves, grates, ranges—principally Falkirk, also various other districts; (*h*) locomotive parts—principal railway centres.

Grindstones are obtained chiefly from the millstone grit sandstones from Derbyshire and the Sheffield and Newcastle districts.

Employed Persons

Reports compiled for January 1926 showed the persons employed on grindstones to be 3,710. In addition, some 3,600 persons were employed in other processes within a radius of 20 feet from the grindstones.

The figures for the different trades are as follows:

TABLE II

Trade	Number of stones	Numbers employed	
		Grinders	Others in proximity
Cutlery: Sheffield	880	882	510
Other districts	107	93	100
Edge tools: Sheffield	623	660	400
Midlands	303	282	131
Other districts	166	145	200
File grinding: Sheffield			
hand	200	120	—
machine	130	110	—
Textile machinery	550	471	583
Locomotive and general engineering	378	369	824
Stoves, grates, etc.	163	148	162
Foundries	147	153	286
Miscellaneous	292	277	389
	3,939	3,710	3,585

Since the time these figures were prepared, there has been a considerable increase in the number of manufactured abrasive wheels brought into use to replace sandstone wheels. This of course has the effect of removing the workers on these grindstones from processes under review and therefore from the risk of silicosis, properly so called, although the latent liability to the disease from exposure in the period of employment remains.

The Inspector of Factories in Sheffield reports that a rough census of the number of grindstones in use in Sheffield in 1926 and in 1929 records a notable change towards the artificial wheels during the three years. The numbers are:

	1926	1929
Cutlery and edge tool trades	1,540	654
Miscellaneous grinding (by hand) . .	70	8

An estimate of the number of grindstones and artificial abrasive wheels in use at the end of 1929 is as follows:

	Grindstones	Artificial wheels
Hand grinding cutlery and edge tools	468	966
Machine grinding circular saws. . .	31	13
Machine grinding files.	104	5
Machine grinding long saws	51	8
	654	992

Operations and Processes

Males only are employed on grinding on sandstone. In the Sheffield trades the hand-grinders serve a term of apprenticeship commencing just after school age. Machine-grinding is done by men who have worked for a time at hand-grinding or some other trade. Occasionally racing of grindstones is done by labourers, but usually it is done by the grinders themselves.

For the purpose of this paper reference is made only to grinding when mechanical power is used in moving the grindstone. In a few factories, in the Sheffield district especially, water power is used; in the great majority of cases steam or internal combustion engines are used.

Grinding may be done wet or dry, and the metal being ground may be moved by hand or by mechanical power on a machine. In wet grinding, the grindstone is mounted on a horizontal shaft, and water is laid on from a tap or spray above the stone, or the lower part of the stone dips to a small extent into a trough beneath it containing water. It is sometimes contended by grinders that the grit which collects in the water of the trough from attrition of the stone is necessary for the process, but in some cases the trough is drained, the water being laid on at the top of the stone. The wet grit mixed with particles of metal produced in grinding is known as " swarf ".

In wet hand-grinding the grinder sits on a heavy saddle-shaped stool called the " horsing ", or straddles on a suspended board. He exerts considerable pressure on the metal which he holds in his hands, or when a suspended board is used a metal piece on the front of this is used to increase the pressure. Except in a few special kinds of grinding, the grindstone revolves in a direction away from the grinder. In wet hand-grinding localised exhaust draught is only rarely provided.

In dry hand-grinding the metal parts being ground are usually of small size, and localised draught is always provided. The grindstones revolve either towards or away from the grinder, depending on the class of work.

Wet grinding is also done by machines, especially in the manufacture of files, saws, large machine-knives and reaper-knives. In this form of grinding the metal being ground is fixed in a part of the machine which moves under or across the revolving grindstone.

The processes of dressing the grindstones are very important from the health point of view, on account of the amount of dust produced. They are " racing ", that is, trueing the surfaces of the grindstone before it is brought into use for the first time; and " hacking " and " rodding " or " scaring ", which are processes of dressing the grinding face of the stone and are carried out frequently in the course of a day's work.

Characters of the Silica Dust

Attrition of the grindstone occurs in all processes in the grinding of metal, and varies in amount with the consistence of the stone, the hardness of the metal, the shape of the article being ground, and the amount of force exerted, and thus depending on the extent to which the stone is cut in the process. Dust is produced as a result of this attrition; its composition corresponds with that of the grindstone, with some added particles from the metal articles being ground. It is doubtful if the metal particles are inhaled in any substantial amount, as they are present only to a very small extent in atmospheric samples of dust.

The amount of dust produced varies within very wide limits in different classes of grinding, and under varying conditions. Gravimetric estimations show that in steel table-blades wet hand-grinding, for example, from 88 to 220 milligrams of dust per 10 cubic metres of air were present in the atmosphere at breathing level. Numerical estimation with Owens' dust-counter shows as an example of a high count at hand-grinding of scythes, 3,205 particles in 1 c.c. of air (in a district where other dusts were at a minimum). Even higher counts are obtained at the processes of racing and " scaring ". These counts include dust which occurs as free particles in the atmosphere. In addition, dust contained in droplets of moisture, that is, " swarf ", are also potential sources of danger when they become dry. An example of the amount of dust contained in a droplet was obtained by counting the particles deposited on a microscope cover-slip in wet hand-grinding table-knives. The dry deposit from the droplet measured 2 millimetres in diameter and the particles composing it numbered, by counting and calculation, 4,383. They appeared to consist entirely of particles from the grindstone and measured from 24 μ down to the limit of visibility under a magnification of 900 diameters.

The size of the particles produced in the grinding of metals on sandstone wheels and found in the atmosphere at the breathing level of the worker, is found by the microscopic examination of samples taken with Owens' dust-counter. As a rule the samples show that from 90 to 97 per cent. of the sandstone particles are under 2 μ in greatest diameter, i.e. are capable of being inhaled into the alveoli of the lungs.

The grinding of metals on sandstone wheels has been recognised for generations as a cause of silicosis and increased mortality from tuberculosis. Especially in Sheffield " grinders' rot " has been notorious and past records of that city show the effects of this on the mortality rates [1].

Statistics are not available for silicosis as a separate disease, but reference is continually made to high mortality rates from tuberculosis. In the city of Sheffield such statistics are kept very carefully with reference to the occupation, so that figures from that city may be quoted.

For the five years 1923 to 1927, the numbers of deaths of grinders from pulmonary tuberculosis were 34, 35, 31, 28 and 38. On the basis of the Census of 1921 this gives mortality rates per 1,000 grin-

[1] Cf. Bibliography, No. (1).

ders living of 6.9, 7.2, 6.3, 5.7 and 7.8, contrasted with rates amongst all persons over fifteen years of age of 1.2, 1.1, 1.1, 1.0 and 1.0 respectively.

These figures agree closely with those of an investigation carried out at the Sheffield Municipal Tuberculosis Dispensary into the particulars relating to all persons over the age of fifteen who died during 1919 and 1920 of pulmonary tuberculosis and who had been examined by the tuberculosis staff and the diagnosis confirmed by them. The mortality rate for grinders in this series was 7.02 per 1,000 living while the rate in the general population of Sheffield was approximately 1.0 per 1,000 living.

Dr. Rennie, Chief Tuberculosis Officer for the city of Sheffield, has provided data which show that in 1928, 25 grinders died of silicosis with or without tuberculosis, and in 1929 (1 January to 22 November) 29 died from these causes. The average age in 1928 was 49.4 years and in 1929, 54.8 years.

The following table includes particulars of 11 fatal cases, which have come to the notice of the Factory Department and in which the diagnosis has been verified by post-mortem examination:

TABLE III

No. (1)	Age (2)	Industry (3)	Occupation (4)	Period of employment (5)	Duration of symptoms (6)	Period of disablement (7)	Cause of death (8)	Remarks (9)
				Years				
1.	45	Textile machinery	Grindstone dresser	10	20 months	8 months	Silicosis and tuberculosis	Left lung weighed 36 ozs. Right lung weighed 28 ozs.
2.	54	Edge tools	Grinder	32	20 years	3 weeks	Silicosis and tuberculosis	Died of hæmoptysis
3.	44	Files	Hand-grinder	30	1 year	6 months	Silicosis and tuberculosis	
4.	38	Files	Hand-grinder	24	6 years	8 months	Silicosis and tuberculosis	Died of hæmoptysis
5.	51	Iron foundry	Grinder of castings	29	2 years	16 months	Silicosis and tuberculosis	
6.	59	Cutlery	Table-blade grinder	46	5 months	1 month	Silicosis and tuberculosis	Tuberculosis of knee at time of death
7.	38	Edge tools	Grinder	18	11 months	4 days	Acute pneumonia and silicosis	X-ray showed silicosis 13 months before death
8.	60	Files	Hand-grinder	35	2 years	6 months	Silicosis and tuberculosis	
9.	52	Files	Hand-grinder	30	—	13 months	Silicosis and tuberculosis	Tuberculous meningitis at time of death
10	64	Edge tools	Grinder	35	2 years	2 months	Silicosis and tuberculosis	
11.	53	Textile machinery	Grinder	—	4 years	11 weeks	Silicosis and bronchitis	Did much "racing" of grindstones

Characters of the Disease

"Grinders' rot", the name formerly given to the silicosis occurring in metal grinders on sandstone, is a type frequently associated with tuberculosis. The period of exposure required appears to vary much with the concentration of the dust in the atmosphere.

A grindstone dresser who was employed in a large textile machinery factory, dressing about seventy stones a week, died of silicosis with tuberculosis after six years of the work, that is, over a period of ten years, four of which were spent in the army.

In the case of grinders, who do their own racing and dressing of the stone, the duration is usually from twenty to forty years, commonly about thirty-five years.

There appear to be two types of the disease: one in which tuberculosis supervenes, the commoner form, and a non-tuberculous type in which pneumonia, oedema of the lungs and heart failure occur. The first form usually shows only a short period of symptoms before the onset of tuberculosis, which usually runs a rapid course, and is frequently marked by severe haemoptysis. In the second form, symptoms appear later in life with increasing dyspnoea, while the clinical examination discloses greatly diminished air entry in the lungs, especially the bases.

The morbid anatomy of the two types is rather distinctive. In the common tuberculous form, there are large irregular areas of consolidation showing more or less caseation and breaking down. Usually there remains some lung tissue relatively free from tubercle and in this the nodules of fibrous tissue can be made out. The pleuræ are densely and extensively adherent. In the non-tuberculous form the lungs are usually bulky, studded throughout with fibrous nodules, often discrete and with the intervening tissue showing emphysema and pneumonic change. The pleural surfaces are covered with discrete whitish nodules.

Methods of Prevention

There are two codes of Regulations made under section 79 of the Factory and Workshop Act, 1901. One of these codes, the Grinding of Metals (Miscellaneous Industries) Regulations, 1925, came into force on 1 November 1926, except that in certain of these Regulations involving structural alterations application was deferred for a period of two years. The other code, the Grinding of Cutlery and Edge Tools Regulations, 1925, came into force on 1 January, 1926, except that the application of Regulations requiring certain structural alterations was deferred until three years later. So far as they are concerned with suppression of dust in the grinding of metals and dressing of grindstones, the provisions of the two codes are similar, that for the cutlery and edge tools being generally somewhat more stringent. These two codes replace a single code of Regulations which came into force on 1 December 1909. The requirements of the Regulations are as follows:

(1) A hood and duct with localised exhaust draught must be provided for all racing, dry grinding or glazing.
(2) Racing must be done in a separate room in cutlery and edge tools shops, excepting shops in use before January 1926. In these shops it is allowed to be done when no other work is going on in the shop, provided the shop is cleaned before work is resumed.
(3) General exhaust and inlet ventilation must be provided, adequate to secure a continuous movement of air from the grinder and to renew the air of the room, twelve—in the case of cutlery and edge tool shops, fifteen—times per hour.
(4) Wet grinding must be carried on in a separate room from glazing or other processes.
(5) An adequate supply of water is required for "hacking" and "rodding", or alternatively adequate provision for intercepting the dust.
(6) The rooms must be of a certain minimum height, windows must be adequate, properly glazed and kept clean.
(7) Floors and walls must be so constructed as to be capable of being cleaned, and all belts, shafts, etc., efficiently covered.
(8) There must be adequate drainage for water.
(9) All floors, walls, ceilings and fixtures must be cleaned periodically.
(10) Spitting is prohibited.
(11) Cloakroom accommodation must be provided.
(12) Grindstones must not be less than the prescribed distance apart.

Since these Regulations came into force considerable success has followed efforts to attain improvement in the methods of dust suppression in both the racing of grindstones and in grinding of metals. Two inventions have been introduced for removing dust at racing of grindstones, which provide powerful suction downwards through the trough over which the grindstone is hung. In one case the process is done dry and the dust is removed by a short wide duct to a portable bag filter. The efficiency of the localised exhaust apparatus appeared to be of a high order when tested by atmospheric air samples, as it effected a reduction in the number of stone particles from about 5,000 to 800 in a cubic centimetre. The other arrangement consists of a copious supply of water laid on at the point of contact of the racing tool and the provision of an exhaust duct connected up with a main exhaust trunk. The application of the exhaust downwards in both cases leaves the view of the operator and his access to the grindstone unrestricted. An apparatus has been brought into use recently for providing exhaust draught in wet hand-grinding on grindstones. Tests of atmospheric dust showed a considerable reduction in the number of particles. The increasing use of machine-grinding and extensive replacement of grindstones by artificial abrasive wheels, which are more readily adaptable to methods of dust suppression, may be regarded as important factors for the future reduction of cases of silicosis in the grinding of metals.

Compensation

A scheme of compensation was made for metal grinders under section 47 of the Workmen's Compensation Act, 1925. This scheme is on different lines from those for the refractories and sandstone industries in that it applies substantially the procedure under the Workmen's Compensation Act in regard to scheduled diseases. It provides for payment of benefits only in cases of total disablement and death.

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Sandstone Industry

The sandstone quarrying and dressing industry represents perhaps the most widespread of all silicosis-producing industries. The sandstones include the sedimentary silica rocks and the industry covers all processes in getting the material from the quarry or mine and the manipulation of the material with a view to manufacture, sale, or use.

Distribution

To a great extent processes in cutting, shaping, dressing, and crushing of the stone are carried out near the places where it is got from the quarry or mine. Thus, the industry finds its most important centres in the sandstone producing districts, the northern, central and south-western countries of England, and the south and east of Scotland.

Employed Persons

About 12,000 men are at present employed in the industry in getting the stone and in processes carried on in the same premises or in the same ownership as the quarries or mines. In addition to this there are masons and others employed in masons' and builders' yards throughout the country.

Operations and Processes

The workers include rock-getters, who work at the stone face in quarry or mine; quarrymen or stonecutters who rough hew the blocks; masons who shape and carve the stone to dimensions or patterns; planers, sawyers and turners who operate stone-cutting machines; drillers with hand (pneumatic) or steam-drills; crushermen; labourers and cranemen; and builders, " fixers " or " wallers " who frequently do some dressing of the stone.

Characters of the Dust

The proportion of silica in sandstones varies from over 99 per cent. in certain quartzites. In many sandstones used for building and the manufacture of grindstones and pulpstones the silica forms from 75 to 95 per cent. of the rock. The rock consists more or less of quartz grains, mixed with a variety of other minerals and held together by a cement of varying composition and proportion. The composition, amount and hardness of the cement are important factors in determining the dangerous character of the dust produced.

In a series of 140 atmospheric dust determinations taken with Owens' dust-counter in the various processes in quarrying and dressing sandstone and granite, certain general conclusions were reached regarding the production of dust liable to be inhaled by the workers. The action of wind has the most important beneficial influence for workers employed in the open. Unfortunately the worker is not always able to stand to windward of the point of origin of the dust produced by neighbouring workers. For example, a sample taken at breathing level of a man dry drilling a quarried block of Derbyshire sandstone with an Ingersoll jack-hammer, $1^5/_8$-inch drill, gave 469 particles in 1 c.c., while another sample taken 8 yards to leeward gave 1,867 particles in 1 c.c. The stone-mason working in closed or partly closed sheds is liable to be exposed to dust produced by his neighbours as well as on his own work. Danger is increased by the practice of brushing the dry dust and debris from the surface of the stone and by blowing with the mouth while carving.

Wetting the surface of the stone by rain has some influence in diminishing dust, more especially in "getting" the stone from the quarry, but it has little effect in reducing the fine dust given off by the action of a cutting tool.

Stone-crushing plants are frequently found in quarry sites for using up rubble for making road material. At the crushers, elevators and screens, dense clouds of dust are frequently given off and travel for considerable distances, so that though few workers may be employed on the crusher-house plant, many may be subjected to the dust produced by it.

Particulars of atmospheric dust samples, taken with Owens' jet dust-counter, are given in table IV.

Evidence of Silicosis being Produced

An investigation into the occurrence of silicosis among sandstone workers was made for the Home Office by Drs. Sutherland and Bryson and a report of the investigation was published in 1929. During this enquiry 454 workers were examined clinically, and of these 266 were selected for radiological examination. The results of the examinations are collected in table V.

TABLE IV

Origin of sandstone	Process	Position	Weather	Number of particles in 1 c.c.	Percentage over 2 μ	Remarks
Newton, Elgin	Cutting wedge holes	—	Fine	216	2	Mineral particles often very fine. About 20% soot particles.
do.	Dry drilling vertical blow-hole	—	do.	457	6	Many fine particles. Soot negligible.
do.	do.	—	do.			Very sparse record — not counted.
do.	Operating planing machine	In shed	do.	198	4	At least 50% soot.
do.	Dressing sandstone with punch	Open air	do.	271	1.6	Many mineral particles very fine. About 50% soot.
Craigleith, Edinburgh	Picking wedge holes	do.	Wind, damp	1,530	1	Majority of particles are refractive. Some soot from crane engine.
do.	do.	do.	do.	1,470	1	do. do.
do.	Shovelling wet stone into cracker jaws	Open shed	—	1,217	1.3	Considerable amount of soot.
do.	Wheeling away barrow from stone breakers	Open air	Wet	1,759	0.5	Much soot, clumped at parts.
Ravelstone, Edinburgh	Picking wedge holes	Sheltered from wind	—	6,687	3.5	Practically all particles stone. Obvious dust.
Corncockle, Lockerbie, Dumfries	At "roughing" machine	In planing shed	—	173	5	Soot negligible. Some splashes.
do.	Using finishing tool	10-ft. to leeward of planing machine	—	96	2.5	Soot negligible.
Locharbriggs, Dumfries	Blowing hole clear	—	—	723	8	Some aggregates. Large number of very fine particles. No soot.
Corsehill, Annan, Dumfries	Bedding a stone with chisel	Open shed	Windy, wet	698	8	Many fine particles under 1 μ. No soot.
do.	Roughing stone in planing machine	Just outside shed	do.	64	4	A very sparse record.
Brunton, Gosforth, Northumberland	Turning up very dry grindstone	Closed shed	—	1,711	8	Some aggregates. Very little soot.
do.	Turning up grindstone (wet)	—	—	1,470	7	About 10% soot.
do.	Feeding grit to saw (wet)	Saw shop	—	—	—	Soot particles with few scattered mineral particles. Sample not counted
Henwick, Alnwick, Northumberland	Wedge holing in dry stone	—	Raining	686	4	About 50% soot. Some aggregates.
do.	Scappling stone block	—	do.	—	—	Obscured by much soot. Mineral particles scanty. Sample not counted.
do.	Feeding wet sand to saw	Saw shed	—	—	—	Soot from crane-engine. Numerous soot particles. Sample not counted.
do.	Dressing walling block with scutching hammer	—	—	72	19	Mineral particles scanty.

TABLE IV *(continued)*

Origin of sandstone	Process	Position	Weather	Number of particles in 1 c.c.	Percentage over 2 μ	Remarks
Elsdon, Northumberland	Scappling large block	Open air	Dry	614	7	Soot negligible. Very few clumps.
do.	do.	do.	do.	3,096	7	Soot not included.
do.	Cutting wedge holes	do.	do.	3,120	9	Nearly all particles discrete. Practically no soot.
do.	Drilling on rock face	Sheltered position	do.	84	13	No cloud of dust.
do.	Operating stone planing machine	—	—	33	10	Mineral particles scanty. Considerable amount of soot.
Darney, West Woodburn, Northumberland	Wet drilling sandstone	—	Dry	265	1.3	Negligible mineral particles. About 90 % soot.
do.	Making wedge holes	—	do.	1,952	0.4	About 80 % soot. Other particles mineral.
Redgate, Wolsingham, Durham	Putting moulding on dry stone with chisel	—	—	518	6	Small amount of soot.
do.	Operating planing machine	—	Dry	650	9	Very little soot. Other particles mineral.
Bankend, St. Bees, Cumberland	Dressing with 4 inch chisel	Open shed	—	—	—	Refractive particles not numerous. Sample not counted.
do.	Cutting wedge holes	Open air	—	994	4	Practically all particles are refractive. Very few soot particles.
Lazonby, Carlisle, Cumberland	Dressing a flag	do.	Wet	325	8	
Remington, Penrith, Cumberland	Bottoming race on post	Open air	Wind, raining	132	4	About 20 % soot.
Bowscar, Penrith, Cumberland	Holing in quarry bottom	do.	Some wind, raining	319	5	Large number of very fine particles. Soot negligible.
Highfield, Penrith, Cumberland	Dressing dimension block with scutching hammer	do.	Windy raining	33	3	Very sparse record.
Ousel Nest, Bolton, Lancashire	Dressing stone with punch	do.	Windy	156	7	Smaller particles down to very fine dimensions and sometimes occur in splashes.
do.	Dry drilling rock on post	do.	do.	433	5	Many particles very fine. No soot.
do.	Holing block on post	do.	do.	66	7	Some particles in clumps. No soot.
do.	Feeding crusher	do.	do.	1,132	5	No soot.
Cox Green, Bolton, Lancashire	Dry drilling	do.	Windy, dry	2,844	10	No soot.
do.	Feeding crusher	do.	do. do.	277	4	Many fine particles, some in splashes. Very little soot.
do.	Dressing stone with chisel	do.	Dry, windy	144	5	No soot.
Hall Cown, Bacup, Lancashire	Sawing	Saw machine shed	Raining	343	0.7	Not more than 10 % of count mineral. Great majority of particles soot, mostly discrete.
do.	Making kerb with chisel	Masons' shed	Raining hard	1,060	6	No soot.
Britannia, Bacup, Lancashire	Dressing kerb with chisel	Open shed	do.	951	11.0	High number of large particles. Soot negligible.

TABLE IV *(continued)*

Origin of sandstone	Process	Position	Weather	Number of particles in 1 c.c.	Percentage over 2 μ	Remarks
Endon, Kerridge, Cheshire	Cutting wedge holes	Open air	Windy	524	3	About 40 % soot.
do.	Dressing dry stone with chisel	2-men shed	—	566	8	About 5 % soot.
do.	Cutting wedge holes	Open air	Windy	222	2	Over 50 % soot.
do.	Making setts	1-man shed	—	—	—	Very sparse record and a large number of particles are soot. Not counted.
Arnagill, Masham, Yorkshire	Cutting wedge holes	Open air	Slight wind, damp	578	1.5	About 50 % soot.
do.	Cutting race on post	Sheltered position	Not raining	5,181	10	Many very fine particles and some overlapping.
Stancliffe, Darley Dale, Derbyshire	Dry drilling	—	Raining	469	2.2	Probably all the particles are derived from the stone. Very little soot (from cranes).
do.	do.	—	do.	1,867	3.6	All particles are stone. Very few aggregates.
do.	Feeding cracker	Crusher house	do.	482	2.5	50 % soot particles.
Birchover, Matlock, Derbyshire	Controlling machine for dressing grindstones (water applied)	—	—	1,144	4.3	All particles are stone.
Kalmesgate, Edinburgh	Putting head on soft freestone with toothed chisel	Open shed	Windy, wet	1,879	0.6	Very large amount of soot.
Northumberland and Durham	Putting head on sandstone with hammer and pointed chisel	do.	do. do.	2,442	3.7	About 60 % mineral, rest soot. Many refractive particles.
do.	Putting a head on hard grey sandstone with hammer and square chisel	do.	Windy	1,626	0.7	Considerable amount of soot.
do.	Putting a head on a close-grained stone with hammer and square chisel	do.	do.	1,132	7.0	Much of stone dust in aggregates.
Woodhouse, Northumberland	Planing	do.	do.	916	1.8	Stone particles less than 50 %; few aggregates.
Shawk white, Cumberland	Dressing with chisel	do.	Damp	197	11.0	All particles refractive No soot.
Shawk red, Cumberland	do.	do.	Dry	687	14.0	Many aggregates. No soot.
Remington, Penrith, Cumberland	Facing red sandstone with chisel	do.	Raining	542	4	Large proportion fine discrete particles. Soot negligible. Some aggregates.
do.	Punching stone with hammer punch-tool	do.	Light wind Raining	91	4	Soot negligible.
Endon, Kerridge, Cheshire	At planing machine	—	—	421	3	Over 50 % soot.
do.	Putting head on stone	In shed	—	927	8	Soot negligible.

TABLE V. — SUMMARY, SHOWING THE NUMBER OF WORKERS EXAMINED IN THE VARIOUS OCCUPATIONS, AND THE NUMBER OF CASES OF FIBROSIS AND OF SILICOSIS

Occupation	Clinical examinations		Radiological examinations	
	Total	Cases of fibrosis	Total	Cases of silicosis
Masons	171	122	116	57
Rock getters	65	32	33	13
Quarrymen	115	72	67	33
Planers	39	21	23	5
Sawyers	14	1	3	—
Turners	4	—	2	—
Quarry labourers	15	2	4	—
Wallstone dressers	8	8	7	4
Drillers	5	2	3	—
Crushermen	5	2	3	—
Builders	4	2	1	—
Carvers	2	2	—	—
Labourers to masons	2	1	1	—
Cranemen	5	1	3	—
Total	454	268	266	112

These figures do not represent the proportion of affected workers in the industry, because, for the purposes of the enquiry a large proportion of workers were selected with longer periods of employment, and of those selected for radiological examination a fairly high proportion showed clinical evidence of some degree of fibrosis.

Silicosis was found to arise in the occupations of mason, rock-getter, quarryman, planer and wallstone dresser. The presence of the disease was verified by radiological examination in these occupations. From the clinical evidence and from the similarity of occupation to one or other of the above, it was concluded that the carver, turner and driller are exposed to a risk of silicosis. In the case of the remaining occupations no definite evidence was obtained from radiological examination, but this does not imply that they are all free from the risk. In the occupations where silicosis was demonstrated by radiographic examination the disease appeared to become more common after forty years of age and after twenty years in the stone industry.

With regard to the varieties of stone met with during the investigation, cases of silicosis had undoubtedly been caused in some instances by one particular stone. In Derbyshire, stones of Darley

Dale, Birchover, Whatstandwell and Tansley; in Northumberland and Durham, Blaxter, Darney and Heworth; in Lancashire, Woolton, and Lancaster, and Halifax local stones; in the west of England, Bristol and Forest of Dean stones. On the other hand, no evidence could be gathered to show that there was any sandstone that could be said to be innocuous to the workman.

Although silicosis is not a reportable disease under the Factory and Workshop Acts, the Factory Department has received from time to time reports of fatal cases occurring in various industries, and especially has this been the case during 1929 owing to the action of His Majesty's Coroners in holding inquests and notifying inspectors of factories in regard to such cases. The coming into force in the beginning of that year of schemes of compensation for silicosis in certain industries has probably been another reason for bringing the matter to the notice of the Department.

Between March 1929 and January 1930, seventeen fatal cases of silicosis have occurred in which the diagnosis has been established by post-mortem examination, and particulars of which have been brought to the notice of the Factory Department (cf. table VI).

Methods of Prevention

These depend on the application of: (1) copious supplies of water or (2) exhaust draught, at the point of origin of the dust, that is, the point of contact of the cutting tool with the sandstone. An example of each of these methods is given.

(1) In dressing grindstones at a quarry in Derbyshire, a machine is used on which the grindstone is laid on a table which revolves slowly on a vertical axis. The tool is made to traverse slowly over each of the surfaces of the grindstone, and, at the point of contact a water pipe supplies water at a pressure produced by compressed air in the water tank at 70 lbs. pressure per square inch. It is not necessary for the attendant to be closely over the tool during the process. This arrangement has all the appearance of efficiently suppressing dust at the point of origin, and it is disquieting to find that an atmospheric dust sample taken at breathing level of the man operating the machine gave 1,144 particles in 1 c.c., all of which were stone particles and many of very fine dimensions, with only 4.3 per cent. over 2 μ. It appears that the dust, produced in a deep cut with great pressure as in this machine, on a hard quartzite rock, cannot be completely arrested by water alone, especially the fine particles. It is probable that exhaust draught will be necessary in addition to the water.

Another example comparing wet and dry turning of grindstones is given in table IV (Brunton, Gosforth).

At another quarry at which grindstones are made, an exhaust

TABLE VI

Occupation	District and stone	Age	Period of employ-ment	Period of symptoms	Period of incapacity	Cause of death	Remarks
		Years	Years				
Mason	South Wales (Forest of Dean and Bath stone)	41	—	Some years	8 months	Tuberculosis with silicosis	
Mason	Leeds (Yorks)	65	50	6 years	6 ,,	Silicosis plus tuberculosis	Worked in open sheds.
Mason	Stoke-on-Trent	48	32	2 ,,	8 ,,	Silicosis plus tuberculosis	
Mason	Huddersfield (Yorks)	49	33	2 ,,	18 ,,	Silicosis plus tuberculosis	Open shed or open air.
Mason (On planing machine)	Huddersfield (Yorks)	54	28	13 ,,	5 years	Silicosis	Left industry 10 years before death owing to signs of mason's disease. No evidence of tuberculosis post-mortem.
Stone planer (Quarry)	Huddersfield (Yorks)	56	40	—	None	Silicosis plus tuberculosis (hæmoptysis)	Work in machine sheds.
Mason	Chester, Cefn, Darley Dale, Brunskill, (Yorkshire)	41	23	5 years	1 month	Silicosis plus tuberculosis (broncho-pneu-monia)	Work in open. 50 % of stone sandstone; 50 % Portland stone.
Mason (pavior, railway)	Stratford (Flagstones and patent Victoria stone for station platforms)	50	21	Some years	10 months	Silicosis (broncho-pneu-monia)	Work mostly in the open.
Mason	Bristol	60	36	7 years	2 years	Silicosis with tuberculosis	
Mason	Lancaster (Lancaster and Darley Dale stones)	44	15 (from age 14 to 21 and 36 to 44)	10 months	10 months	Silicosis plus tuber-culosis (hæ-moptysis)	Silica formed 14 % of total mineral matter and iron oxide 9 % in the lung. (D. S. Ashcroft, M.B.)
Mason	Darwen (Lancashire)	59	44	A few years	3 ,,	Heart failure due to silicosis	
Quarryman stone dresser	Huddersfield (Yorks)	57	40	A few weeks	1 week	Silicosis (broncho-pneu-monia)	In open air and in open sheds.
Mason	Birmingham Hollington stone (Staffords-hire)	52	32	12 months	8 months	Silicosis plus tuber-culosis	
Mason's labourer	London (? stone)	58	? 10 (before 1906; after-wards on lime-stone)	10 years before death	2 years	Fibrosis of lungs. Sili-cosis (non-tubercu-lous)	Silicosis diagnosed by X-ray in 1906. Probable exposure to silica dust before then. History not obtainable.
Mason	Leeds (Yorkshire)	51	35	10 years	1 year	Silicosis plus tuber-culosis	
Mason	Harrogate (Yorkshire)	47	20	6 months	6 months	Silicosis	
Stone crusher-man	Leeds (Yorkshire)	49	17	—	9 ,,	Silicosis plus tuber-culosis	

apparatus is used in which the dressing tool is carried by the pivoted duct which is connected with a settling box by a flexible extension.

(2) The application of exhaust is illustrated by the apparatus designed by Captain Hay, of the Safety in Mines Research Board, for use with rock drills in mines, and adapted by him, in conjunction with His Majesty's Office of Works, to hand pneumatic tools for dressing stone [1]. The appliance for use in mines is already on the market. That for stone-dressing is demonstrated by a special exhibit at the Home Office Industrial Museum, London.

The method adopted to trap the dust is to fit, as near as possible to the cutting point of the tool, a hood through which exhaust draught is provided by an ejector provided with a jet, designed to operate off the compressed air supply. The air containing the dust from the working point is carried to a special filter bag, which, in the case of mines is suspended in the working, but in stone-dressing would be installed outside the workplace in an enclosed ventilated cabinet.

Experiments have been carried out with the dust trapping apparatus in use and the results controlled by samples taken with Owens' dust-counter. The results show that the device provides a high degree of protection. Samples taken with the device in operation gave counts up to 150 particles in 1 c.c. of air, while samples taken with the exhaust cut off gave counts of over 2,000 particles in 1 c.c. of air. A sample taken at the ventilation opening of the collecting bag cabinet indicated that only a small proportion of the finest particles of stone dust passed through the filter bag and escaped to the outside air.

These two examples do not cover all the processes in quarrying and dressing of sandstone, but they might form a basis for methods of dust suppression from which modifications for the other processes can be adapted.

Legislation in Force for Prevention

In processes in quarries where the stone contains not less than 80 per cent. of silica, a code of Special Rules made under the Quarries Act, 1894, is applied by the Mines Department [2]. This code corresponds with the Regulations for Refractory Materials under the Factory and Workshop Act, but in the case of quarries the Special Rules are applied whether the material is to be used as refractory material or not.

The chief provisions of the Special Rules are as follows:

1. Rock drilling by mechanical power to be provided by efficient water jet or other efficient means to prevent escape of dust.
2. Stone to be broken by manual labour in the open air only, and a wet canvas cloth to be used to prevent escape of dust, or suitable respirators to be provided and renewed unless the work is carried on so as not to expose the workers to the inhalation of dust.

[1] Cf. Bibliography, No. (7).
[2] Cf. Bibliography, No. (1).

3. Machines for crushing and grinding of stone (*a*) to be provided with exhaust draught and dust collecting appliances, or with efficient water or steam spray or other arrangement to prevent escape of dust; or (*b*) to be entirely enclosed.

4. In sawing, planing and turning the stone to be kept wet.

5. Workmen dressing stone not to work nearer than 6 feet from each other.

6. The dressing of stone not to be carried on in any closed shed unless exemption is granted on the ground of exhaust ventilation being provided.

Compensation

A scheme of compensation known as the Sandstone Industry (Silicosis) Scheme, 1929, came into force on 1 April 1929 and applies to all workmen employed in the sandstone industry, as defined in the scheme. For the purposes of the scheme the industry means all processes in or incidental to the getting or manipulation of sandstone with a view to manufacture, sale, or use, which are carried on at or within the close or curtilage of any mine or quarry or at any premises worked in conjunction with a mine or quarry, wherever situate.

For the purposes of the scheme, "sandstone" includes ganister, gritstone and quartzite rocks, but does not include rotten stone or natural sand.

The scheme does not apply to: (*a*) premises to which the Refractories Industries (Silicosis) Scheme, 1925, applies; (*b*) any premises not being part of a mine or quarry, for the manufacture of silica flour; (*c*) where sandstone is only occasionally worked and without explosives or mechanical power; (*d*) certain employments carried on apart from the processes; (*e*) certain processes in the manufacture of artificial stone; (*f*) any mine or quarry in which the stone worked is proved, by chemical analysis, to contain not more than 50 per cent. silica (free and combined).

This scheme is on the lines of the Refractories Industries (Silicosis) Scheme, and by it special medical provisions have been made whereby a specialist medical board carries out periodic medical examinations and examinations for certificates of compensation of all the persons to whom the scheme applies. The medical board consists of whole-time medical men with their administrative centre in Sheffield, which is a convenient centre for this and the refractories industries, which shares with this scheme the services of the same Medical Board. Subsidiary centres of the Board are established at Bristol and Newcastle-on-Tyne.

The scheme provides for compensation in cases of partial and total disablement or death due to silicosis and silicosis with tuberculosis.

Those workmen in the sandstone industry who are not employed in or in connection with a mine or quarry are not included under the Sandstone Industry (Silicosis) Scheme. For these workmen provision is made under the Various Industries (Silicosis) Scheme, 1928, which is on the lines of the Metal Grinding Industries (Silicosis) Scheme, 1927, which provides for compensation in cases only of total disablement or death.

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Granite Industry

The granite quarrying and dressing industry may be regarded as including all processes in getting the material from the quarry and manipulation of the material with a view to manufacture, sale, or use.

Granites and allied rocks of igneous origin are characterised by a crystalline structure, more or less apparent, and a certain hardness or toughness which demands special methods for quarrying them and adapting them for use. From the point of view of the production of silicosis it is important to distinguish the true granites, or acid igneous rocks, from the intermediate and basic igneous rocks, having regard to the proportion of free quartz in their composition.

Distribution

True granites are found in Cornwall and Devon, the Lake district of England, and in several districts in the west and north of Scotland. Other igneous rocks, resembling granite, are distributed in many parts of England, Wales, and Scotland. The processes are carried on for the most part at or near the district in which the rocks are quarried.

Operations and Processes

The occupations in the granite industry may be classified, for the present purpose, as follows: labourers, getters, drillers, settmakers, kerb-dressers, crushermen, building masons, monumental operatives, polishers.

(1) *Labourers* are unskilled workers employed in removing overburden, loading and filling granite, and they may assist in blocking, or getting, or drilling.

(2) " *Getters* " are skilled quarrymen who get the granite from the quarry face, roughly square it into blocks of suitable size. The group includes blockers and rockmen.

(3) *Drillers* include workmen employed in all forms of drills—hand drills, steam drills, wet and dry air drills.

(4) *Settmakers* shape the setts or stone blocks for road material by means of hand hammers. They work in a shelter or open shed.

(5) *Kerb-dressers*, sometimes referred to as masons, particularly in Leicestershire.

(6) *Crushermen* include all workmen employed in crushing mills and in concrete works. The group includes breakermen, screenmen, oilers, labourers about the mill, and loaders.

(7) *Building masons* are skilled workmen engaged in cutting and dressing granite in builders' yards. Some of these work only with hand tools and others use pneumatic tools. The use of the pneumatic tool varies considerably in different districts. In Cornwall it is used to a comparatively slight extent. In Aberdeen the pneumatic tool was found to be more in evidence among building masons. These pneumatic tools may be for cutting or surfacing. Building masons work in open sheds.

(8) *Monumental operatives* or monumental masons. This group includes squarers, duntermen, finishers, and turners working in monumental yards. The squarer uses a hand chisel and a pneumatic cutter. The dunterman is employed in operating the pneumatic dunter or surfacing machine. The finishers use the pneumatic tool almost exclusively for their work. Turners work with a power driven lathe. The squarers can work in a shed by themselves or in the same shed as finishers. The duntermen work in widely open sheds in the yard. Turners are, as a rule, in the same shed as the polishers.

(9) *Polishers* are employed in monumental yards. Polishing is a wet process; it may be done by hand, but, as a rule, machinery is used.

Characters of the Dust

The composition of the dust given off in the processes depends on the character of the stone being worked. In the so-called true granites there is a varying proportion of free silica in the form of quartz. In the other igneous rocks the proportion of quartz varies to a considerable extent, and in some of the igneous rocks, including some foreign stones, free quartz may be absent.

True granite consists of orthoclase felspar, quartz, and mica. The chemical composition is distinctly acid, there being from 65 to 75 per cent. of silica. In intermediate rocks, for example the syenites and diorites, the silica percentage varies from 60 to 55; while in the basic rocks—dolorite and gabbro—the silica content is from 45 to 55 per cent. The proportion of free silica as quartz varies considerably in different specimens; for example, in some of the Aberdeenshire granites: Rubislaw, 23 to 29 per cent., Sclattie, 27 per cent.; Kemnay, 20 per cent.; Peterhead 10 per cent.

In the city of Aberdeen, the centre of the monumental granite trade, a large proportion of foreign stones are worked, amounting to over 80 per cent. of the output. Many of these foreign stones are not true granites and have a low quartz content. For example, Emerald Pearl (Norway), 13 per cent.; Bonaccord Black and Green (Sweden), no free quartz; Balmoral Red (Sweden) 11 per cent. In others the quartz content is high; for example, " Glencoe ", from Finland, contains 35 per cent. quartz.

With regard to the conditions of work, there is a definite opinion amongst men who have worked in America that the risk there is greatly increased with the use of closed sheds, rendered necessary by severe cold weather. Work is not done in this country under quite the same conditions; this is especially true of work done near quarries, whilst in Aberdeen, though sheds are covered in, free ventilation is maintained.

The atmospheric dust produced at most of the processes in granite quarrying and dressing was sampled with Owens' jet dust-counter, at the place of work. Table VII gives particulars of the results of the examination of these samples. The conditions which favour the production of dust or its suppression are similar to those which affect similar processes in the sandstone industry. Speaking generally, however, there appears to be less tendency for the dust from granite to rise to the breathing level of the worker.

Evidence of Silicosis being Produced

A Medical Enquiry was made for the Home Office, in conjunction with the Mines Department, in 1929 by Drs. C. L. Sutherland, S. Bryson, and N. Keating, members of the Medical Board under the Refractories Industries and Sandstone Industry (Silicosis) Schemes,

TABLE VII

Origin of granite	Process	Position	Weather	Number of particles in 1 c.c.	Percentage over 2 μ	Remarks
Rubislaw, Aberdeen	Making "crossing setts"	Open shed	Fine, wind	566	13	Practically all particles are mineral.
do.	Making setts	In shelter	do. do.	469	23	Larger number of large particles.
do.	Drilling side hole in block	Open air	do. do.	4,796	7	Practically all particles are mineral.
do.	Drilling vertical hole	do.	do. do.	434	7	Practically all particles are mineral.
Sclattie, Bucksburn, Aberdeen	Air-drilling	Quarry bottom	Dry	3,337	3.6	Practically all particles mineral. Soot negligible.
do.	Hand-drilling	—	do.	—	—	Scattered particles of mineral only seen. Scanty record. Not counted.
Persley, Bucksburn, Aberdeen	do.	To leeward	Strong wind	87	1.7	Mineral particles nearly all fine, chiefly in diffuse splashes. No soot.
do.	Punching sett	Shelter of shed	Windy	138	10	Very little soot.
Kemnay, Aberdeen	Attending crusher and screens	Open air	do.	951	11	Particles almost colourless. Soot negligible.
do.	do.	do.	do.	1,313	7	Similar to above: but more fine particles.
do.	Clearing crusher jaws	On platform	do.	2,422	13	Many discrete fine particles. Soot negligible.
do.	Screening dust from crusher	—	do.	2,783	7.5	Similar to above, but more fine particles.
do.	Making crossing setts	Open shed	do.	204	12	Particles sometimes occur in loose splashes.
Kemnay, Aberdeen	Making steps	Open shed	Windy	3,145	8	Discrete particles. Many angular fragments. Soot negligible.
Balmeddie, Aberdeen	Feeding crusher jaws	—	do.	253	12	Some aggregates. No soot.
do.	Attending below elevators	—	do.	2,325	13	Some aggregates around larger particles. Some soot, nearly all in clumps.
do.	Wet drilling at face	—	do.	343	1.5	Soot from crane engine. About 70 % soot; rest mineral, all fine.
Blackhill, Longhaven, Aberdeen	Between 2 men drilling granite	Top of quarry	Some wind, dry	84	3	Soot negligible.
Guite, Longhaven, Aberdeen	Between 2 men hand drilling granite	—	do.	96	3	Similar to above.
Bonawe, Taynuilt, Argyll	Dry drilling	—	Slight wind, sunny	180	6	Soot negligible.
do.	Axing a nidged sett	—	do.	674	8	Soot negligible.
do.	Dry drilling for pop holes	—	do.	2,434	8	No soot.
do.	Wet drilling same hole	—	do.	259	5	Considerably larger number coloured particles than above and fewer larger particles. No evidence of clumping.
do.	Using sett hammer	—	do.	56	9	Some splashes. Soot not included.
do.	Feeding crusher jaws	Crusher-house	Slight wind, bright	951	11	Some aggregates. Many particles from 5 μ to 8 μ. Soot not included.

TABLE VII *(continued)*

Origin of granite	Process	Position	Weather	Number of particles in 1 c.c.	Percentage over 2 μ	Remarks
Bonawe, Taynuilt, Argyll	Working below screens	Crusher-house	Slight wind, dry	2,325	16	Many particles over 5 μ up to 15 μ. No soot.
Craignair, Dalbeattie, Kirkcudbright	By the screens	Small crusher-house	—	614	14	
do.	Feeding gyratory crusher	Shed open one side	Windy	2,325	13	Many large aggregates. Soot negligible.
do.	Filling 3/8th inch crushed granite from shoots	Large crusher-house	Damp, windy	—	—	Record sparse and ill-defined. Not counted.
Cove Bay, Kincardine	Dry drilling vertical hole	—	—	1,506	4	Very few aggregates. Soot negligible.
do.	Dry drilling breast hole	—	—	1,144	5	Similar to above.
do.	On platform looking over plant	Crusher-house	—	915	17	Large number of particles, many rounded.
Eskdale, Cumberland	Hand drilling for pop hole	—	Dry	602	4	A few aggregates. No soot.
Waberthwaite, Cumberland	Rock drilling with wet tripod air drill	—	—	265	10	Mineral particles nearly all in small aggregates, studded over with soot particles. Nearly all discrete particles are soot, clumped in parts.
do.	Dressing sett	Open shed	—	205	6	Some small aggregates. Very little soot.
Embleton, Cumberland	Shovelling crushed stone into elevator	Crusher-house	Dry	2,265	15	Some close aggregates. No soot.
do.	Settmaking	1-man shed open one side	do.	675	9	No soot.
do.	Dry drilling	—	do.	1,349	3.5	Majority of particles very fine. Very little aggregation. Soot practically negligible.
Threlkeld, Cumberland	Filling tubs from hoppers at granulator and screens.	—	do.	2,024	13	Many large close clumps and masses. Soot almost absent.
do.	Feeding stone crusher	—	do.	976	25	Considerable number of clumps.
Shap Fell, Westmorland	Making setts	Open shed	do.	626	8	Many fine particles adherent to larger particles; others in splashes. Soot negligible.
do.	Dry drilling	Mouth of open shed	do.	7,447	6.8	Many fine discrete particles and a few clumps. Soot negligible.
do.	do.	Quarry face	do.	6,675	6.0	Resembled above in general characters.
do.	Crushing	Crusher feed	do.	3,157	10	Some clumps of mineral particles and some splashes. Soot clumped.
Mount Sorrel, Leicester	Air drilling on block	Open air	Windy	482	5	Particles mostly discrete. No soot.
do.	Screening while machine starting to run	In screening house, provided with exhaust draught	—	168	9	Larger mineral particles in clumps. Some soot.
do.	Stone passing in screens	do.	—	229	8	Considerable amount of soot.

TABLE VII *(continued)*

Origin of granite	Process	Position	Weather	Number of particles in 1 c.c.	Percentage over 2 μ	Remarks
Mount Sorrel, Leicester	Screening	Under hatch cover in housing while stone was passing	—	—	—	Record too dense to count. Particles overlapping.
do.	Crushing	Crusher-house	—	2,362	13	A considerable number of very fine particles.
do.	Settmaking	In shed	Windy	409	5	Some very fine particles in groups. Soot negligible.
Groby, Leicester	At tarring plant	Rail track in the open	do.	3,120	25	Many large masses and aggregates
do.	Operating shoot hopper	Tar mixing plant	do.	4,555	23	Many large masses and aggregates of stone particles. Some soot in fine particles.
do.	At mixing cylinder	—	—	2,699	21	Much dust in masses.
do.	Feeding cracker jaws	In covered shed	—	933	10	Particles nearly all discrete.
Dalbeattie, Kirkcudbright	Feeding gyratory crusher	Open shed	Windy	747	11	Many very fine particles. Some aggregates. No soot.
Eskdale, Cumberland	Feeding cracker jaw	do.	do.	5,157	11	10 % of particles soot; others mineral.
Waberthwaite, Cumberland	Crushing plant	On staging where aerial ropeway delivers buckets	do.	2,524	10	Many very fine particles, some in splashes. No soot.
do.	No work being done	Artificial flag shed	do.	96	8	Control for above sample. No soot.
Craignair, Dalbeattie, Kirkcudbright	At little dunter	Open air except for head cover	Windy	120	12	
do.	Turning a pillar on machine	Turning shed, door open	do.	36	6	A few aggregates of fine particles. Some soot clumped — not counted.
Craignair, Dalbeattie, Kirkcudbright	Rough dressing granite stone with punch	Open shed	Windy	855	9	Soot absent.
Creetown, Kirkcudbright	Putting bed on stone with chisel	—	do.	1,337	6.3	About 50 % of particles stone dust. Some aggregates.
do.	Putting bottom bed on headstone with pneumatic chisel	—	do.	130	12	Soot negligible.
do.	Using pneumatic surfacing ool	Closed shed	—	2,470	12	Soot negligible
do.	Dressing top head of stone with punch	do.	—	397	15	Soot negligible.
do.	Lettering headstone with chisel	Carving shop	—	265	13	Soot negligible.

the report of which is in course of preparation. The investigation was carried out on the lines of that for the sandstone industry and included the clinical examination of 494 workers, of whom 211 were examined radiologically. The results of the radiological examinations are given in the following table:

TABLE VIII

Occupation	Number examined	Number X-rayed	Silicosis found on X-ray
Labourers	7	2	—
Getters	52	17	1
Drillers	66	25	1
Settmakers	88	41	1
Kerb-dressers	30	13	—
Crushermen	105	36	8
Building masons	85	45	16
Monumental masons	54	29	9
Polishers	7	3	—
Totals	494	211	36

In the cases of silicosis, the stage reached, as shown by X-ray examination, together with the district in which the workers were examined, are shown in table IX.

TABLE IX

Occupation	Area	Number positive	Stage of silicosis
Getter or blocker	Leicestershire	1	Ib.
Settmaker	Cumberland	1	Ia,
Crushermen	Cumberland	2	Ia, Ib.
	Leicestershire	3	Ia, Ia, IIc.
	North Wales	3	Ia, Ia, IIb.
Masons	Cornwall	8	Ia, Ia, Ia, Ia, Ia, Ia, Ia, Ib.
Building masons	Aberdeen	8	Ia, Ia, Ia, Ia, Ia, Ia, IIa, IIa.
Monumental masons	Aberdeen	9	Ia, Ia, Ia, Ia, Ia, Ib, Ic, IIa, IIc.
Driller	Cornwall	1	IIb.

Note. — The getter or blocker had worked most of his time as a settmaker. The driller had worked much longer in tin mines than in granite. Therefore no cases among blockers and drillers really.

TABLE X. — PARTICULARS OF CASES OF GRANITE WORKERS, DIAGNOSED AS SHOWING SIGNS OF SILICOSIS BY RADIOLOGICAL EXAMINATION, WITH A NOTE ON THE CHARACTERS OF THE SHADOWS

District and stone	Age	Occupation	Period of employment	Symptoms	Stage of silicosis	Remarks
			Years			
1. Leicestershire (Syenite. Total silica = 66.48 %)	50	Crusherman	27	Slight cough and sputum	Ia.	Finely granular disseminated fibrosis.
2. do.	51	Crusherman oiler	30	—	Ic.	Very finely granular disseminated fibrosis.
3. Leicestershire (Total silica = 67.16 %)	59	Crusherman (Foreman for 24 years)	35	Dyspnoea	IIc.	Nodules present.
4. do.	44	Settmaker Getter and Blocker	22 10	—	Ia.	Very slight nodulation in the upper and middle zones. At bases only fine striation.
5. North Wales (Total silica = 58.06 %)	53	Crusherman Coal mine 5 years, of which 2 were on cutting hard ground	26 5	Slight cough and sputum	IIb.	Rather dense fine shadows middle zones. Apices rather clear.
6. do.	73	Crusherman Screens	47	Dyspnoea, cough and sputum	Ia.	Fine diffuse shadows, except left middle zone, which is clear.
7. do.	53	Crusherman	25	Slight dyspnoea cough and sputum	Ia.	No definite localising signs.
8. Cumberland (Total silica = 67.18 %)	52	Crusherman	28	—	Ia.	Increased mottling with very slight, rather fine nodulation.
9. do.	52	Crusherman Quarryman	20 19	—	Ib.	Middle zone on the right, slight faint mottling. Less on the left.
10. Cumberland (Diorite, total silica = 75.22 %)	75	Settmaker Blocking	41 20	Very slight cough	Ia.	Slight increased mottling, very slight nodulation.
11. Aberdeen (local, home and foreign granites)	48	Monumental operative Dunterman squaring and finishing	19 9	Pain in the chest and dyspnoea	IIc.	Marked deep irregular shadows in all areas, with clear spaces between.
12. do.	52	Monumental operative (4 years on Blue Pennant, South Wales; 3 months on Derbyshire grit)	32	—	Ia.	Marbling and mottling. Not very definite nodules.
13. do.	56	Monumental operative (6 years in United States)	42	Some dyspnoea	IIa.	Increased root shadows. Slight fine mottling and nodulation left middle zone.
14. do.	55	Granite mason (Home granites) (2 years in United States)	38	Slight dyspnoea and sputum	Ia.	Diffuse fine nodulation and much fine mottling.
15. do.	57	Monumental Building (2 years in United States) (Mostly home granites)	5 34	Dyspnoea on exertion	Ia.	Rather dense thickening. Slight nodulation.

TABLE X *(continued)*

District and stone	Age	Occupation	Period of employment	Symptoms	Stage of silicosis	Remarks
			Years			
16. Arberdeen (local, home and foreign granites)	53	Stone cutter Fixer (including pneumatic tool; 20 years in closed sheds). 20 years on home granite	24 } 6 }	—	IIa.	Definite nodulation over both lungs.
17. do.	51	Monumental operative	35	—	Ia.	Increase fine striation and reticulation. No definite nodules.
18. do.	52	Monumental operative (24 years on pneumatic tools, 10 years in United States)	34	Some dyspnoea	Ic.	Considerable amount of fine nodulation in middle zone and right base especially.
19. Aberdeen (Local, home and foreign granites)	50	Monumental operative (Pneumatic tool 2 days a week last 15 years. One year in United States)	32	Some dyspnoea 4 years	Ia.	Fine mottling and increased shadows.
20. do.	61	Monumental operative Building 5 years	45	Slight cough occasionally	Ib.	Mottling with fine nodules.
21. do.	58	Monumental operative Squarer Finishing	 35 } 6 }	 Tightness of chest 2 to 3 years. Slight cough	 Ia.	 Fine mottling and nodules, right upper. Much increase of striation.
22. do.	60	Stone dresser, (7 years in South Africa on granite)	38	Dyspnoea on exertion. Slight cough	Ia.	Much fine mottling with fine nodules, diffuse over both lungs.
23. do.	58	Building mason	41	—	Ia.	Much fine mottling and nodules over outer zones.
24. do.	63	Building mason	41	Dyspnoea, increased over the last 10 years	Ia.	Much mottling and diffuse fine nodules, especially in the outer zones.
25. do.	62	Building mason (South Africa 6 years, United States 1 year)	44	Dyspnoea 1 year. Sputum in the morning	IIa.	Definite nodulation in both lungs.
26. do.	67	Building mason (United States 2 years, South Africa 12 years, of which 5 on sandstone)	52	Dyspnoea on exertion 2 years	Ia.	Very little nodulation. Increased striation.
27. do.	64	Pneumatic dunter Stone cutter	30 } 18 }	Dyspnoea 3 years	Ic.	Much fibrosis with fine nodules.
28. Cornwall (Total silica = 72.05 %)	50	Granite mason	30	Slight dyspnoea	Ib.	Rather dense woolly shadows. Nodulation at parts.
29. do.	52	Granite mason (United States 2 years)	27	Dyspnoea 6 years	Ia.	Increased fine striation and slight fine nodulation.
32. do.	48	Mason (2 years on Blue (Pennant sandstone)	32	—	Ia.	Increased fine striae. No definite nodules.
31. do.	65	Granite mason (Last 25 years on dunter. United States 22 years on dunter)	49	—	Ia.	Rather dense diffuse fine nodular shadows, all areas.

TABLE X *(continued)*

District and stone	Age	Occupation	Period of employment	Symptoms	Stage of silicosis	Remarks
			Years			
30. Cornwall (Total silica = 72.05 %)	44	Air driller 5 years. Worked in granite Tin miner on top Tin miner underground (including 5 years with jack hammer)	9 3½ 18	Dyspnoea 8 years	Ia.	Nodulation on finely woolly base in upper zones only.
33. do.	58	Mason (3 years in United States. 8 years on Blue Pennant sandstone)	42	—	Ia.	Increased striation with fine mottling and very fine nodules
34. do.	58	Mason (5 years in South Africa, all on granite)	39	Dyspnoea on exertion	Ia.	Increased striation with fine nodules.
35. do.	68	Mason	54	Tightness of the chest on exertion	Ia.	Increased striation, very fine nodules, especially the middle zone.
36. do.	58	Granite mason	35	Dyspnoea on exertion for 6 months. Slight cough	Ia.	Increased hilus shadows, mottling and fine nodules on the outer middle zone and right base.

Examination of the radiograms in the positive cases classed as silicosis shows that the prevalent type of the shadows indicating fibrotic changes is somewhat different from that found in workers exposed to silica dust in other industries. In the radiograms of granite workers there are usually the increased hilus, linear and reticular shadows, but instead of the discrete, dense nodules found to a greater or less extent over the whole of both lungs, there is a diffuse, cloudy or woolly effect with more or less definite fine or very fine nodules occurring in areas irregularly placed over the lungs. In the whole series the radiogram showing the most discrete nodules of the silicotic type is in the case of a man who worked for nine years as a driller on granite, but had been employed for eighteen years as a tin miner underground. Amongst the other cases, who had been almost exclusively employed on granite, there appears to be some relationship between the composition of the rock and the character of the fibrosis, as shown on the radiogram. The difficulty of obtaining accurate histories of workers employed exclusively on any particular rock in this country makes it impossible to draw substantial inferences on this point, but it might be kept in mind for future investigation into the effects of dusts such as silicates.

Table X gives some particulars of employment of the workers in granite, diagnosed as cases of silicosis by the writers of the Medical Report referred to, and notes by the present writer on the radiograms examined independently.

Clinical evidence of fibrosis, as distinguished from radiological evidence of silicosis, was found in 260 cases, or 52.6 per cent. of the 494 workmen examined.

The distribution in districts and occupations is shown in table XI.

Comparing the results of the medical examinations in the sandstone industry and the granite industry, the proportion of cases of fibrosis amongst sandstone workers was 59 per cent. of those examined, compared with 52.6 per cent. in the case of granite workers. The cases of silicosis in sandstone workers was 42 per cent. of those radiologically examined, and 17 per cent. in the case of the granite workers.

If fibrosis of the lungs, diagnosed by clinical examination, be regarded as representing a slighter or earlier involvement of the same character as silicosis, then it would seem that granites and the igneous rocks of granite type produce less injury to the lungs than do the sandstone. Having regard to the appearances of the radiograms in the two series of workers, there is a probability of a difference in character of the types of fibrosis produced by the two kinds of dust, and this probability is increased by the proportion of cases of fibrosis in the granite series showing an approximation to that found in the sandstone series, while the proportion of silicosis cases remains far behind.

Methods of Prevention

The processes in the granite industry are similar to those in the sandstone industry, and the principles of dust suppression in the one case can usually be applied in the other. In the granites and allied rocks generally, the rock is harder or tougher than in the sandstones, and in the processes of quarrying, more drilling has to be done. In cutting and surfacing pneumatic tools are more often used on granites. The dunter or surfacing machine gives rise to much dust and it is difficult to apply exhaust draught owing to the wide movements of the tool and the vibration produced. Drilling could be dealt with by the application of water spray or hollow drill feed, or by the Hay type of exhaust apparatus. Cutting and turning will require specially adapted exhaust which could be provided on the lines suggested under Sandstone.

There are no special regulations in force in factories or workshops in connection with granite working, but the general provisions of the Factory and Workshop Act, 1901, apply.

TABLE XI. — CASES DIAGNOSED CLINICALLY AS FIBROSIS OF THE LUNGS, AND RADIOLOGICALLY AS SILICOSIS, WITH THE DISTRICTS AND OCCUPATIONS

(The proportion of cases of fibrosis are stated as a percentage of the workers examined. The proportion of cases of silicosis are stated as a percentage of the workers radiographed.)

District	Occupation	Number examined	Fibrosis	Number radiographed	Silicosis
Leicestershire	Labourers	2	—	—	—
	Getters	22	10	9	1
	Drillers	14	3	7	—
	Settmakers	26	15	9	—
	Kerbdressers	30	13	13	—
	Crushermen	67	22	12	3
		161	63 (39.1%)	50	4 (8%)
Cumberland	Labourers	4	—	1	—
	Getters	11	4	4	—
	Drillers	9	4	5	—
	Settmakers	13	8	10	1
	Crushermen	14	8	6	2
		51	24 (47%)	26	3 (11.5%)
Cornwall	Labourers	1	—	1	—
	Getters	8	3	2	—
	Drillers	9	3	4	1
	Masons	34	22	23	8
		52	28 (53.8%)	30	9 (30%)
North Wales	Getters	11	5	2	—
	Drillers	10	9	3	—
	Settmakers	18	12	6	—
	Crushermen	11	10	9	3
		50	36 (72%)	20	3 (15%)
Aberdeenshire	Drillers	24	9	6	—
	Settmakers	31	21	16	—
	Crushermen	13	6	9	—
	Building masons	51	28	22	8
	Monumental masons	54	41	29	9
	Polishers	7	4	3	—
		180	109 (60.5%)	85	17 (20%)
	Totals	494	260 (52.6%)	211	36 (17%)

Compensation

The granite industries are not at present included in any scheme of compensation for silicosis.

Bibliography

(1) *The Problem of Dust Phthisis in the Granite Stone Industry.* By F. L. Hoffman, LL.D. United States Department of Labour, Bulletin No. 293. Washington, Government Printing Office, May 1922.

(2) *Report on the Occurrence of Silicosis among Granite Workers.* By Drs. C. L. Sutherland, S. Bryson and N. Keating. 1930.

Slate Quarrying and Dressing Industry

The industry is concerned with the quarrying of the rock and making into slates for roofing, structural, blackboard, sanitary and electrical uses.

Distribution geographically and the numbers of persons employed are given in the following table of wage earners employed in slate mines and quarries in 1928:

TABLE XII

Division	County	Number employed	
1.	Aberdeen	10	361
	Argyll	300	
	Banff	9	
	Caithness	2	
	Dumbarton	9	
	Perth	31	
2.	Cumberland	92	184
	Westmorland	92	
5.	Lancashire	332	9,751
	Isle of Man	24	
	Carnarvon	6,161	
	Denbigh	223	
	Merioneth	2,972	
	Montgomery	39	
6.	Cardigan	7	7
7.	Carmarthen	46	74
	Pembroke	28	
8.	Cornwall	473	530
	Devon	5	
	Somerset	52	
			10,907

Operations and Processes

In the open quarries of North Wales the slate is got by means of blasting and wedging. Suitable sizes of slate so obtained are conveyed to the mills. Overburden consisting of inferior slate, igneous rock and soil has to be removed as the quarry extends.

In the mills the large blocks are sawn to required sizes, by power-driven circular saws cutting across the grain. The smaller blocks are then split by means of a broad flexible chisel and a mallet, and cut to rectangular form either by hand or by the revolving blades of a machine.

In some small quarries there are no mills and the splitting is carried out in the open. The occupations may be divided into (*a*) rockmen who work at the mine or quarry; (*b*) labourers who assist rockmen in the quarry and remove overburden; (*c*) drillers who use pneumatic drills; (*d*) millmen who are employed in sawing, splitting and dressing; (*e*) saw sharpeners, mechanics, etc.

The distribution of persons in the different occupations can be seen from the following figures taken from two large slate quarries in North Wales:

TABLE XIII

	Quarry A	Quarry B
Rockmen, that is, getters, all of whom can do drilling	91	64
Quarrymen, that is, slate makers, including sawers, splitters and dressers	234	271
Labourers, including trammers, rubbishmen, etc.	96	129
Day men, including slate loaders, tradesmen and ropeway men	89	97
	510	561

Special Characters of the Dust

Slate is the typical cleaved rock. The most important constituents quantitatively are silica, free as quartz and combined as silicates, alumina, iron, alkalis and other bases. Silica as quartz exists in Penrhyn (Welsh) slates to the extent of from 34.66 per cent.

to 43.26 per cent., while total silica (free and combined) is from 57.75 per cent. to 63.01 per cent. [1]

A series of dust counts taken with Owens' jet dust-counter at slate quarries in North Wales in 1926, gave the following results:

At the Quarry:

(1) At breathing level of a driller dry drilling with pneumatic drill,
674 particles in 1 c.c., 8 % over 2 μ.
Many very fine particles in the sample.

(2) At breathing level of a driller on quarry-top dry drilling a vertical hole in slate with Ingersoll pneumatic drill, ¾″. Wind blowing the dust away. Slight rain.
566 particles in 1 c.c., 10 % over 2 μ.

(3) Dry drilling as in (2). Sample taken 3 yards to leeward of the drill hole,
361 particles in 1 c.c., 7 % over 2 μ.

(4) Dry drilling at breathing level of a breast (horizontal) hole, about 18″ above ground, in slate quarry-top,
650 particles in 1 c.c., 25 % over 2 μ.
Many large aggregates account for the high proportion of larger particles.

In the Mills:

Quarry A.

(1) At breathing level of a man at the saw table in slate dressing shed,
1,036 particles in 1 c.c., 17 % over 2 μ.
There are many aggregates, varying in size from 2 μ to 10 μ, and consisting of a very few to several score of particles, most of which are between 1 μ and 2 μ in size. The great majority of the particles are irregularly rounded. Some are plaque-like, and a very few are angular. Most are almost colourless and there is a fairly regular sprinkling of deep red or black or dark green particles; the coloured particles being nearly always in aggregates. An aggregate is counted as one particle, so that the presence of these reduces the count.

(2) Near the middle of the same shed,
2,361 particles in 1 c.c., 11 % over 2 μ.
The general characters of the particles are like those of No. 1, but there are larger aggregates and a higher proportion of fine particles.

(3) In a slate dressing cubicle off the large shed. At breathing level between two men, one splitting and one dressing with a hand knife,
855 particles in 1 c.c., 15 % over 2 μ.
The general characters are similar to those of (1) and (2).

(4) In another cubicle off the same shed, four men working, two splitting and two dressing with hand knives,
241 particles in 1 c.c., 23 % over 2 μ.
A higher proportion of large particles and aggregates than in (3).

Quarry B.

(1) Near the centre of the dressing shed (in this shed splitters and dressers work in a large room and not in cubicles as at Quarry A).
1,494 particles in 1 c.c., 8 % over 2 μ.

(2) Near the same point as (1), at breathing level of splitter,
3,325 particles in 1 c.c., 6 % over 2 μ.
There is a very large proportion of extremely fine particles and aggregates of large numbers of these fine particles.

(3) In the same dressing shed, at breathing level of a dresser working at a revolving slate dressing machine,
927 particles in 1 c.c., 9 % over 2 μ.
Fairly large aggregates of many fine particles, reducing the count.

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[1] Cf. Bibliography, No. (1).

The general appearance of the microscope samples obtained at these processes conveys the impression that slate dust tends to form aggregates readily.

Evidence of Silicosis being Produced

In 1926 Dr. T. W. Wade, of the Welsh Board of Health, made an investigation into an alleged high mortality rate from tuberculosis amongst slate workers in a district of North Wales. Dr. Wade's observations and conclusions are contained in pages 28 and 29 of his Report [1]. He says:

> The mortality tables of the Gwyrfai Rural District exhibit over a long series of years a very high death-rate from tuberculosis of the respiratory system, which is considerably higher for males than for females. The mortality figures from this disease, both for males and females, show high death-rates during the young adult periods of life. The maximum mortality rate for males is, however, reached during the old-age period of life, and this high mortality at the later age chiefly determines the difference between the male and female death-rates from tuberculosis. It is probably true that the high death-rates from tuberculosis of the respiratory system among young adults of both sexes are produced by the same influences. The great majority of the women are engaged in domestic duties in their homes, wherein the men spend a part of their daily life. It is reasonable to assume that the differences between the male and female mortality rates at the later stages of life are in large measure the result of influences outside the home. . . .

The mortality tables in the Report show that in the earlier periods of working life "other males" are less favourably placed than "workers in the slate industry", but that from thirty-five years of age onwards, and particularly in the later ages of life those engaged in the slate industry are very unfavourably placed.

The standardised mortality of males aged sixty to sixty-five, in certain occupations, given by the Registrar-General in the Decennial Supplement for 1921 [2] shows that the comparative mortality figures for slate miners and quarriers compared with 1,000 for all occupied and retired civilian males, were, for respiratory tuberculosis 1,594; diseases of the respiratory system 703; bronchitis 520; pneumonia 451; the comparative mortality figure for all causes being 944, as compared with 1,000 for all occupied and

[1] Cf. Bibliography, No. (2).
[2] Cf. Bibliography, No. (3).

retired civilian males. Contrasted with these low figures for respiratory disease other than tuberculosis is the high rate for valvular disease of the heart, which is 1,647 amongst slate miners and quarriers, compared with 1,000 for all occupied and retired males.

While the local mortality rates and the occupational mortality rates point to a high mortality rate from pulmonary tuberculosis, there is little evidence that respiratory disease independent of tuberculosis is excessive.

On the evidence I think there is little doubt that the workers in slate sheds are subjected to an injurious dust . . . The late age at which the mortality curve for tuberculosis of the respiratory system reaches its maximum may be due to the fact that the amount of dust in slate sheds is not very great and also that slate dust when moistened makes up into a clayey material which makes expulsion from the respiratory passages more assured than otherwise.

A Medical Enquiry was undertaken by the Mines Department in 1928. It was carried out by Drs. Sutherland and Bryson, who issued a Report in the form of a *Memorandum to the Health Advisory Committee of the Mines Department.* The investigation was made in North Wales in the district which was the subject of Dr. Wade's enquiry. Clinical examinations were made of 120 workers and from amongst these 61 were selected for radiological examination.

The results of examination in the various occupational groups were as follows:

Rockmen. — Fifteen rockmen were examined clinically and 6 radiologically. No case of silicosis was found. The average age of the group was 52.5. The average number of years spent as rockmen was 18.6, but the average time spent in the industry of this group was 30.8 years.

Drillers. — Six drillers were examined clinically and 3 were X-rayed. An average of only 3 years had been spent in drilling. No silicosis was revealed.

Millmen form the largest occupational group. The total number examined clinically was 96 and radiologically 52. Of those X-rayed 14 were found to be suffering from silicosis. The average age for this group was 46.37 years, and the ages ranged from 19 to 71 years. The average period in the occupation as millmen corresponds very closely to the average time spent in the industry. A number of the millmen had worked in coal mines for a few years and of these 7 had been employed in hard heading work. None of these was included among those X-rayed.

Clinical examinations show that severe fibrosis exists amongst the older millmen. Fibrosis is also present in the older rockmen, but to a less extent. In the drillers there is evidence of fibrosis of a slight degree, but in the remaining two occupations no evidence was found.

The 14 cases of silicosis found among the millmen could be placed as follow: 12 in the first stage, one in the second, and one in the third. The earliest age at which silicosis was found was 40 years. Most of the cases, however, occurred in the 50-59 years age-group. The earliest period of occupation group to show fibrosis was 20-29 years, but the majority of cases occurred in the 40-49 years group.

Tuberculosis, apart from silicosis, was diagnosed in three instances —one rockman and two millmen. The radiograph in these cases showed no definite indication that silicosis was present. The case of silicosis in stage 3 was also probably accompanied by tuberculosis.

Three of these cases were in the age-group 60-69 and one in the 40-49 years group. The number of years employed in the slate industry in the 4 cases was 26, 42, 47 and 53 years respectively.

In four of the cases no symptoms were complained of. In 6 cases the sole complaint was shortness of breath; a further 2 had cough and dyspnoea and the remaining 2 complained of cough, spit and dyspnoea. Dyspnoea was therefore the most common symptom. Pain was not complained of in any of the cases.

In view of the ages reached by many of the workmen while still remaining fit for work, it may be assumed that there is no general disability occurring amongst these workmen from exposure to dust in their occupations. The rockmen show lower age periods, but their work is rendered arduous by reason not only of the heavy character of the work itself, but also by the climbing from the deep quarries which their work involves. This would not be possible with a severe degree of respiratory disease. It is possible that a considerable degree of vocational selection is present and this is borne out by the standard of physique, which the Report shows to be much higher in rockmen than in millmen. Amongst rockmen no men were examined over 30-39 years' employment, but it is in this period that most of the cases of silicosis are found amongst millmen, namely, 9 cases out of 14; so that, although there appears to be less exposure to dust in the work of rockmen than in that of millmen, there is not sufficient evidence to make it possible to say that cases of silicosis would not occur amongst rockmen if later employment periods were reached.

The presence of tuberculosis, fibrosis, and silicosis has been established. Is it possible to establish also a relationship between them? The Report shows that fibrosis and silicosis occur in this industry and since extraneous sources of dust have been, to a great extent, excluded by the selection of cases for examination, it may be assumed that this change in the lungs is due to the inhalation of slate dust. The view is generally accepted that fibrotic changes due to the inhalation of silica dust react unfavourably towards tuberculosis, and the same may be true of slate dust which contains free as well as combined silica.

It seems extremely probable that the cases of pulmonary tuberculosis occurring for the most part at advanced ages, in subjects who have been exposed to the inhalation of dust and developed fibrosis, are of a very chronic character. The period of infectivity extends over many years and since the presence of the disease is not suspected, precautions against the spread of infection are not taken. The opportunities for the spreading of the disease are considerable in the case of millmen in slate factories, and the control of the excessive incidence of tuberculosis amongst these workers appears to depend upon the removal of sources of infection.

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(3) *Registrar-General's Decennial Supplement*, 1921. Part II: " Occupational Mortality ". His Majesty's Stationery Office, 1927. Price 7s. 6d.

Coal Mining

The distribution of the coal-mining industry in Great Britain is indicated in the following table of employed persons.

TABLE XIV. — NUMBER OF WAGE EARNERS ON COLLIERY BOOKS IN EACH OF THE MINING INDUSTRY ACT DISTRICTS OF GREAT BRITAIN ON 8 FEBRUARY 1930

Division	County	Numbers employed	
1.	Fife and Clackmannan	23,847	101,818
	The Lothians	13,824	
	Lanarkshire	51,332	
	Ayrshire	12,815	
2.	Durham	142,108	201,531
	Northumberland	49,333	
	Cumberland Westmorland	10,090	
3.	Yorkshire, South	118,082	171,361
	West	53,279	
4.	North Derby	52,239	118,380
	Nottingham	51,277	
	Leicester	11,072	
	South Derby	3,792	
5.	Lancashire and Cheshire	76,334	120,101
	North Staffordshire	28,800	
	North Wales	14,967	
6.	South Wales and Monmouth	180,856	186,362
7.	Part above and Forest of Dean	5,506	
	Cannock Chase	23,342	57,721
8.	Warwick	17,061	
	South Staffordshire and Worcester	4,932	
	Kent	4,694	
	Somerset	3,895	
	Shropshire	2,786	
	Bristol	1,011	
Total in Great Britain		957,274	

The processes underground in a coal mine, which may involve exposure to silica dust are:

(1) Ripping: taking down the roof or top of roadway, to make height;
(2) Brushing: ripping or blasting of the roof and the using of debris for building stone packs;
(3) Driving a hard-heading: a drift, tunnel or roadway driven in rock or through hard measures;
(4) Driving a cross measure drift: driving a roadway in such a direction as is necessary to form a travelling road from stratum to stratum.

The drills used are mostly of the percussive type, operated by compressed air. Table XV indicates the number and distribution of coal mines in which drills are used, and special measures adopted for dealing with the dust. The table includes mines in which measures are required to be taken under section 78 of the Coal Mines Act, 1911, for the use of water sprays or jets or other efficient means when drilling in ganister, hard sandstone or highly siliceous rock " the dust from which is liable to give rise to fibroid phthisis ".

In the " Midland and Southern " Division where such dust is not liable to be produced, there is one colliery where dust traps are used because the men prefer to do all drilling in this way, even although there is a low percentage of silica in the rock.

Special Characters of the Silica Dust

The dusts met with in these processes are mainly those evolved from (1) clift, bind or shale, which may contain as much as 40 per cent. to 60 per cent. free silica; (2) rock, bastard rock or sandstone, in which the free silica may range from 60 per cent. to 85 per cent.

The following particulars are from three mines where highly siliceous rock is worked.

	Mine A	Mine B	Mine C
Free silica in the rock. . .	57.0 %	73.3 %	73.2 %
Combined silica	6.5 %	9.9 %	4.3 %
Dust counts during boring (Owens' jet dust-counter, particles in 1 c.c.) . . .	2,290	2,180	2,220

Excluding the large particles and masses, the average size of the particles was 1.5 μ and they were generally angular and of crystalline structure with here and there opaque mineral matter resembling coal.

TABLE XV. — DRILLING IN ROCK LIKELY TO BE DANGEROUS FROM THE POINT OF VIEW OF SILICOSIS AND MEASURES TAKEN TO DEAL WITH DUST

Division (1)	Number of mines (2)	Total number of drills in use (3)	Measures taken to deal with dust (4)	Number of drills used when no measures taken to deal with dust (5)	Remarks (6)
Scotland	20	57	With 4 drills respirators are used. With 10 drills water put into boreholes.	43	
Northern	20	208	With 74 drills water sprays used.	134	50 drills are in use at one mine where no precautions are taken but Inspector states conditions are naturally damp.
Yorkshire	23	192	With 16 drills, respirators used. With 45, water or wet brattice applied. With 3 water put into boreholes. With 2 water flows through hollow drills	126	One mine where respirators are used a Hay Dust trap is to be ordered.
North Midland	3	23	With 2 drills, water jets in use. With 21, respirators in use	Nil	Of the total number of drills not all are in use regularly. At one colliery (20 drills) trials are being made of dust traps.
North Western	4	Not given	At one mine respirators used. At one mine dust trap used. At one mine dust collectors being installed	1 (mine)	
Cardiff and Forest of Dean	18	Not given	At 3 mines dust traps used. At 9 mines water spray used. At 2 mines respirators used	4 (mines)	At 4 mines where water sprays or respirators used, dust traps are on order.
Swansea	29	54	With 8 drills dust traps used. With 15 drills water sprays used. With 2 drills respirators used	29	One mine where water sprays in use, a dust trap is on order.
Midland and Southern	Nil	Nil	Nil	Nil	At one colliery dust trap used with hammer drills in every type of rock.
Totals	117	534 (where given)	219	337	

Evidence of Silicosis being Produced

During recent years evidence has been accumulating which shows that certain workers employed below ground in coal mines contract a disabling and even fatal fibrosis of the lungs. Some particulars are given in the table below of fatal cases where the diagnosis has been verified by post-mortem examination, and which have come to the knowledge of the Mines Department.

These cases, although at first sight they seem so varied, when reduced to main factors show that all the men worked for a certain time in rock. Many of the men who drive cross measure drifts do no other form of underground work, but there is also a large number of workers who work on the coal face or as repairers during most of their time and only do brushing or ripping from time to time.

Where the post-mortem findings indicated silicosis there has always been a definite history of stone drilling, though the period of such employment may have been short or even very short.

TABLE XVI

No.	Age	Occupation	Period of employment	Duration of symptoms	Period of disablement	Cause of death	Remarks
			Years	Months	Months		
1.	46	Coal miner	15	18	7	Silicosis and tuberculosis	Worked in hard ground nearly all of 15 years (South Wales).
2.	—	Labourer and coal miner's assistant	6 (on hard ground)	—	—	Silicosis and tuberculosis	Hard ground = 56.1 % total silica. Clift with occasional beds of sandstone (South Wales).
3.	38	Hard heading hammer drill	9	9	6	Silicosis and tuberculosis, pleurisy and nephritis	8.631 grammes of dried lung yielded 0.31 grammes silica (South Wales).
4.	47	Hard ground borer coal miner	3 17	—	5	Silicosis, anthracosis and acute bronchitis	Pennant rock; respirators worn during last 5-6 years. No water used with the drills (South Wales).
				Years			
5.	54	Hard ground 1914-1921	7	2	3	Silicosis and tuberculosis	Hard ground, mostly clift (South Wales).
6.	54	Coal miner	25	4	3 yrs.	Silicosis	18 years ago worked on hard ground, rock contained 37.8 % free silica (Somerset).
7.	36	Coal miner	22	5	—	Silicosis and tuberculosis	Ash of lung contained 18.4 % of silica. 20 years ago used hand drills (South Wales).
8.	59	Coal mine "repairer"	—	4	6 mths.	Silicosis	Always worked in hard headings, shale and Pennant rock.
9.	49	Mine sinker and making overcasts	14	—	—	Massive silicosis cerebral hæmorrhage, vascular degeneration	Stone = 51.3 % free silica.

It is impossible as yet to arrive at the true incidence of silicosis in the coalfields, but now that the condition has been brought within the application of the Various Industries (Silicosis) Scheme a more uniform standard of diagnosis may be expected and systematic records are more likely to become available.

Preventive Measures

These either take the form of the application of water as a spray or through a hollow drill, or the extraction of dust by means of an exhaust dust trap. Those mostly in use are: (i) the Hay original model, (ii) the Hay modified model, of which there are 90 in use (February 1930) (the whole of the equipment weighs only 27 lb.), and (iii) the Sgonina.

Legislation

The Coal Mines Act, 1911, section 78, enforces the use of water sprays or jets or other efficient means when drilling in ganister, hard sandstone or highly siliceous rock "the dust from which is liable to give rise to fibroid phthisis".

General Regulations (Statutory Rules and Orders, 1920, No. 873) dated 3 June 1920, apply to all mines under the Coal Mines Act, 1911, in which ganister or other stone containing not less than 80 per cent. of silica (SiO_2) is worked with a view to sale or manufacture.

Compensation

The Various Industries (Silicosis) Scheme, 1928, which came into force on 1 February 1929, includes provisions for the payment of compensation in cases of total disablement or death due to silicosis or silicosis accompanied by tuberculosis in workmen employed in "drilling and blasting in silica rock, in or incidental to the mining or quarrying of other minerals".

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Tin Mining

Distribution

The mining and quarrying of tin ore in this country is almost entirely confined to Cornwall.

Employed Persons

In 1901, 3,678 men were employed underground, and 2,690 males and 357 females above ground. The Census for 1921 gives 2,098 workers below ground and 1,004 males and 37 females above ground and in open workings.

In 1928 the number of wage earners was 2,800. There are employed on rock drills some 700 men, and 240 rock drills are in use. Of these, 220 are provided with water jets or sprays and 20 are without.

Characters of the Dust

Dust arising from drilling, blasting and handling the material is derived from the hard stone (containing 1 to 4 per cent. of binoxide of tin) of which the lodes consist, and from the containing rock, consisting of granite and " killas ".

Evidence of Silicosis

In the *Registrar-General's Decennial Supplement for 1921*, it is stated that the mortality of tin and copper miners in Cornwall is excessive; the comparative mortality figure from all causes is $3\ ^1/_4$, and for underground workers $4^1/_3$ times the average. It is pointed out that at this time the industry was depressed and probably most of the able-bodied men had secured mining work elsewhere. Almost all causes contribute to this excess mortality, but chiefly tuberculosis and respiratory diseases. The phthisis death rate is 12 ½ times the normal and that for respiratory diseases 6.3 times. " No other occupation in this country suffers to anything like the same extent from silicosis, or illustrates like these men the liability of this condition to lead to tuberculosis. " Deaths from chronic interstitial pneumonia numbered 27 out of the 2,110 underground tin miners; compared with 60 deaths from this cause amongst 912,126 coal miners.

Besides the dust in tin mining itself, a factor in producing the high incidence of silicosis and tuberculosis in the past was the practice among tin miners of working for a time in the gold mines of South Africa, where in former times the amount of silica dust in the atmosphere was very great and the incidence of silicosis was correspondingly high. There is no doubt, however, that tin mining in Cornwall has produced silicosis in persons who have not worked outside of this country. The following case illustrates this.

A tin miner who died in November 1928 had worked underground in two tin mines in Cornwall for at least seventeen years, and had never been in South Africa.

Post-mortem examination of the lungs was made and the following condition was found. The surface of the right lung was rough and the basal lobe was disintegrated owing to dense adhesions of the pleura, which was torn. The inter-lobar fissures were obliterated by adhesions. The left lung appeared to be voluminous and dark grey in colour. The pleural surface was free from adhesions, except between the lobes, and showed sub-pleural nodules, about 2 mm. in diameter, with white centre. The right lung, on section, was of a dark grey colour, thickly studded with nodules averaging 2 mm. to 3 mm. in diameter. The nodules were hard to the touch and could be easily removed from the adjacent tissue. At the right apex there was a dense mass of fibrous tissue, about the size of a walnut, with whitish bands. The lower lobe showed a red congestion with saneous exudation. The left lung on section was seen to be studded throughout its whole extent with nodules similar to those found in the right lung. There was, however, more inter-nodular tissue and much of this was emphysematous, especially on the anterior aspect. There was no evidence of tuberculous change at any part of the lung on macroscopic examination. The glands about the bifurcation of the bronchi were enlarged, matted together, and almost black in colour. In consistence they were as hard as cartilage. On section, they showed almost black surface with white fibrous striæ and fine mottling as of nodules.

Microscopic examination of the lungs shows the nodules to be composed of a centre of structureless substance, with few distinguishable cellular elements and with groups of dust particles, numerous at parts. This area is surrounded by bands of fibrous tissue, the elongated nuclei lying at right angles to the radius of the nodule. Outside of this is an area of less densely formed fibres, with a considerable cellular infiltration and many blood vessels. In this zone cells are seen with well-stained nuclei containing dust particles in the protoplasm. Giant cells are seen in the inner zone of fibrous tissue. In the alveoli and in the interalveolar septa, numerous cells are seen loaded with dust particles; many cells containing particles are seen around the larger blood vessels: in these the majority of the particles are under 1 μ and many appear to be carbonaceous. Larger particles with a crystalline appearance are to be found in the interalveolar tissue.

Section of a bronchial gland shows great increase in fibrous tissue arranged in nodules, and with thick deposits of dust in the tissue between the nodules.

Methods of Prevention

A Report on the health of Cornish miners [1] states that " the dust produced by rock drills can easily be prevented by a very small water jet. The dust from blasting in close ends can be laid by a powerful jet of water and air; and can in any case be avoided by the man ".

Metalliferous mines are worked under Special Rules under the Metalliferous Mines Acts.

Compensation

The Various Industries (Silicosis) Scheme, 1928, applies to all workmen employed on or after 1 January 1929 in certain processes. Amongst these is included, " drilling and blasting in silica rock, in or incidental to the mining or quarrying of other minerals ". The Scheme provides for the payment of compensation in cases of total disablement and death.

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Pottery Industry

This industry includes several distinct branches, the subdivision being determined by the nature of the article manufactured and the materials entering into the composition of the ware. The principal

[1] Cf. Bibliography, No (1).

divisions are: (1) general earthenware; (2) china; (3) tiles; (4) sanitary earthenware; (5) electrical fittings; (6) jet and Rockingham; (7) sanitary fireclay; (8) stone ware; (9) coarse ware.

The subject of silicosis is especially bound up with the first five of these subdivisions, though the others have also some interest. For the purposes of this paper the term " pottery industry " will be restricted to subdivisions 1 to 5, and the others will be referred to by name where necessary.

Distribution Geographically

A large portion of the pottery industry is concentrated in the North Staffordshire Potteries, the city of Stoke-on-Trent. Other groups of potteries are found in Derbyshire, Scotland, Dorsetshire, Devonshire, Yorkshire, Shropshire, Worcester, Newcastle-on-Tyne, Bristol and other places.

Employed Persons

In a Census of Employees of the British Pottery Manufacturers' Federation, for 14 January 1926, the numbers employed in the five subdivisions of the industry referred to above were: males 18,424 and females 23,402. In the several subdivisions the numbers were:

	Males	Females
General earthenware	8,892	13,783
China (combined with earthenware).	2,041	2,810
China.	1,835	2,806
Tiles	2,370	1,729
Sanitary earthenware.	2,081	285
Electrical fittings	1,205	1,989
Totals	18,424	23,402

Operations and Processes

From the point of view of the production of silicosis the industry is divisible into two main parts: (1) earthenware, including general earthenware; sanitary earthenware, earthenware tiles and earthenware electrical fittings, and (2) china.

In the manufacture of earthenware the ingredients—ball clay, china clay, china stone, felspar, and flint, in a ground state—are mixed together in the form of liquid slip, from which the excess water is removed by pressing; the resulting composite body is made into the consistence convenient for the manufacture of the various articles. In the plastic state it is used by throwers, pressers, jiggerers and jolliers, handlers, modellers, etc., in the potters' shops. So long as it remains moist it is harmless, but in the process of manufacture fragments fall on benches and floors, or adhere to the clothing of the workers, become dry and give rise to dust. After the article has been made in the plastic form, partly dried, it is frequently subjected to the process of towing, that is, application of tow or other similar substance to the surface of the article while it revolves on a mechanically driven disc, thus giving rise to large quantities of dust for which localised exhaust is required to be provided. In other cases the formed article in the " green " state is fettled, that is, irregularities of surface and edges are removed by hand by rubbing or scraping. This gives rise to dust as in the case of " towing ", and with large articles such as sanitary ware the application of localised exhaust is difficult.

In the potters' shops, the body or slip may be used by the potter, " caster ", in the liquid state instead of in the plastic state. When this is done it is poured into moulds of plaster of Paris and allowed to set. Afterwards the parts of the moulds are removed and the article in a semi-dry state is subjected to the process of fettling and finishing, as in the case of " thrown " or pressed articles.

When the articles shaped by the potter into their final form have been dried in a drying chamber to a condition known as " white hard ", they are placed in " saggers "—large flat-bottomed basins made of fireclay—for firing in the oven. In the case of earthenware the material is " placed " in the saggers by " placers ", the articles being prevented from touching the sagger or each other by interposing some siliceous sand or coarsely ground silica rock. In the case of china, however, the articles require much more support in the process of firing than do earthenware articles, and to provide this, finely ground flint is used. Flat ware is embedded in flint to a greater or less extent, by the processes of " placing ", called " flinting ", where enough flint is used to separate the flat ware when arranged in a pile in the sagger; " bedding " when the whole sagger full of ware is filled up with ground flint, and " settering ", when a separate mould covered with flint is used for each piece of ware. Hollow-ware is treated on similar lines so far as its form will allow, cups and similar articles being placed with the rims, to which an adhesive is applied, in apposition. The process is known as " boxing " of cups.

In the processes of " placing " earthenware and china in saggers, the placers are exposed to dust produced in the manipulation of the placing material, a relatively coarse sand in earthenware, a finely ground flint in the case of china. The processes in china placing are therefore relatively much more dangerous, involving handling of the more finely ground and more highly siliceous flint. The china " placers " rank amongst the most severely affected workers who contract silicosis in the pottery industry.

After the firing in the ovens, the saggers are removed by " biscuit" oddmen, who remove the ware now known as " biscuit " from the saggers, empty out the placing sand or flint and sift it for future use when mixed with a proportion of fresh or " green " placing sand or flint. After removal from the saggers the ware is placed in baskets and conveyed to the biscuit warehouse where it is subjected to a variety of processes to remove the adherent placing sand or flint, in preparation for glazing or underglaze decoration. The biscuit warehouse processes include hand brushing, placing in and removal from scouring machines, in the form of rumblers, " flat knocking ", " batting " and fine brushing. All these processes in the biscuit warehouse give rise to dust from the adherent placing sand or flint. They are carried on almost entirely by women.

When the biscuit ware has been cleaned, no substantial risk of silicosis arises in the subsequent processes of manufacture until glazing and decoration has been completed. Then polishing and grinding are employed to remove blemishes, etc. This is done by means of a revolving wheel which may be composed of cork or stone, to which ground flint is applied mixed with water, or an abrasive wheel of carborundum or similar material may be used. Where flint is used, it gives rise to dust and is liable to produce silicosis.

Glazes contain some free silica, but the evidence that disabling silicosis is produced from this source is not conclusive.

The industry can be divided into some sixty occupations. Half of these are occupations in which the worker is exposed to the inhalation of silica dust to a greater or less extent. The following is a list of these occupations, with the approximate number of persons employed:

		Males	Females
1.	Millmen	208	—
2.	Slipmakers and dust house attendants	811	13
3.	Modellers	64	1
4.	Mould makers (dust of plaster of Paris)	555	6
5.	Throwers and lookers-to ware	202	147
6.	Turners and lathe treaders	471	295
7.	Handlers	258	720
8.	Plate makers and towers	583	788
9.	Dish makers	138	132
10.	Hand basin makers	92	132
11.	Saucer makers	186	497

		Males	Females
12.	Cup and bowl makers	75	702
13.	Jiggerers and jolliers	307	535
14.	China flat jiggerers and jolliers	74	16
15.	Casters, earthenware and china	307	914
16.	Sanitary casters	729	13
17.	Hollow-ware pressers, earthenware and china	229	5
18.	Sanitary pressers	132	1
19.	Tile pressers	306	712
20.	Electrical dust pressers	25	520
21.	Fettlers (electrical fittings)	16	479
22.	Sagger and marl grinders	760	—
23.	Biscuit placers	1,158	23
24.	Biscuit oddmen	272	16
25.	Biscuit firemen	219	1
26.	Biscuit warehouse	180	1,710
27.	Glost placers and oddmen	1,723	162
28.	Polishers and grinders	419	37
29.	Tile slabbers	124	5
30.	Labourers	526	3

The exposure to risk of dust inhalation in these occupations may be stated briefly as follows:

1. *Millers and mill labourers.* — Only men are employed. They carry out the preparation of flint—calcining, breaking, crushing and milling, and the exposure is to flint dust. They are also employed in grinding broken biscuit ware (pitcher) in the preparation of glaze; manipulation and milling china clay, ball clay, china stone, felspar; calcining and grinding of bone; grinding of marl and fireclay.

2. *Slipmakers* include slipmakers' assistants, slip pressers and press emptiers. It includes those employed in mixing and manipulation of the mixed materials for the body of earthenware, sanitary earthenware, china, fireclay, mixed fireclay and earthenware and marl. It also includes those engaged in the preparation of a material known as "dust" for the body of tiles and electrical ware. Further processes in the preparation of this dust consist in the drying and pulverising, remoistening and sifting, before the tiles or electrical fittings are pressed into their final shape.

3. *The potters' shop.* — In the potters' shop are those employed in the manufacture of the ware before it is fired. The group includes those engaged in the following occupations: throwers, turners and lathe treaders, hollow-ware and sanitary pressers, ornamenters and figure makers, casters and spongers and fettlers for casters, handlers and handle makers, electrical and tile dust pressers and fettlers, machine workers (jiggerers and jolliers), plate makers, saucer makers, flat pressers, hand basin makers, dish makers, general jiggerers and jolliers, cup and bowl makers; also those workers attached to machine workers, towers, spongers, fettlers, scallopers, etc. In the potters' shop the workers are exposed to dust from the mixed body of the ware, the character of the dust varying according to the composition of this body.

4. *Mould makers* are employed in making moulds from plaster of Paris, to which dust they are alone exposed unless by proximity they are also exposed to dust from potters' shops.

5. *Modellers* are occasionally employed as mould makers as well as modellers of the ware.

6. *Sagger makers* are engaged in grinding marl, broken saggers, etc., and the sifting of such material in the manufacture of saggers by hand and by machine. The exposure is to dust of marl and a varying quantity of flint or ware body from old saggers, etc.

7. *Biscuit placers* and *biscuit oddmen* include those engaged in the handling and sifting of flint or sand in preparation for its uses in placing; in the placing or bedding of biscuit ware in the sagger house; in the preparation of the ovens, and in emptying the ovens and the removal of ware, sand and flint from saggers. In the manufacture of china, the bedding material is flint, and the workers in these occupations are exposed to dust of flint. In earthenware, sanitary, and other types of ware, the placing material is sand, and it is to the dust of this sand that workers are exposed.

8. *Biscuit firemen* include those employed in firing biscuit ovens, but not in connection with the bedding of biscuit ware.

9. *The biscuit warehouse* includes those engaged in handling the ware after its removal from the biscuit sagger house; in charging and emptying rumblers and other mechanical apparatus for cleaning the ware; in brushing, stopping, stamping, selecting and looking over the ware. The dust to which these workers are exposed is, in the case of china, flint; in the case of earthenware, the placing sand.

10. *Glost placers and glost oddmen* include those employed in the preparation of new saggers, by flinting and glazing the exterior and flinting the interior of the saggers; in the placing of glost materials, the filling and emptying of glost ovens, the emptying of glost saggers, and in brushing saggers. There is a slight degree of exposure to flint dust.

11. *Polishers and grinders* include those employed in the polishing and grinding of ware by the use of mechanically driven wheels, on some of which ground flint is placed, or by the use of a sandblast. Exposure is to finely divided flint dust.

12. *Tile slabbers* are employed cutting and grinding tiles for fitting. The dust is that of the fired tile body.

13. *Labourers* include all those engaged in sweeping the shops and yards and in cleaning localised exhaust plants, rumblers, sandblast, etc.

14. *Slip carriers and mould runners.* — The exposure to dust varies greatly according to the particular duties and the type of ware produced.

Special Characters of the Silica Dust and Reference to the Presence of Other Dusts

The composition and character of the dust to which workers in the pottery industry are exposed, vary according to the occupations and the branch of the industry in which the worker is engaged.

In the manufacture of earthenware, at which the slip or body is liable to become dry, i.e. at all parts of the process before the first firing, the dust produced consists of the body, that is, a mixture of clays, china stone, felspar and flint in a fine state of division. China stone contains about 73 per cent. total silica, part of which is free as quartz. Flint is almost pure silica, containing 98 per cent. SiO_2, in an extremely fine crystalline (crypto-crystalline) condition, set in colloidal silica which makes up 1.5 per cent. to 2 per cent. of the rock. Felspar contains about 64 per cent. of silica combined as silicates.

In the manufacture of china no flint is added to the body of the ware, which consists of calcined bone, china clay and china stone. A small amount of free silica as quartz is derived from the china stone.

The chemical composition of atmospheric dust in certain pottery processes has been determined by H. Oliver, B.Sc., in a Report on an investigation of atmospheric dust in pottery workshops [1] (the Report was for private circulation).

TABLE XVII. — TABLE OF COMPLETE ANALYSES OF DUSTS COLLECTED

No.	Process	SiO_2	TiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	K_2O	Na_2O	Loss on ignition	P_2O_5	Total	Remarks
2.	Towing Earthenware	53.80	Less than 0.01	16.80	0.90	2.80	0.90	2.60	2.50	20.00	—	100.30	
3.	Brushing Earthenware	62.08	0.48	16.36	0.80	2.44	0.12	1.10	3.00	14.08	—	100.46	Sand very dry. Centre of room.
4.	Dry Fettling China	36.34	0.00	26.54	0.48	16.64	0.02	1.92	1.84	8.18	8.26	100.22	
5.	Placing, etc. China Biscuit	96.20	0.00	1.74	0.12	0.68	0.00	0.08	0.64	1.04	Trace	100.50	Alumina and Phosphate indicate dust from green ware.
9.	China Biscuit Brushing	82.88	0.00	1.82	0.54	2.52	0.00	1.52	1.56	8.68	Trace	99.52	Alumina and Phosphate indicate abrasion of ware.
10.	Placing China Biscuit	74.80	0.00	3.16	0.64	2.84	0.04	3.70	1.50	13.12	Trace	99.80	
12.	Flint Sieving	84.80	0.00	1.20	0.48	3.48	0.16	2.80	0.90	6.08	—	99.90	

The relatively high alkalis and lime in every case indicate that these are general constituents of atmospheric dust, although a portion of the lime may be from the moulds and bats.

[1] Cf. Bibliography, No. (1).

An investigation into the dust content of the atmosphere of workplaces in the pottery industry was undertaken to provide a connecting link between the state of health found by examination of the workers and the hygienic conditions under which their work is carried on, with a view to the elucidation of the physical aspect of the causation of disease and to assist in the problems of the improvement of those conditions. The notes on the incidence of respiratory disease which follow the dust determinations in the occupational groups of this section have been taken from the Report of a Medical Enquiry carried out by Drs. Sutherland and Bryson in 1925 [1], under the direction of the Home Office.

This section covers most of the occupations in which there is exposure to silica dust in the manufacture of earthenware and china, and in addition, some investigation into the stoneware branch of the industry. From the hygienic point of view the stoneware industry is probably similar to the jet and Rockingham branch of the industries, in which there is at present no conclusive evidence of incapacitating silicosis.

Flint Milling

While the preparation of powdered flint is essential for the manufacture of all classes of pottery except coarse ware, stoneware and fireclay, although in these it may be used for the glazes or surface body, it might be considered as separate from the processes of pottery manufacture. Although some potteries have their own flint-milling department either within the precincts of the pottery or in a separate factory, the industry of flint milling is commonly carried on by separate firms who may supply the flint for purposes other than pottery manufacture, and they may combine the milling of other materials with that of flint. Further, the workers in this industry do not belong to the Societies of Pottery Workers.

The methods in general use are as follows. Home or foreign flints are placed in a large kiln with fine coal and fired, continuously. As required, the calcined flints are removed, together with the ashes of the fuel, from a small orifice at the bottom of the kiln, and are washed by spraying with water from a hose or are shovelled dry into barrows and wheeled to the mill room or to a stone crushing machine. The flints may be broken by hand hammer, the remainder of the grinding being done wet in buhrstone mills, or a preliminary crushing may be done before the material is placed in the mills.

[1] Cf. Bibliography, No. (2).

The grinding is done with sufficient water to keep the mass fluid: from the mills it is passed to sedimenting tanks where the water is separated and the flint is dried by heat until it contains only from 5 to 10 per cent. of its weight of water. The mass is broken up and removed by shovelling as required. Dust is produced in removing the calcined flints from the kiln, though most of this dust is ash: any process of manipulating the flints in this condition

TABLE XVIII

	Process	Number of particles in 1 c.c.	Percentage over 2 μ	Remarks
(1)	Raking calcined flints from the kiln	2,687	2.6	Most of the particles are mineral.
(2)	Sieving flint chips from the kiln	2,289	2.8	The sample closely resembles (1).
(3)	Sieving calcined flints with an enclosed mechanical shaker	1,793	0.7	Not more than 10% of the particles are mineral; others are soot.
(4)	Shovelling crushed calcined flints into crusher: to windward	2,132	1.7	About 15% of the particles are mineral; others are soot.
(5)	Charging the flint crusher; sample taken to leeward of machine	4,314	9.1	A dense sample; the amount of soot is negligible.
	Compare (5) with the following sample taken at a pottery in Glasgow, at the crusher, under cover, where the material was kept wet with water from a hose.			
(6)	Shovelling calcined flints, wet, into the crusher	458	6.8	A sparse record; particles evidently flint, varying in size from 1 μ to 6 μ.
	Sample taken at a flint-milling factory in Glasgow, in a neighbourhood free from excessive dust and smoke, and in damp weather.			
(7)	Control taken in yard, to windward of process	1,156	0.3	Most of the particles are soot.
(8)	Shovelling calcined flints and ashes from the kiln: to windward	1,807	2.2	Particles apparently include flint, ash, and coal.
(9)	Sieving ashes, containing flint chips, from the kiln: open air	1,325	0.6	About half of the particles are refractive, and probably some of this is flint.
(10)	Shovelling calcined flints in the open: to windward	1,120	1.0	Fine ashes and some refractive material, probably flint.
(11)	Breaking calcined flints with a hand hammer	1,446	0.6	Flint forms about 50% of the total.
(12)	In the drying room, turning over masses of ground flint	1,530	0.8	Occasional large particles, apparently flint.

is liable to produce dust, shovelling, knapping by hand hammer, sieving and, especially, grinding in a stone-crushing machine. A small amount of dust arises in shovelling the dried flint into carts or bags, and where bags are used much dust may be produced in handling them.

Two series of dust samples were taken with Owens' jet dust-counter, one in Stoke and the other in Glasgow, and since the general atmospheric conditions are not comparable, the series are stated separately.

Samples taken at a flint-milling department in a pottery in Stoke-on-Trent are given in table XVIII.

The most dangerous process in the milling of flints for use in pottery manufacture is that of crushing the calcined flints in a machine crusher. Sometimes this is replaced by breaking with a hand hammer, with much less risk, especially if the flints are freely wetted during the process. A liberal use of water immediately after drawing the flints from the kiln and at the crushing process would minimise or remove the danger: while sieving could be done by covered machines or could be modified by a process of washing.

Silicosis was diagnosed by radiological examination in 3 flint-millers out of 7 examined; the earliest definite evidence occurred after employment for from ten to fifteen years. Fibrosis of the lungs was diagnosed by medical examination in 8 out of 13 flint millers examined, the earliest manifestation being after ten to fifteen years' employment.

Note. — Some of these classed as flint millers had been employed for various periods at other occupations in potteries or otherwise.

China

The following series of dust determinations represent processes which fall into three groups: (1) processes before biscuit placing, in which the dust is derived from the unfired body; (2) processes in biscuit placing, and (3) processes after the firing of the biscuit ware, in which the dust is derived from the flint, adhering to the articles as a result of the process of placing them in the saggers for firing.

In column (5) an estimate is given of the proportion of the count which consists of particles, apparently composed of flint. To arrive at the actual pollution of the atmosphere by flint it is necessary to estimate the number of particles of flint per cubic centimetre of air by taking the percentage given in column (5) out of the number in column (3).

(1) *Processes before Biscuit Placing (in the Potters' Shops)*

TABLE XIX

Process (1)	Position (2)	Number of particles in 1 c.c. (3)	Percentage over 2 μ (4)	Remarks (5)
(1) Jollying hollow-ware	Jolly shop	5,350	1.1	About 20% of the particles are refractive; clumps and splashes.
(2) Dry fettling	Hollow-ware casting shop	6,916	2.5	At least 50% of particles are refractive; splashes, aggregates and clumps.
(3) Dry fettling	China casting shop	5,567	2.1	About 20% of the particles are refractive; splashes and loose aggregates. Numerous smoke particles, discrete and clumped.
(4) Fettling china hollow-ware	China potters' shop.	4,470	0.9	Much soot. About 10% of the particles are refractive.
(5) Dry fettling on whirler	Jolly shop	6,169	2.3	About 30% of the particles are refractive; splashes and clumps. Considerable amount of soot.
(6) Dry fettling on whirler	Jolly shop	7,157	2.2	Over 80% of the particles are refractive; numerous splashes and closely aggregated masses.
(7) Dry fettling on whirler	Jolly shop	4,555	1.8	About 30% of the particles are refractive; others soot.
(8) Looking over and dusting	Greenhouse	3,615	2.0	About 40% of the particles are refractive; others soot.

This series of dust counts is sufficient to indicate that a source of danger exists in workrooms in which the china body is in the damp or even wet state. The dust is certainly derived from particles of dry material floating in the air of the rooms. In the wet processes the dust is produced from fragments falling on the benches, floors and clothing of the workers, where it dries readily in the high temperatures prevailing and is set free as adventitious dust. In the fettling processes, the ware is sometimes sufficiently dry to cause dust directly from the action of the fettling tool.

Silicosis was diagnosed by radiological examination in china saucer-makers employed 15-20 years, in flat jiggerers and jolliers employed 20-25 years, and in a sliphouse worker employed over 40 years. Fibrosis of the lungs was diagnosed, by medical examination of china workers, in sliphouse workers and in handlers, employed 10-15 years; in saucer-makers and flat fettlers, employed 15-20 years; in lookers-to-ware and flat jiggerers and jolliers, 20-25 years; in throwers, employed 25-30 years; in lathe-treaders, employed 30-35 years; and in turners and hollow-ware pressers, employed over 40 years.

(2) *Processes in Biscuit Placing*

In the manufacture of chinaware, the principal dust hazard is due to the use of flint as the placing material in which the green ware is fired.

The process, as denoted in column (3), relates to the variety of placing adopted with different forms and classes of ware. Control samples were taken, three in the yards of the potteries and one inside a placing room, in which no work had been done that day, for the purpose of comparison.

Looking at the data provided by the tests the actual number of particles of flint, that is, the percentage in column (5) of the number in column (3), the following facts appear. The lowest counts are controls; number (18) taken in Hanley with the wind blowing over Hanley Park, which gave 65 particles of mineral; and number (19) at Fenton, which gave 151 particles. The lowest placing sample is number (15) with 338 particles—flinting with a current velocity of 800 feet at an exhaust opening 24 by 2 inches. Four placing samples are recorded below 500 particles in a cubic centimetre, out of 29 samples taken at all the varieties of placing china biscuit ware. Eleven are over 500 and below 1,000 particles in a cubic centimetre. Eight are over 1,000 and below 2,000 particles and six are over 2,000 particles in a cubic centimetre.

Silicosis was diagnosed by radiological examination in 16 china-biscuit placers out of 22 examined: the earliest definite evidence was found after 10-15 years' employment. Fibrosis of the lungs was diagnosed by medical examination in 19 china-biscuit placers out of 25 examined, the earliest case occurring after 5-10 years' employment.

TABLE XX

No. (1)	Process (2)	Number of particles in 1 c.c. (3)	Percentage over 2 μ (4)	Remarks (5)
1.	Control: centre of yard	4,554	0.1	Over 90% of the particles are soot.
2.	Bedding saucers	6,175	0.5	30-40% of the particles are flint.
3.	Boxing cups	5,699	2.6	60% of the particles are flint.
4.	Control: centre of yard	2,602	0.3	Over 90% of the particles soot.
5.	Bedding	647	4.6	About 80% of the particles flint: some aggregates.
6.	Flinting	825	3.6	General characters similar to (5).
7.	Boxing cups	6,832	0.8	About 20% of the particles flint.
8.	Bedding	5,940	0.3	About 40% of the particles flint.
9.	Flinting	5,916	0.27	Characters similar to (8).
10.	Bedding	4,482	0.7	30% of the particles are flint.
11.	Flinting	5,615	0.5	30% of the particles flint: similar to (10).
12.	Bedding	3,807	0.3	10-20% of the particles flint.
13.	Boxing cups	5,097	1.1	40% of the particles are flint.
14.	Bedding	1,434	2.5	About 50% of the particles flint.
15.	Flinting	3,384	0.1	About 10% of the particles are flint: difference between 14 and 15 due to the effect of exhaust draught.
16.	Settering	2,554	0.6	20-30% of the particles flint.
17.	Bedding	2,530	1.3	About 30% of the particles flint.
18.	Control: outside	1,373	0.3	A few isolated mineral particles; others soot.
19.	Control: placing room	1,518	0.2	Off work all day: 10% of particles are mineral.
20.	Boxing cups	2,506	1.2	40-50% are flint particles: some aggregates.

TABLE XX *(continued)*

No. (1)	Process (2)	Number of particles in 1 c.c. (3)	Percentage over 2 μ (4)	Remarks (5)
21.	Bedding	3,338	0.1	40-50% are flint particles some fine clumping.
22.	Flinting	1,759	0.8	20% flint particles: clumping of soot.
23.	Bedding and flinting	4,808	0.5	40% flint particles: some clumps.
24.	Boxing cups	5,266	0.7	Similar to (23), but less clumping.
25.	Bedding	4,241	0.2	A large proportion of fine particles of flint.
26.	Boxing cups	8,989	0.4	About 15-20% are flint parts: fine clumping.
27.	Settering	2,807	0.4	20-30% are flint particles.
28.	Boxing cups	3,060	0.3	About 20% of the particles are flint.
29.	Settering	4,109	0.2	About 20% of the particles are flint.
30.	Settering	2,723	0.9	About 30% are flint particles.
31.	Bedding	3,747	0.1	Only about 10% are flint particles.
32.	Flinting	4,964	0.2	About 10% are flint particles.
33.	Settering	5,603	0.1	About 10% are flint particles.

(3) *Processes after Firing of the Biscuit Ware*

The series of dust counts given in table XXI, representing processes undertaken for the removal of adherent flint from fired china-biscuit ware, serves to show that a high degree of danger exists to the workers in these processes. An inspection of this work demonstrates the necessity for concentrating attention on the removal of as much of the flint as possible in the earlier processes after the ware is taken from the saggers. It is just in these early processes that the methods are inclined to be haphazard and the labour less skilled, with the result that the workers in subsequent processes are exposed to a high degree of risk.

Silicosis was diagnosed by radiological examination in biscuit-oddmen, employed 5-10 years, and in biscuit warehouse-women employed 15-20 years. Fibrosis of the lungs was diagnosed by medical examination in biscuit-oddmen employed less than 5 years, and in biscuit warehouse-women employed from 5-10 years.

TABLE XXI

Process (1)	Position (2)	Number of particles in 1 c.c. (3)	Percentage over 2 μ (4)	Remarks (5)
1. Emptying saggers	Mouth of china biscuit oven	11,724	0.5	About 50% refractive particles; others soot.
2. Sifting flint	Hovel of No. 1 biscuit oven.	3,916	5.3	About 60% of the particles are refractive. Aggregates and masses.
3. Filling and drawing	Mouth of mechanical flat knocking machine.	11,544	0.6	Quite 50 % of particles are refractive; others soot.
4. Emptying hollow-ware	Scouring shop	10,411	0.8	Over 50 % of particles are refractive; others soot. Very few clumps.
5. Filling racks for drums	Scouring shop	9,194	0.6	At least 80% of the particles are refractive.
6. Filling racks of hollow-ware	Scouring shop	5,121	1.0	About 40% of the particles are refractive; others soot. Groups and masses.
7. Placing cups in racks	China biscuit scouring shop	7,423	1.3	About 30% of the particles are refractive, probably flint; others soot.
8. Removing cradles of ware	China biscuit scouring shop	5,964	0.2	Only about 10% of the particles definitely refractive.
9. Emptying scouring drum	Scouring shop	9,616	0.6	A large proportion, over 80 %, of particles are refractive.
10. Emptying racks of hollow-ware	Scouring shop	5,157	0.9	About 40% of particles are refractive; others are soot.
11. Batting before printing	Scouring shop	10,399	0.3	Over 50 % of particles are refractive. Dense sample.
12. Batting with jet of compressed air	Scouring shop	8,242	0.3	About 70 % of the particles are refractive; others are soot.
13. Fine-brushing saucers with revolving brush	Scouring shop	7,073	0.5	Majority of particles are soot; not more than 20% are refractive. Soot thickly clumped at parts.

Earthenware

In the manufacture of earthenware there are many processes which give rise to dust: these may be divided into four groups; (1) the handling of the raw materials up to the completion of the "body"; (2) the fashioning and drying of articles of pottery; (3) the placing of biscuit ware, emptying saggers, and preparation for glazing; (4) the making and applying of glaze, glost placing and polishing. Other incidental occupations are mould and sagger making.

When the slip or body has been made, and passed to the potter to be fashioned into an article of pottery, portions of the body become detached and, falling on the benches or floor, become dry and are crushed and give rise to dust. This dust exists in the atmosphere of the workplace as free particles of the constituent ingredients of the body, and also as minute masses of all the ingredients together. Collected with the Owens' dust-counter and examined under the microscope, the particles are seen to consist of masses firmly bound together, aggregates of loosely attached particles, and splashes of particles which appear to have been held together until the mass struck the surface of the recording slide. Under these conditions the clay particles appear with a faintly differentiated outline, as contrasted with the angular or finely facetted and highly refractive flint or quartz particle. Discrete particles are also seen scattered throughout the field, both of the clay and the crystalline character.

The following samples were taken in the processes of manipulating the plastic "body":

TABLE XXII

Position (1)	Number of particles in 1 c.c. (2)	Percentage over 2 μ (3)	Remarks (4)
1. Potters' throwers shop. Same factory as (2) and (3)	1,398	20	Many discrete refractive particles.
2. Turners' shop — a large room in which throwers also were at work	783	4.6	About 50% of particles are refractive.
3. Hollow-ware pressers' shop	1,265	2.2	Much of the sample is soot; there are discrete refractive particles.

TABLE XXII *(continued)*

Position (1)	Number of particles in 1 c.c. (2)	Percentage over 2 μ (3)	Remarks (4)
4. Hollow-ware pressers' shop—a very large room (same factory as (5))	1,458	3.6	50%-70% of particles are mineral.
5. Hollow-ware casters' shop—a large room	1,506	0.5	The splashes contain refractive particles.
6. Small jolly shop. General air of room at breathing level	916	5.6	Many close splashes. Impossible to count refractive particles in splashes.

In the above six samples the notable feature is the presence of splashes which account for most of the mineral content of the atmosphere, while free particles are comparatively scanty.

The following samples were taken at processes in manipulating the dried body, i.e. unfired or green ware:

TABLE XXIII

Position (1)	Number of particles in 1 c.c. (2)	Percentage over 2 μ (3)	Remarks (4)
7. In drying stove: a boy moving to and fro with ware and moulds	1,000	6.3	Much of the mineral matter is in clumps and splashes.
8. Jolly shop. Dry fettling edges of earthenware saucers	2,036	2.7	About 50% of particles are mineral, some discrete and some in splashes.
9. Flat pressing shop. Fettling plates in the green state	337	4.2	A very sparse sample.
10. Towing flat ware at a temporary bench, without exhaust: room warm	964	17.2	Most of the mineral material is in clumps and splashes. In this sample clumps are counted as single particles over 2 μ.
11. Towing. Same as (10) but with the instrument warmed to temperature of room or slightly above it, to test variation in formation of aggregates	1,048	8.9	Similar to (10) but shows slightly less clumping and is more uniform.

TABLE XXIII *(continued)*

	Position (1)	Number of particles in 1 c.c. (2)	Percentage over 2 μ (3)	Remarks (4)
12.	Towing. Same factory as (10) and (11). Provided with localised exhaust	1,036	8.9	Character of sample resembles (10) and (11), and counts are remarkably similar. The effect of localised exhaust draught in this case is probably nil, or is counterbalanced by a current of dusty air drawn past the worker from the same or adjoining rooms.
13.	Towing. Under hoods, with exhaust	1,747	3.0	Many splashes of mineral matter, also many free particles.
14.	Towing. With localised exhaust and with a hood not in position	747	2.1	About 50% of particles are mineral, chiefly in splashes.
15.	Towing. Same as (14) but with hood in position	807	1.4	Similar to (14) but soot particles are more frequently single, increasing the count.
16.	Towing house in another factory. Under localised exhaust	3,012	1.0	Many of the particles are soot; less than 20% mineral.
17.	Towing plates. Towing shop. With exhaust	1,590	1.1	Much soot. About 15% to 20% mineral.

Samples in which the dust is from the placing sand:

TABLE XXIV

	Position (1)	Number of particles in 1 c.c. (2)	Percentage over 2 μ (3)	Remarks (4)
18.	Placing biscuit ware in saggers.	1,723	7.4	About 70% of particles are mineral, much in splashes.
19.	In the kiln; one man inside, 4 men outside and one just outside, emptying saggers. Placing sand is a pounded sand	2,879	0.6	Great majority of particles are soot (80%); some of the mineral in splashes and clumps. Large sand particles scanty.
20.	Biscuit warehouse. Brushing biscuit earthenware, 3 girls helping	2,108	0.6	About 90% soot. Mineral for the most part discrete.
21.	Ornamenting shop. Ornamenting dinner-ware. Large room with windows open	1,108	0.7	Particles are chiefly soot, with a few scattered discrete and clumped refractive particles.

Of workers employed in the manufacture of earthenware in occupations in which the unfired composite body is handled, that is, from the sliphouse to towers and lookers-to-ware, 46 males and 15 females were examined radiologically. Silicosis was diagnosed in 26 males and 3 females. The male cases of silicosis were distributed amongst platemakers, handlers, dishmakers, throwers, jiggerers and jolliers, hollow-ware pressers and casters (some of whom had been employed previously as hollow-ware pressers). The female cases of silicosis were found amongst towers, fettlers-for-casters and cupmakers.

Fibrosis of the lungs was diagnosed by medical examination in 49 males out of 88 examined and in 12 females out of 89 examined. Bronchitis was found in 13 and some evidence of tuberculosis in 3 male workers.

Radiological examinations were made of 7 earthenware-biscuit placers and 1 case of silicosis was diagnosed. Two earthenware biscuit warehouse-women were examined radiologically and 10 medically, with negative results. Fibrosis of the lungs was diagnosed in 10 out of 18 male earthenware biscuit placers. The dust hazard to which these workers are exposed is that from the placing sand.

Tiles

Ornamental and plain tiles are made from a body resembling that of earthenware; in the case of white body there is up to about 40 per cent. of flint. In preparing the body for the press, the slip is freed from excess moisture by pressure, dried and ground. The dust given off into the atmosphere in the process of grinding the dried mass consists of the total constituents of the body, and as regards the tendency to aggregate formation and the physical separation of the particles, the conditions are similar to those obtaining in the manufacture of earthenware, in which the body becomes disintegrated about the benches, floors, stoves, etc., in potters' shops.

In one tile-making factory, 5 samples were taken at some of the dusty processes (cf. table XXV).

Another kind of dust is met with in tile manufacture—the

TABLE XXV

Process (1)	Position (2)	Number of particles in 1 c.c. (3)	Percentage over 2 μ (4)	Remarks (5)
1. Control	Grinding room. Taken at 2 p.m. work having been suspended for an hour	1,277	1.5	About 10%-15% of the particles are mineral some in aggregates.
2. Feeding hopper of grinding machine	Same grinding room at 2.35 p.m., work having been resumed at 2.15	3,868	12	Very dense sample with many aggregates. The whole count represents mineral.
3. Shovelling material into hopper. Most parts of grinding machine are enclosed, but a slight leakage with visible dust escaping	Grinding room of another factory	1,458	19.0	Most of material is in the form of clumps and splashes. Very little soot.
4. Control	Tile pressing room, taken at 1.55 p.m., work suspended since 1 o'clock	4,060	1.0	Great majority of the particles are soot; other particles apparently mineral, up to 4μ
5. Tile pressing	Same room; sample taken ½-hour after work was resumed after dinner interval	3,530	1.8	Very much less soot than in (3), and great increase in mineral particles.

TABLE XXVI

Process (1)	Position (2)	Number of particles in 1 c.c. (3)	Percentage over 2 μ (4)	Remarks (5)
6. Brushing biscuit tiles	Biscuit warehouse	2,265	1.9	About 20 % of the particles are mineral; there are few aggregates.
7. Emptying saggers and looking over biscuit tiles	Biscuit warehouse	2,181	0.9	About 20 % of the particles are mineral. General characters similar to (6).

placing sand giving rise to dust in the biscuit warehouse when the tiles are removed from the saggers and looked over and brushed. This work is done by women and girls. Two samples were taken in the biscuit warehouse (cf. table XXVI).

Two tile-sliphouse men were examined medically and radiologically; one of these showed evidence of silicosis after being employed 25-30 years: in both workers a diagnosis of fibrosis of the lungs was made. Three male tile-pressers were examined radiologically and all of these showed evidence of silicosis, the earliest signs appearing after employment for 10-15 years. Six were examined medically, and of these 3 showed evidence of bronchitis and 2 of fibrosis of the lungs.

Nineteen female tile-pressers were examined medically and 5 also radiologically. In one case, employed 25-30 years, silicosis was diagnosed. Fibrosis of the lungs was found in 2 cases and bronchitis in 1 case.

Of workers exposed to dust from the placing sand, 3 placers were examined medically and radiologically. One man employed 35-40 years showed evidence of fibrosis of the lungs, but there was no evidence of silicosis in the group. One warehouse-woman was examined medically, with negative result.

Of tile slabbers, who are exposed intermittently to the dust of the finished tile, 3 were examined medically and radiologically; all showed evidence of fibrosis of the lungs, but none of silicosis. None of the men had been employed for more than 20 years.

Electrical Fittings

These articles may be made from a body consisting simply of ball clay, such as is used for stoneware articles, or from a composite body which resembles that of earthenware but contains usually only about 10 per cent. of flint. When the composite body is used the articles are formed by pressure from the so-called dust which contains about 15 per cent. of moisture (cf. table XXVII).

Composite Body

TABLE XXVII

Process (1)	Position (2)	Number of particles in 1 c.c. (3)	Percentage over 2 μ (4)	Remarks (5)
1. Sieving damp dust	—	2,422	4.8	About 50% of the particles are mineral, most of them in splashes, refractive particles mixed with clay.
2. Pressing	Die-pressing shop	1,976	3.2	Some aggregates and splashes, accounting for most of mineral particles: about 40% mineral.
3. Between 2 dry fettlers	Fettling shop	1,855	1.7	Most of the particles are in splashes. About 40% mineral.
4. Precision grinding electrical fittings, unglazed or biscuit ware. Without exhaust	Fettling shop	2,096	4.7	About 40% mineral; most as discrete particles.

Stoneware Body

The articles are formed from plastic clay by pressure in moulds which are previously dusted with fine flint in a cloth bag; no obvious dust is produced in dusting the moulds (cf. table XXVIII).

TABLE XXVIII

Process (1)	Position (2)	Number of particles in 1 c.c. (3)	Percentage over 2 μ (4)	Remarks (5)
5. Pressing small articles in moulds dusted with flint	Pressing shop	2,036	1.3	About 20% refractive particles; much of mineral in splashes.
6. Wiping dry dipped article to remove marks	Dipping house	2,097	4.2	About 50% of the particles refractive.

Fifty-one workers exposed to dust of the composite body of electrical fittings were examined medically and 21 radiologically. One man employed as a turner for 35-40 years, and two women employed as pressers for 20-25 years and 25-30 years respectively, were found to show signs of silicosis.

Fibrosis of the lungs was diagnosed in 1 jiggerer, 2 turners, 3 sliphouse men and 4 female pressers. Two of these pressers and 1 sliphouse man showed evidence of bronchitis.

Of those exposed to the dust of placing sand, one placer was examined and showed evidence of fibrosis of the lungs after employment for 25-30 years.

Sanitary Ware

The body may be fireclay or a white body similar in composition to that used for earthenware. The preliminary manipulation of the ingredients for the white body involve exposure to the dust of clay, Cornish stone and flint; while the processes of casting and fettling involve exposure to dust of the mixed body, as in the case of earthenware (cf. table XXIX).

It would not be possible to make a differential count of the highly refractive and other particles with polarised light, because of the illumination of the clay particles. This is one example, like that found in the manufacture of firebricks, of the effect of clays in fixing free silica particles in the atmosphere, and not within the lungs, and probably explains the diminished power of free silica to produce silicosis in the presence of clays, though the dust may be capable of producing other forms of respiratory disease and even fibrosis of the lungs[1] (cf. table XXX).

TABLE XXIX

Process (1)	Position (2)	Number of particles in 1 c.c. (3)	Percentage over 2 μ (4)	Remarks (5)
1. Shovelling	Cornish stone drying beds	662	7.1	Splashes and some large refractive particles up to 16 μ.
2. Wheeling flint on to weigh machine	Slip making and weighing house	976	3.7	About 50% refractive material.

[1] Cf. Bibliography, No. (10).

TABLE XXIX *(continued)*

Process (1)	Position (2)	Number of particles in 1 c.c. (3)	Percentage over 2 μ (4)	Remarks (5)
3. Loading charges of ground flint. Shovelling damp flint		1,180	0.7	About 80% of particles are clear (flint).
4. Sandpapering and brushing sanitary fitting.	Sanitary ware casting shop	1,771	8.8	A dense sample owing to large number of splashes.
5. Dry fettling	do.	1,000	3.2	Most of mineral matter in splashes. Discrete mineral particles form under 50% of other free particles.
6. Do.	do.	964	2.5	About 30% of particles refractive; others soot. A few splashes.
7. Sweeping floor	do.	1,674	11.7	Most of mineral matter in form of splashes. Highly refractive particles standing out from surrounding debris; these are probably flint.

TABLE XXX

Process (1)	Position (2)	Number of particles in 1 c.c. (3)	Percentage over 2 μ (4)	Remarks (5)
8. Sandpapering and brushing biscuit sanitary ware	Stopping warehouse	554	14	About 80% of particles are discrete and rather coarse. Particles generally highly refractive.
9. Enamelling fireclay	Enamelled fireclay brushing department. Workers stopped for dinner 5 minutes before sample was taken	1,036	4.2	The larger particles and most of small ones are clear and refractive.

Thirteen sanitary casters were examined medically and 10 of these also radiologically. All of these had been employed previously as sanitary pressers and some also as earthenware hollow-ware pressers. Silicosis was diagnosed in 4 cases; fibrosis of the lungs in 7, and bronchitis in 3. Of sanitary pressers 7 were examined medically and 5 also radiologically. Silicosis was diagnosed in 2 cases after employment in this occupation for 25-30 years and previous employment as earthenware hollow-ware pressers. Five were found to show evidence of fibrosis of the lungs and 2 of bronchitis.

Of workers in sanitary ware exposed to dust from placing sand, 1 placer employed 25-30 years, was examined medically and radiologically, and fibrosis of the lungs was diagnosed. Two biscuit warehouse-women were examined medically, one of them also radiologically, with negative results: they had been employed for 18 and 20 years respectively.

Stoneware

The manufacture of stoneware is not regarded as part of the pottery industry in the ordinary sense. The trade is not carried on in North Staffordshire but is scattered throughout the country, especially in Scotland, and the workers are not members of the Pottery Workers' Trade Unions. The articles made include jam jars, stone bottles, teapots, spirit and chemical jars, electrical fittings, etc. The body consists entirely of ball clay made plastic by milling with water. Flint is present in the glaze and in the sagger wash (cf. table XXXI).

Polishing

The processes of polishing are carried out for the purpose of removing blemishes and thimble marks from the glazed ware. In general, the processes consist of abrasion by a rapidly revolving wheel or brush to which is applied finely powdered flint mixed with water; or the wheel itself is constructed of an artificial abrasive and flint is not used. The wheel or brush rotates in a direction downwards towards the operator. Close application of the worker is necessary. In some polishing shops localised exhaust draught is

TABLE XXXI

Process (1)	Position (2)	Number of particles in 1 c.c. (3)	Percentage over 2 μ (4)	Remarks (5)
1. Drying stoves with revolving carriers	Jolly shop	723	10.0	About 50% of particles are mineral; others soot.
2. Working at lathes; ware carriers passing to and from room	Turning shop	735	15	Character of sample similar to (1) but larger masses present, up to 16 μ, and a higher proportion.
3. Jollying	Jolly shop	1,385	2.9	Few discrete mineral particles; most of mineral matter occurs in splashes. Soot also present.
4. Jollying jam jars	Jolly shop — another factory	1,964	1.0	Mineral matter in splashes with refractive particles embedded, and as discrete particles which form about 10% of count.
5. Turning jam jars	Turning shop	1,844	2.8	Splashes which include refractive particles. Discrete refractive particles form about 10%.
6. Dipping articles for glazing	Dipping house			Sample taken showed no evidence of danger from liberation of flint particles from glaze into atmosphere.

Note. — Stoneware was not included in the branches of the industries in which medical and radiological examinations were made.

provided for each polishing lathe; in others no localised exhaust draught is provided. The dust from polishing consists of the abrasive thrown off by the wheel or brush; this is either flint or the material of which the abrasive wheel is composed. Dust from the ware will consist of fired glaze and is probably not important.

Four samples were taken in a large polishing shop in which 15 lathes were working. In this shop there is a system of localised exhaust ventilation by which a current velocity, averaging 1,500 linear feet per minute at the openings of the ducts, is obtained, and a total ventilation of 10 changes per hour of the air in the room. The shop measures 70 × 37 × 11½ feet with a cubic content of approximately 30,000 cubic feet (cf. table XXXII).

TABLE XXXII

Process (1)	Position (2)	Number of particles in 1 c.c. (3)	Percentage over 2 μ (4)	Remarks (5)
1. Polishing with flint on a revolving brush	Polishing shop	2,446	10.0	Refractive particles vary in size from 6 μ down to under 1 μ, and form about 50% of count.
2. Polishing on an alundum wheel, without flint	Polishing shop	1,337	3.3	Refractive particles form about 20%; others soot.
3. Polishing on a mica wheel, with flint	Polishing shop	1,687	2.6	Refractive particles not numerous, about 10%
4. Polishing on a cork wheel, with flint	Polishing shop	1,952	1.0	Refractive particles form about 10%.

At a china polishing shop in another factory 4 samples were taken; in this polishing shop there is no localised exhaust ventilation; the room is much smaller than in the above-mentioned polishing shop, and only 4 lathes were in use (cf. table XXXIII).

TABLE XXXIII

Process (1)	Position (2)	Number of particles in 1 c.c. (3)	Percentage over 2 μ (4)	Remarks (5)
5. Polishing dish on cork wheel with flint	Polishing shop	2,265	8.8	A large proportion of particles are refractive.
6. Buffing dinner plate with brush, flint being applied	Polishing shop	1,988	13.3	Characters similar to (5), but large proportion of clumps.
7. 'Scaring' an alundum wheel	Polishing shop	4,145	10.3	Great majority of particles refractive.
8. Control; general air of polishing shop	3 yards from nearest working lathe	2,205	3.3	About half of particles refractive; others soot

Two samples were taken in an earthenware polishing shop in which there is no localised exhaust draught (cf. table XXXIV).

TABLE XXXIV

Process (1)	Position (2)	Number of particles in 1 c.c. (3)	Percentage over 2 μ (4)	Remarks (5)
9. Polishing on cork wheel, with flint	Polishing shop	1,639	1.4	Between 30% and 50% of particles are refractive, apparently flint, discrete, with few aggregates
10. Polishing a large surface with flint on cork wheel	Polishing shop	2,157	3.3	Similar to (9) but slightly more dense.

Fourteen polishers were examined medically and eight of these also radiologically. Silicosis was diagnosed in a polisher of earthenware who had been employed for thirty-six years. Ten cases were diagnosed of fibrosis of the lungs, and in one case there was some evidence of tuberculosis.

Mould Making

A sample was taken at the breathing level of a mould maker in a stoneware pottery, while mixing plaster of Paris with water; this process occupies about three minutes at intervals of fifteen minutes throughout the working day. A flatware presser at work in the same room.

The sample is very dense and cannot be counted owing to crowding and overlapping of particles, and the presence of numerous aggregates. The individual particles are of various shapes, but the majority are of an elongated form with straight edges and right angles: they vary in size from 14 μ down to the limit of visibility. With polarised light the particles are diffusely luminous with here and there a brilliant point.

A mould maker in Hanley, aged sixty-five, who had been employed on plaster of Paris for fifty years, had no chest trouble and did not know of any mould makers who had suffered from " potters' asthma "; he was subject to frequent colds from the open doors and windows: he had had pneumonia three years ago and was laid up for two months. There was no evidence of irritation of the upper respiratory tract in the early period of employment or on resuming after a holiday.

Thirteen mould makers were examined medically and three of these also radiologically. Two cases of fibrosis of the lungs and one of bronchitis were diagnosed, but silicosis was not found.

Evidence of Silicosis being Produced

In the Report by Drs. Sutherland and Bryson, already referred to, the number of cases diagnosed as silicosis amongst the workers in the pottery industry examined during the medical enquiry, was given as 87 out of 250 examined radiologically.

The distribution in occupations is given in the following table:

TABLE XXXV

Occupation	Males			Females		
	Number examined	Number X-rayed	Silicosis found	Number examined	Number X-rayed	Silicosis found
Millers	13	8	3	—	—	—
Slipmakers and dusthouse attendants	24	13	3	2	—	—
Modellers	4	2	—	—	—	—
Mould makers	13	3	—	—	—	—
Throwers and lookers-to-ware	14	5	1	6	—	—
Turners and lathe treaders	16	3	1	8	3	—
Handlers	7	5	3	25	5	—
Plate makers and towers	20	11	7	20	4	1
Dish makers	6	2	1	1	1	—
Handbasin and chamber makers	6	1	—	4	1	—
Saucer makers	7	6	5	9	—	—
Cup and bowl makers	1	—	—	19	2	1
Jiggerers and jolliers	12	6	4	4	1	—
Flat jiggerers and jolliers (china)	7	5	3	2	2	—
Casters (earthenware and china)	13	6	4	22	6	1
Sanitary casters	13	9	4	—	—	—
Hollow-ware pressers	17	11	6	1	—	—
Sanitary pressers	7	5	2	—	—	—
Tile pressers	6	3	3	19	8	1
Dust pressers (electrical)	2	2	—	17	7	2
Fettlers	2	1	—	11	3	—
Sagger makers and marl grinders	22	9	3	—	—	—
Biscuit placers	48	33	17	—	—	—
Biscuit oddmen	12	7	2	—	—	—
Biscuit firemen	5	1	1	—	—	—
Biscuit warehouse	4	2	—	53	25	5
Glost placers and oddmen	9	3	1	—	—	—
Polishers and grinders	14	9	1	—	—	—
Tile slabbers	3	3	—	—	—	—
Labourers	9	4	1	1	—	—
Red marl workers	8	4	—	—	—	—
Totals	344	182	76	224	68	11

Since the coming into force of the Various Industries (Silicosis) Scheme, 1928, on 1 February 1929, fatal cases of silicosis, or at least the majority of cases, occurring in the Potteries district of Stoke-on-Trent, have been the subject of enquiry by His Majesty's Coroner. The results of these enquiries, together with the results of the post-mortem examinations, have come to the notice of the Factory Department, and some particulars of these cases are given in the following table.

TABLE XXXVI. — FATAL CASES OF SILICOSIS WHICH HAVE OCCURRED SINCE FEBRUARY 1929, AND WHICH HAVE COME TO THE NOTICE OF THE FACTORY DEPARTMENT

(The diagnosis has been verified by post-mortem examination)

Branch of industry	Process	Age	Period of employment	Period of symptoms	Period of incapacity	Cause of death	Remarks
1. General earthenware	Flint miller	48	Years 21	2 years	9 months	Silicosis and Tuberculosis	Exhaust applied during 21 years of employment. Dust sample showed 2,277 particles in 1 c.c., 10% over 2 μ.
2. do.	Miller's engineman 13 years Miller 25 years	51	38	1 ½ ,,	6 ,,	Broncho-pneumonia and silicosis	Silicosis diagnosed when an X-ray was taken for a broken collar bone.
3. do.	Miller	65	20	A number of years	2 weeks	Broncho-pneumonia and silicosis	Silicosis in second stage.
4. do.	Sliphouse labourer 33 years Mill labourer 9 years	54	42	7 months	4 months	Silicosis and tuberculosis	Mill dusty and exhaust was not applied till a year ago.
5. do.	Boiler fireman and potter's oddman 29 years Mill labourer 14 years	55	43	3 years	5 ,,	Silicosis	
6. do.	Dish maker	48	34	Few years	10 days	Lobar pneumonia accelerated by silicosis	
7. do.	Saucer maker	50	33	8-9 ,,	5 ,,	Broncho-pneumonia silicosis and chronic bronchitis	
8. do.	Plate maker	61	51	Several years	1 ¼ years	Silicosis and tuberculosis	
9. do.	Jiggerer	39	22	7 ,,	2 weeks	Broncho-pneumonia and silicosis	
10. do.	Jiggerer	63	53	3 ,,	2 months	Silicosis	
11. General Earthenware	Presser and caster	58	48	4 ,,	2 ,,	Silicosis	
12. do.	Potters' shop 30 years Presser 10 years	58	40	6 ,,	6 years	Silicosis and tuberculosis	

TABLE XXXVI *(continued)*

Branch of industry	Process	Age	Period of employment	Period of symptoms	Period of incapacity	Cause of death	Remarks
			Years				
13. do.	Presser and caster	47	33	7 years	11 days	Silicosis	
14. do.	Flat presser and bowl jollier	58	48	1 ,,	1 year	Silicosis and tuberculosis	
15. do.	Hollow-ware presser	56	43	A number of years	6 months	Silicosis	
16. do.	do.	51	41	1 year	2 week	Silicosis	
17. do.	Hollow-ware jollier	53	40	2-3 years	3 days	Broncho-pneumonia and silicosis	Had not slept in bed for 5 months owing to dyspnoea.
18. do.	Sweeper of floors in potters' shops 23 years	63	50	?	5 months	Silicosis and tuberculosis	
19. do.	Biscuit placer or in Potters' shop	56	47	11 months	4 ,,	Silicosis and tuberculosis (hæmoptysis)	Was employed as a sanitary earthenware placer previously.
20. do.	Glost placer	59	49	?	1¼ years	Silicosis and tuberculosis	No signs of lead poisoning.
21. do.	Glost placer	52	40	8 months	7 months	Silicosis and tuberculosis (hæmoptysis)	No signs of lead poisoning.
22. do.	Polisher	56	46	6 years	3 weeks	Silicosis	
23. do.	Polisher	44	27	2 ,,	1 week	Silicosis	
24. do.	Polisher	57	40	5 ,,	1 ⅓ years	Silicosis	
25. Sanitary earthenware	Presser and caster	53	38	9 months	9 months	Silicosis and tuberculosis	
26. do.	Presser and caster	65	57	Some years	1 year	Silicosis and tuberculosis	
27. do.	Presser and caster	64	50	Several years	6 months	Silicosis and tuberculosis	
28. China	Turner	53	41	3 months	3 ,,	Silicosis and tuberculosis	Work confined to china body.
29. do.	Plate maker	56	46	4 years	4 ,,	Broncho-pneumonia and silicosis	
30. do.	Saucer maker	56	40	2 ,,	1 year 2 months	Silicosis and tuberculosis	
31. do.	Sauce maker 39 years; Coal miner 5 years; Slag crusher 5 years; Sagger crusher 3 years	62	52	,,	5 months	Silicosis and tuberculosis	
32. do.	Flat presser	62	54	2 years	2 ,,	Silicosis and tuberculosis	
33. do.	Biscuit odd-man (flint siever)	59	47	5 ,,	11 ,,	Broncho-pneumonia and silicosis	
34. Tiles	Earthenware plate maker 5 years; Earthenware biscuit placer 4 years; Tile glost warehouse 10 years; Dust tile maker 15 years	52	34	2 ,,	9 ,,	Silicosis and tuberculosis	Employed in coal mine 1 year.
34. do.	Dust grinder 7 years; Tile maker 24 years	51	31	Some years	9 days	Silicosis and bronchitis	A coal miner in South Wales up to 20 years of age
35. Electrical fittings	Dust grinder	56	44	,, ,,	2 ⅓ years	Silicosis	

Methods of Prevention

The present Code of Regulations for the Manufacture of Pottery [1] was made in January 1913, and applies to all factories and workshops in which the manufacture or decoration of pottery or any process incidental thereto is carried on. For the purposes of the Regulations certain processes and technical terms are defined and a Schedule is appended, divided into two parts, Part I including lead processes and Part II other processes. Evidence was taken as to the working of the present Regulations by the Departmental Committee on Compensation for Silicosis dealing with the Pottery Industry [2].

In making certain recommendations the Committee believed that, except as regards the processes of fettling and china biscuit emptying, their proposals did not go beyond what is already the practice in some factories. So far as the Regulations are concerned the processes dealt with may be grouped under three headings: (1) those involving the use of powdered flint in the making of china ware; (2) certain processes carried on in potters' shops, and (3) other processes such as flint milling, polishing, sorting, and grinding.

(1) *Processes involving the use of powdered flint.* — In these processes the workers run the greatest danger of direct exposure to silica dust. They include: the placing of china ware in saggers; drawing of china biscuit oven and emptying of saggers; the process of flat knocking and flint sifting; emptying the ware from baskets and other receptacles, and scouring. The present Regulations require the provision of exhaust draught for (2) the processes of bedding and sifting (Regulation 7 (*a*) (vii)); (*a*) the removal of bedded ware from the saggers after firing (Regulation 7 (*f*)); (*c*) flat knocking and fired flint sifting (Regulation 7 (*g*)), and (*d*) scouring of biscuit ware which had been fired in powdered flint (Regulation 7 (*a*) (ix)).

The Committee's recommendations were:

(*a*) *China biscuit placing.* — The requirement of exhaust draught should be extended to include the "placing" of hollow-ware.

(*b*) *Drawing of china biscuit ovens.* — The requirement of exhaust draught should be extended to the emptying of all saggers if powdered flint has been used and not only to bedded flat ware.

(*d*) *China scouring shops.* — That exhaust draught should be required for (i) emptying of biscuit ware which has been fired in

[1] Cf. Bibliography, No. (3).
[2] Cf. Bibliography, No. (4).

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powdered flint from baskets or other receptacles, except where special general ventilation is provided; (ii) filling and emptying of cradles or other receptacles when ware has been fired in powdered flint.

Cleaning of floors in china biscuit placing and scouring shops. — Regulation 12 (*c*) requires that the floors shall be impervious and thoroughly sprinkled and swept at least once a day. The Committee regarded the cleaning by vacuum as the most satisfactory method and should be encouraged. Failing that, an efficient moist method such as the use of damped sawdust.

(2) *Certain processes carried out in potters' shops.* — The evidence is that the dust in potters' shops arises mainly from two sources, (*a*) dirty floors and benches, and (*b*) the process of fettling.

(*a*) *Cleaning of floors and benches.* — The Committee recommend that an efficient moist method should be required as now recommended for china biscuit "placing" and scouring shops, and that every encouragement be given to firms to provide impervious floors on the lines suggested by the Research Committee of the National Council for the Pottery Industry. They also recommend that provision of sufficient accommodation be made for moulds and that arrangements should be made that the moulds be returned to the store and not left lying about the shop so as to impede the cleaning.

(*b*) *Process of fettling.* — Exhaust is at present required by Regulations for (1) fettling of flat ware by towing or sandpapering, with certain exceptions; (2) any other process of fettling on a wheel driven by mechanical power, except where (*a*) the fettler is fettling as an occasional operation, (*b*) fettling is done wholly with a wet sponge, or (*c*) fettling is done by the worker who has made the articles while the latter are still in a moist state. The Committee recommended that as the fettling of " white hard " ware is a very dusty process, if done on any wheel, whether driven by mechanical power or not, exhaust draught should be required for (i) all fettling of flat ware by towing or sandpapering; (ii) any other process of fettling flat ware except where (*a*) fettling is done with a wet sponge; (*b*) fettling is done while the articles are still damp. They further recommended that efficient exhaust draught should be required for all fettling of hollow-ware and other ware not dealt with above, unless the articles are so moist that no dust is given off.

Brushing of earthenware biscuit ware. — Efficient exhaust draught is required for this process under Regulation 7 (*a*) (viii) unless it is carried on in a room which has been certified by the Inspector of Factories to be adequately provided with general mechanical or other ventilation.

(3) *Polishing, sorting, and grinding processes.* — Exhaust draught can be required for these processes under Regulation 7 (*m*), but the Committee recommend that a definite requirement for exhaust draught be included in the Regulations.

The Committee recommended that in addition to those processes in which protective clothing was already required under Regulation 4, overalls and head coverings be required and worn by all workers exposed to pure flint dust, and by young persons who carry scraps from potters' shops, and that accommodation for depositing clothing put off during working hours be required for all workers who are required to wear overalls.

Recommendation was also made that Regulation 6 (*a*), which prohibits workers from taking meals or remaining during meal times in certain rooms, should be extended to processes involving exposure to flint dust, and that messroom accommodation be correspondingly extended. Similarly, that Regulation 11, requiring washing accommodation, should be extended to include all persons whose occupations exposed them to powdered flint.

Self Inspection

The Home Office Committee of 1908 [1] pointed out that to ensure satisfactory compliance with the Regulations, it is essential that every department of every factory should be under constant and regular supervision, which should be organised from within the factory. In accordance with their recommendations, Regulation 27 of the present Code requires the occupier of every factory to appoint a person or persons whose duty it is to carry out systematic inspections of the working of the Regulations in the factory and generally to enforce the observance of them. The evidence received by the Committee showed that in some of the larger works the system has resulted in considerable improvement. In the smaller works, however, equally satisfactory results do not appear to have been achieved. It appeared that this was partly due to the appointment of unsuitable persons and failure to allow sufficient time and facilities for carrying out the work. The Committee considered that the Regulations should be retained and should be more rigorously enforced, and expressed the view that conditions in potteries cannot be adequately controlled without daily inspection, and provided really suitable persons are appointed and given the whole-hearted support of the employers and workers alike, the Regulations should be invaluable.

Placing of China without Flint

The attention of the Committee was drawn to one or two practical experiments carried out by firms with a view to the abolition of the use of flint for china biscuit placing. In one case the setters for settering china flat ware are coated with a patent wash. Another firm have experimented satisfactorily with materials to take the place of flint for all placing of china biscuit ware. It seemed that it

[1] Cf. Bibliography, No. (5).

is within the range of possibility that at no distant date it may be practicable to supersede the present method of firing china ware in flint.

Compensation

Reference has already been made to the Report of the Departmental Committee on Compensation for Silicosis, dealing with the Pottery Industry. The Committee felt that a scheme on the lines of the Refractories Industries Scheme would have great advantages in that the interests of the employers and the workers could be adequately safeguarded and that in the long run it would prove more economical to the industry as a whole. A scheme of compensation was suggested on the lines of the Refractories Industries Compensation Scheme, but this was not given effect to. At present compensation is provided for under the Various Industries (Silicosis) Scheme, 1928 [1], which came into force on 1 February 1929, and applies to all workmen employed on or after 1 January 1929 in the following processes in potteries:

(*a*) The milling of flint or crushing or grinding of silica rock or dried quartzose sand.

(*b*) Any process in or incidental to the manufacture of china or earthenware, including sanitary earthenware, electrical earthenware and earthenware tiles, up to and including the preparation for glazing, but excluding underglaze decorating, and modelling and mould making, where these processes are carried on in separate rooms.

(*c*) The polishing, sorting or grinding on a power driven wheel in connection with the grinding of glost ware, and tile slabbing.

The Scheme provides for compensation in cases of total disablement and death only.

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(3) *Regulations for the Manufacture and Decoration of Pottery.* Statutory Rules and Orders, 1913, No. 2. His Majesty's Stationery Office. Price 2d.

(4) *Report of the Departmental Committee on Compensation for Silicosis dealing with the Pottery Industry.* His Majesty's Stationery Office, 1928. Price 1s. 3d.

(5) *Report of the Departmental Committee on the Dangers attendant on the Use of Lead and the danger of injury to health arising from Dust and other*

[1] Cf. Bibliography, No. (6).

Causes in the Manufacture of Earthenware and China. His Majesty's Stationery Office, 1910. Price 1s. 5d.

(6) *The Various Industries (Silicosis) Scheme, 1928.* Statutory Rules and Orders, 1928, No. 975. His Majesty's Stationery Office.

(7) *Mineral (Non-Metallic) Dusts, the Manufacture of Pottery, etc.* By Dr. J. T. Arlidge. London, Royal Sanitary Institute, 1893.

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(9) "Dust Counting in the Pottery Industry, with Special Reference to Health Considerations." By Dr. E. L. Middleton. *Transactions of the Ceramic Society*, Vol. XXIV, 1924-1925.

(10) "The Pulmonary Lesions produced by the Inhalation of Dust in Guinea Pigs." By H. M. Carleton. *Journal of Hygiene*, Vol. XXII, No. 4, p. 438. July 1924.

Sandblasting

Sandblasting is the process of projecting sand or other grit by means of compressed air or steam against a surface. It is used: (1) in metal works to remove adherent sand and irregularities from castings and to produce a surface of desired quality; (2) for etching on glass.

The process is employed in many industrial centres throughout the country.

Both sexes are employed on sandblasting small articles, but men only on the heavier metal work. It is not possible to state the numbers employed in the process, which is a small subsidiary of the industries, but experience indicates that the process is receiving increasingly wide application.

In metal working sandblasting is employed for cleaning castings of all kinds and for producing a surface on the metal suitable for subsequent treatment. In metal work instead of sand, chilled iron shot, ground granite or flint may be used.

The article of metal may be placed in the open air and sprayed with the abrasive from a nozzle. Usually with large articles the work is done in an enclosed chamber, the worker being covered with protective clothing and provided with a helmet with an independent air supply. Small articles are done by adapting the process within a smaller closed cabinet before which the worker stands, passing his hands through guarded holes to direct the abrasive from the nozzle, while watching the process through a glass panel in the front of the cabinet.

In the etching of glass, the article is held against a stencil plate, the abrasive reaching it through the stencil and being retained in the machine by a suitable collar of rubber or other material. A cabinet such as that used for treatment of metal articles may be used for glass.

The dust hazard in the cleaning of castings is from the moulding sand and from the abrasive, where this is sand or siliceous grit such as flint or granite. Where clean castings or other metal articles are treated the danger is from the siliceous abrasive alone. The sand, granite or flint, by repeated use in the machine, becomes finely comminuted and fine dust escapes in spite of the precautions required to be taken. Unwarrantable risks are incurred by workers in faulty methods, such as opening the door of the hand cabinet to look at or move the work, while the air within the cabinet is full of fine dust, instead of allowing the exhaust draught time to act before opening the door. In the large chambers the workers are sometimes found to leave the door partly open, thus interfering with the exhaust; or they may remove the helmet while still working in the dust laden air of the chamber.

Defects in the apparatus are bound to occur from time to time, and the closest attention is necessary to detect and remedy leaks. Even with the closest attention the process of sandblasting appears to carry a serious danger of producing silicosis where siliceous abrasive is used.

Five cases of silicosis, two of them fatal, have been brought to the notice of the Factory Department since August 1928, and as silicosis is not statutorily notifiable it may be presumed that other cases may have occurred.

Particulars of the five cases are given below:

TABLE XXXVII

Industry	Sex	Age	Period of employment in sand-blasting	Process	Diagnosis	Remarks
Cycle accessories	Male	Years 40	20 years	Cabinet type	Silicosis	Fatal. Radiogram shows numerous dark nodules over whole of both lungs; no tuberculosis.
Steel works	do.	—	12 ,,	? Chamber	do.	Diagnosis confirmed by radiograph. No tuberculosis.
Motor accessories	Female	—	. —	Cabinet	do.	Occasional hæmoptysis; no other sign of tuberculosis.
do.	Male	21	12 months	do.	Silicosis and tuberculosis	
Carburetters	do.	54	7 ½ years	do.	do.	Fatal; diagnosis confirmed by post-mortem.

Regulations for the Grinding of Metals (Miscellaneous Industries)[1] came into force on 1 November 1925, and they include Regulations for sandblasting in the cleaning or smoothing of castings by a jet of sand, metal shot or grit or other abrasive, propelled by a blast of compressed air or steam.

The Regulations provide that: (1) sandblasting shall not be done in any room except in an enclosed chamber or cabinet in which no other work is ordinarily performed and at which efficient means are provided to prevent escape of dust to the outside of the chamber or cabinet. (2) No person may perform sandblasting in the open air or work within 30 feet of such unless he is wearing a suitable protective helmet and gauntlets; during sandblasting in a chamber overalls are also required. (3) The protective helmet must be provided with a supply of pure air, means of escape for exhaust air, and it must bear the mark of the person using it. (4) Before being used by another person the helmet must be thoroughly disinfected.

The prevention of silicosis would best be attained by the use of a non-siliceous abrasive such as metal grit, where possible. Some manufacturers have adopted this line primarily with the health of the worker in view.

Compensation

The Various Industries (Silicosis) Scheme, 1928, provides for compensation in cases of total disablement and death of workmen employed in foundries and metal works on " Sandblasting of metal or articles of metal by means of compressed air and with the use of quartzose sand or crushed silica rock or flint ".

Bibliography

(1) *Regulations for the Grinding or Glazing of Metals, or processes incidental to the Grinding of Metals or the Cleaning of Castings.* Statutory Rules and Orders, 1925, No. 904. His Majesty's Stationery Office. Price 2d.

(2) *The Various Industries (Silicosis) Scheme, 1928.* Statutory Rules and Orders, 1928, No. 975. His Majesty's Stationery Office. Price 3d.

Silica Milling

This industry is concerned with the grinding of silica rock, crystal quartz or silica sand, all containing a very high proportion, usually about 98 per cent., of free silica. The silica-flour so produced is used for many purposes, as the manufacture of scouring powders, paint fillers, wood fillers, silica glass, and for foundry use.

[1] Cf. Bibliography, No. (1).

The rock, quartz or sand is quarried and dried (the rock is sometimes calcined) and crushed and ground by machinery to a fine powder. In some works a system of exhaust draught is provided over the crushing, grinding, sieving and conveying machinery and the exhausted air is collected in filter bags, the finest powder being collected in this way.

The industry is not extensive; it is distributed near the source of the raw material, most being in the north-west of England. A considerable amount of ground silica is imported from the Continent and from America.

The amount of dust liberated in the processes is frequently very great. At a silica grinding factory where the machinery was enclosed and localised exhaust draught was provided, the following atmospheric dust samples were taken with Owens' dust-counter:

(1) Outside. Filling a truck with silica rock from a rail dump,
229 particles in 1 c.c., 2% over 2 μ.
The wind disperses much of the dust here.

(2) Feeding the crusher with silica rock,
1,169 particles in 1 c.c., 11% over 2 μ.

(3) Same as (2).
1,385 particles in 1 c.c., 14% over 2 μ.

(4) At a bagging shoot,
1,205 particles 1 c.c., 14% over 2 μ.

(5) Same as (4).
1,096 particles in 1 c.c., 14% over 2 μ.

At this factory, dust escaped from a number of slight defects in the housings enclosing the machinery, as inevitably happens as a result of vibration, and the escaping dust was seen to rise upward. A dust sample taken on the staging above the tube mills, about 16 feet from the floor, gave:

4,061 particles in 1 c.c., 12% over 2 μ,

indicating a high concentration of dust.

At a working where vein quartz was obtained and crushed to sizes from $^1/_8$ to 1 inch, the following counts were made from atmospheric dust samples taken at breathing level in some of the processes.

(1) Hand drilling in the open; running water in the working,
15 particles in 1 c.c., 4% over 2μ.

(2) Feeding the crusher, wet,
168 particles in 1 c.c., 3% over 2μ.

(3) Weighing " fines " (1/8 inch) in the open,
385 particles in 1 c.c., 10% over 2μ.

(4) Bagging " fines ", in shelter of a shed,
2,301 particles in 1 c.c., 10% over 2 μ.

From the low counts, which include many fine particles, it appears that work done in the open, on wet material, carries a low or negligible risk. The weighing and bagging processes here did not involve continous exposure. As the working was at a remote spot in the hills, the counts may be regarded as free from extraneous dusts.

At a factory where pure quartz crystal is used, an atmospheric dust sample at breathing level of a girl sieving quartz under exhaust gave a count of

5,977 particles in 1 c.c., 10% over 2 μ.

By rearranging the work this process was entirely enclosed and the exposure of the worker to dust was obviated.

Evidence of Silicosis

One fatal case of silicosis with tuberculosis, the diagnosis confirmed by post-mortem examination, occurred in a silica milling factory. The man, aged fifty, had been employed for 3½ years up to a period four months before his death.

Methods of prevention include the use of water where possible and localised exhaust draught, especially when combined with enclosure of the machinery.

Compensation

The Various Industries (Silicosis) Scheme, 1928, includes " breaking, crushing, grinding, sieving, mixing or packing of silica rock, or of dried quartzose sand or any dry deposit or dry residue of silica or any admixture containing such materials; or any process incidental thereto "; and " handling or moving of silica rock, or of dried quartzose sand or any dry deposit or dry residue of silica, in or incidental to the processes mentioned in the foregoing paragraphs ".

Bibliography

The Various Industries (Silicosis) Scheme, 1928. Statutory Rules and Orders, 1928, No. 975. His Majesty's Stationery Office.

Processes in which Ground Silica is Used

Silica enters into the composition of many industrial materials in virtue of one or other of its properties, as abrasive, inert filler, refractory material, insulator, or acid in vitreous bodies. In all the processes where the silica, dry, and in a fine state of division, is liable to give off dust, the risk to health from its inhalation must be assumed, since the conditions are comparable with those known to produce silicosis in industries where its presence is found.

Scouring Powders

Scouring powders are chiefly used as domestic abrasive cleansers. The manufacture consists in mixing the abrasive, which may be finely ground silica rock, or ground pumice, with other ingredients, soda ash, powdered soap, etc., and filling the mixture into cartons, packets or bags. Sometimes the ground abrasive is packed without admixture with any other substance.

Distribution

A considerable number of small undertakings were started, frequently as a subsidiary branch of another business, in widely scattered places over the country, in which the proprietors and workers had little or no knowledge of the risk to health or the means necessary for avoiding it.

Employed Persons

The number of employed persons fluctuates, but there are probably less than 500 employed. Men are usually employed on mixing machines, women and girls on packing.

The Processes

Except in a few of the largest works, the silica rock is obtained already finely ground. It is usually a highly siliceous quartzite rock, containing 96 to 98 per cent. free silica, and it may be calcined before being ground. The silica flour, as it is called, is mixed with powdered soda ash, soap, and sometimes other substances, either by hand with a shovel, or in a mixing machine. Filling of the cartons may also be done by hand, or the mixed powders may be conveyed automatically to mechanical fillers; the lids are then placed and fixed by a machine.

Characters of the Dust

The dust to which the workers are exposed is silica, before the process of mixing and in packing where no other ingredient is added. Frequently the silica is mixed with powdered soap, and with carbonate of soda, and sometimes with gypsum, pumice, or other substance. The mixed powders, necessarily kept dry, are liable to give off dust in the mixing, conveying and filling machines. The presence of free alkali with the silica dust may have an important influence in producing injury to the lungs.

At one factory, that at which the fatal cases described later were employed, atmospheric dust samples were taken at breathing level of the workers, with Owens' dust-counter, with the following results. The particles were nearly all colourless, of irregular shape, and appeared to be derived from the process. No soot particles are included in the counts.

TABLE XXXVIII

No.	Process	Number of particles in 1 c.c.	Particles over 2 μ
1.	Emptying ground silica into the mixing machine	1,048	11
2.	Carton filling machine	1,193	20
3.	Putting lids on cartons	891	16
4.	Fixing lids by machine	735	6.5
5.	Filling cartons by hand	590	18

Localised exhaust draught was provided at all the processes.

Evidence of Silicosis

In one factory in which about 22 persons were employed in the manufacture of scouring powder, 4 deaths occurred within a remarkably short space of time. There was some evidence that 4 other workers at the same factory who were said to have died of pulmonary tuberculosis may have died from silicosis. These workers were employed in the factory before localised exhaust draught had been provided, when the employers were unaware of the danger to which the workers were exposed.

Brief notes on the 4 cases on which post-mortem examinations were made, are as follows:

Case I. — Died 16 June 1928, aged 19, female. Employed as a carton filler from March 1924 until May 1928—4 $^2/_{12}$ years. History of pleurisy: December 1927, cough and pains in the chest, temperature 99.6° F. No tubercle bacilli in the sputum. X-ray examination —appearance of miliary tuberculosis. Admitted to hospital 1 June and died 16 June 1928.

Post-mortem, showed poor general development, heart muscle soft and flabby; air passages congested and contained muco-pus; adhesions over the right pleura and fluid in the pleural cavity. The lungs were of firm consistence and were covered with grey nodules which showed a tendency to coalescence in the right lung. There were no cavities and no necrotic areas as in pulmonary tuberculosis. The bronchial and tracheal glands were enlarged, firm, grey, and not caseated.

Microscopic examination of the lungs showed dense nodules of fibrous tissue, with areas of necrosis and chronic catarrhal inflammation, and a terminal inflammation at parts due to pneumococcus. No tubercle bacilli were found in the lung, although prolonged search was made. The glands were necrosed and what appeared to be a few tubercle bacilli were found in them. Polarised light showed granules in large numbers in the lung and chest glands.

Case II. — Died 4 June, 1928, aged 17½, female. Employed as a carton filler from 9 October 1925 to 17 March 1928—2½ years. Since December 1927, she had complained of headache, nose bleeding and vomiting in the morning. She was treated for bronchial catarrh. She went into hospital on 30 April 1928 with a diagnosis of pulmonary tuberculosis. She suffered from dyspnœa. There was irregular pyrexia. The sputum was repeatedly negative on examination for tubercle bacilli.

Post-mortem examination: the findings closely resembled those described in Case I. Microscopic examination of the lungs showed numerous large fibrotic patches surrounded by a small cell infiltration, and in the interstices were finely granular pigmented or black deposits. The alveolar tissue was much reduced; the walls were thickened with fibrous tissue and the alveoli were filled with albuminous exudate. The general picture was that of chronic inflammation with fibrosis. The glands appeared to be almost completely fibrosed. There was no evidence of tuberculosis and tubercle bacilli were not seen.

Case III. — Female, aged 23. Employed from July 1919 to November 1928. She was usually employed on wax polishes and occasionally worked overtime in the scouring powder department. She would not work more than 6 hours in any week and for a few weeks only in any year. This employment on scouring powder began about 1921. She was ill about six weeks with cough, loss of weight and loss of appetite. Removed to hospital on 6 December and died on 3 January. While in hospital the chief symptoms were cough and dyspnoea. The sputum was scanty and was negative for tubercle bacilli at first, but later was positive. This patient was X-rayed in June 1928, and the film showed slight general diffuse fibrosis.

Post-mortem, the lungs showed the presence of silicosis and tuberculosis. In this case the silicosis was less advanced than in Case I. Microscopic examination of the lungs and glands showed deposits of silica revealed by polarised light.

Exposure to the dust of scouring powder over a period of 7 years and was intermittent. This difference in the history of exposure from Cases I and II appears to be of special interest in view of the differences in the nature of the silicotic lesions in the lungs and also of the presence of tuberculosis.

Case IV. — Male, aged 19, employed from February 1926 to April 1928. He was employed in the mixing room and on packing, about equally. He first complained of cough in August 1927. Off work five weeks. He was ill again in April 1928, and was treated in a sanatorium. He went back to work for 9 weeks, but not on scouring powder, the manufacture of which had been given up. He was admitted to hospital on 28 January 1929 with open pulmonary tuberculosis, pyrexia, and emaciation. He died on 27 December 1929.

Post-mortem examination: lungs showed tuberculous cavities in all lobes. The remaining parts of the lungs were hard and contained a large number of hard nodules the size of a pea. Glands at the roots of the lungs were enlarged and very hard.

Microscopic examination of the lung showed chronic tuberculosis. The gland showed much fibrosis with patchy distribution of yellowish brown granular material, suggesting silicosis. In this case the silicotic process appeared to be present in the lungs in an early stage.

Prevention

Suppression of dust in the processes of mixing and filling are by no means easy. Even with exhaust draught, the powders, owing to dryness and fineness, are liable to liberate dust. Success appears to be best attained by making use of mechanical methods to the utmost extent, enclosing the machinery and applying exhaust draught to the housings so as to maintain an inward directional air current, and to all points where feeding or discharging takes place and dust is liable to be liberated.

Compensation

The Various Industries (Silicosis) Scheme, 1928, applies to workmen employed in certain specified processes which include sieving, mixing or packing of silica rock, or of dried quartzose sand or any dry deposit or dry residue of silica or any admixture containing such materials; or any process ancillary thereto; and to the handling or moving of these materials in or incidental to the processes mentioned.

The Scheme provides for payment of compensation in cases of total disablement or death from silicosis or silicosis accompanied by tuberculosis.

Bibliography

The Various Industries (Silicosis) Scheme, 1928. Statutory Rules and Orders, 1928, No. 975. His Majesty's Stationery Office.

Flint Crushing

Apart from the milling of flint for use in pottery manufacture, flints are crushed for poultry grit and for grit for sandblasting, and sandpapers. The industry is a small one, employing few persons, and is carried on chiefly in the south of England.

The flints are broken in a stone crusher, passed through rotary sieves and sorted into required sizes. The processes are usually carried on in open sheds and localised exhaust draught is provided at the points where dust is produced.

The dust is of raw (uncalcined) flint and the amount produced would undoubtedly involve risk of silicosis, but in most of the processes there is no constant exposure or close application of the workers, and the open character of most of the works buildings allows of the free action of wind.

In this, as in all the silica industries, the actual danger cannot be assessed, as silicosis is not a reportable disease under the Factory and Workshop Acts. As many of the processes belong to ill-defined industries, the labour turnover is considerable and the nature of a man's employment may be lost sight of should he develop symptoms and signs of silicosis some years after he has left it.

Flint Knapping

The making of flints for flint-lock guns or pistols. This ancient industry is confined to the village of Brandon in Suffolk. It was investigated by Dr. E. L. Collis in 1911.

The numbers employed have steadily diminished in the last fifty years. In 1911 about 12 men, and in 1929, 5 men only were employed, and these not constantly owing to fluctuations in the demand.

The interest of this industry lies in its antiquity and the fact that it is a pointer to, if not a measure of, the danger of inhalation of flint dust—almost pure silica—carried on in small workshops in rural surroundings and therefore unaccompanied by the other industrial hazards so frequently met with in silicosis producing occupations.

The process consists of splitting flints with a hand hammer into pieces about 1 by $^3/_4$ inch in size, flat on one side and with bevelled edges on the other side, the faces showing the typical conchoidal fracture of flint. The flints are packed in small sacks of 200 and are exported for bartering with natives of Africa. The hammer blows fall on the flint with remarkable rapidity and with each blow a small, scarcely perceptible, cloud of fine dust is liberated.

Two samples of atmospheric dust were taken at breathing level of two men knapping flints. The counts gave 1,313 and 1,192 particles in 1 c.c., with 1.4 and 2 per cent. particles over $2\,\mu$ respectively. Most of the particles were under $1\,\mu$ in size. Some dust is liberated when the work benches are cleared of debris, but mixed with this dust is chalk from the outside of the flints.

The evidence of silicosis being produced is, at present, entirely statistical. From data provided by the Registrar-General's Department, Collis reported 27 deaths during the twenty-five years 1886-1910. Of these, 21 were from phthisis, 2 from other respiratory disease, and 4 from other causes. The average age at death of the 21 who died from phthisis was 42.3 years. The death rate was 41.0 per 1,000 living compared with 0.8 for the Brandon Rural district and 1.58 for all males, England and Wales, for the same period.

Methods of Prevention

As the workers maintain that the flint must be dry for proper working, water cannot be employed. Localised exhaust draught would be too costly for this decadent and precarious industry in which no mechanical power is used. Respirators, standardised to protect against this very fine dust, would be difficult to attain, but at least partial protection might be afforded in this way, and, together with the intermittency of the work and the possibility of working in the open air, as is done in summer, sufficient relief from exposure might be attained to carry the worker through his life without a disabling degree of silicosis.

Compensation

The Various Industries (Silicosis) Scheme, 1928, covers the breaking of flint. Probably there is no one employed in this industry at present who comes within the definition of " workman " in the Workmen's Compensation Act, 1925.

Bibliography

The Various Industries (Silicosis) Scheme, 1928. Statutory Rules and Orders, 1928. No. 975. His Majesty's Stationery Office.

Millstone Dressing

This is an occupation in which a comparatively small number of persons are employed. It consists in dressing the millstones for the grinding of corn in distilleries, corn and fodder mills, and for grinding chocolate in chocolate factories.

The process is carried on in many districts throughout the country, where the mills exist.

The persons employed may be specially skilled men who have learned the trade and are solely employed on the process, or the work may be done as a part-time occupation.

The corn mills consist of two circular stones placed horizontally. They may be composed of any hard stone but are usually a hard quartzite grit, chert or buhrstone—a chalcedonic form of silica—or artificial stones. Dressing of the stones is done with an adze-shaped steel tool, by chipping along the ridges which run radially from the centre. During chipping a slight cloud of fine dust rises.

Two cases of death from silicosis and tuberculosis in millstone dressers have come to the knowledge of the Factory Department recently. The first case was of a man, aged fifty-four, employed as a cornmillers' stone-dresser since boyhood, with the exception of a few years in the Army in early manhood. Eight months before his death he gave up work on account of dyspnoea and loss of weight. X-ray examination showed silicosis and tuberculosis.

Post-mortem examination confirmed the diagnosis. There were besides the tuberculous lesions, innumerable nodules of silicotic fibrosis confirmed by microscopic examination.

The stones dressed by this man were 90 per cent. Derbyshire silica rock, the remainder French buhrstone.

The second case was a man who died, aged thirty, from silicosis and tuberculosis, but no post-mortem examination was made. He was constantly employed from boyhood on dressing Derbyshire millstones in a corn mill. He became totally disabled by the disease, six months before his death.

Prevention of inhalation of dust in the process could be achieved by the provision of localised exhaust draught, but this would have to be by a flexible duct so that the hood could be moved during the process of chipping the stone which remains in situ.

Compensation

The Various Industries (Silicosis) Scheme, 1928, applies to workmen employed in " sawing, planing, dressing, shaping, cutting, or carving of silica rock ". For the purposes of the Scheme silica rock includes quartz, quartzite, ganister, sandstone, gritstone and chert.

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The Various Industries (Silicosis) Scheme, 1928. Statutory Rules and Orders, 1928, No. 975. H. M. Stationery Office.

PNEUMOCONIOSIS IN ITALY

BY PROFESSOR GIOVANNI LORIGA,

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Italian research workers have furnished several interesting contributions to the knowledge of respiratory diseases due to the inhalation of dust. This is proved by the bibliography on the subject, which during the last twenty-five years has enriched knowledge of this question and which comprises numerous studies and results of experimental research on the pathological action of dusts, numerous clinical observations on diseases of the respiratory system met with in workers engaged in dusty operations of various kinds, as well as accurate investigations into the health conditions of special groups of workers exposed to forms of pneumoconiosis. In addition, however, other references to pulmonary diseases of these workers are frequently to be found in other books and monographs.

Nevertheless, it must be recognised that the study of these disease forms has not been so extended or profound in Italy as in certain other countries, especially the Anglo-Saxon countries and Germany. The scarcity of contributions by Italian scientists is evident, in particular, in regard to that form of pneumoconiosis which accompanies mining or operations connected with stone or clay, and which has been fully studied in other countries under the designation of " miners' phthisis ".

In seeking the cause of this phenomenon, it is not, in our opinion, possible to plead either the limited number of workers engaged in dusty operations in our mines, quarries or other places in which stone or clay is manipulated, or the temporary character of most work of this kind (such as, for instance, in the case of workers engaged in the excavation of railway tunnels or in the paving of streets), or hygienic conditions superior to those in other regions, or again the instability of most of the workers in question who, as is well known, quit work very readily in the dusty trades and immediately find other occupations. Further, in Italy, analogous conditions and inconveniences are found in similar occupations, hardly differing at all from those attaching to the corresponding work in other countries.

It is almost certain, on the other hand, that the reason why Italian medical bibliography on the subject is not so rich as that of the other countries above referred to should be sought in the small number of workers affected by miner's phthisis who come under medical observation, and especially in the fact that it is a question of isolated cases, or rather that pneumoconiosis does not assume the character of a mass infection or a focal disease, and that therefore it is not strictly related to a given locality or to a certain quality of material, as would appear to be the case in other countries.

It is, however, very probable that the limited extension and the less serious nature of the cases depend on the fact that in our country the composition of the minerals extracted or worked presents a relative poverty of siliceous material.

It is well known, in fact, amongst medical men that the most dangerous mineral dusts are those of a siliceous nature, since the presence of silicic acid gives to the dust particles greater hardness and a remarkable irregularity of form by means of which their surface becomes very rough, sharp and cutting and they are therefore rendered capable, not only of considerable injury to the tissues, but also of remaining insoluble amongst these. Recent studies, the conclusions of which have been confirmed by the Papers presented by Mavrogordato and Irvine to the fourth meeting of the Permanent International Committee for the Study of Occupational Diseases (Lyons, April 1929), and have given support to the older statements of Weigmann and of Lubenau, lead to the belief that the most harmful dusts are those containing siliceous oxides (SiO_2 = silicic anhydride or bioxide of silicon). To this category belong quartz dusts and those of its various forms (rock crystal, agate, amethyst, chalcedony, jasper, onyx, opal) as well as siliceous sand, fossil dust, granite and sandstone.

There would, on the other hand, be considered in the second place, that is, as of average harmfulness, the *silicates*, those of the heavy metals: for instance, silicates of copper (malachite and azurite) and of zinc (calamine) or others variously mixed with other clays (asbestos, mica, slate, kaolin, cement).

Besides the poverty in silica of the mineral deposits, there must, however, be kept in mind, in our opinion, other factors concurring to augment or diminish the pathogenic capacity of all the dusts, especially when the disease attacks large groups of workers, and when the conditions in question vary greatly in different localities.

Such conditions are in the first instance those relative to the hygienic conditions obtaining in the workers' homes and in the workplaces, and secondly, *the duration of exposure* of the worker to the action of the dust.

Nevertheless, it is not difficult to recognise that many of those who insist on a special and extraordinary gravity of silicosis have overlooked almost entirely this influence, whilst they have attributed great importance to the physical properties of the dusts inhaled, when engaged in research for the causes thereof or in research relative to the pathogenic interpretation of the pneumoconiosis described by them. We suspect, on the other hand, that such information may play a role which will become preponderant when the study of the disease has been completed by enquiry into the physical and social environmental conditions.

We do not desire thereby to deny that more serious pulmonary diseases and also perhaps more rapidly developing forms are caused by siliceous dust, but we only wish to insist on the fact that in the first instance we cannot recognise any specific character in their pathogenic action, such as certain authors desire to do, some of whom have almost made of silicosis a separate disease to be distinguished from the general pathological picture of pneumoconiosis, presupposing even a hypothetical chemical or chemicotactic influence exercised by the above-mentioned dusts on the lymphatics and other cellular elements.

It seems to us that this aspect of the problem may be highly interesting, but requires to be still further investigated and cleared up by means of accurate experimental research, since the statement has so far not been supported by sufficiently convincing proof.

Secondly, we must make certain reservations in regard to the specific nature of the supposed cause which imparts to silicosis the particular character of a focal disease or a mass disease, such as it has assumed in some countries, and therefore also in regard to the applicability of preventive and social measures edicted by the legislation in Anglo-Saxon countries and in Germany, to other countries in which the disease above referred to does not present the same characteristics relative to its incidence and clinical gravity.

Obviously, in order to form a rational criterion in regard to this special aspect of the question, it would be advisable to take into consideration the other causative elements, mention of which has been made, and which seem to us of primary pathogenic importance, especially the following:

(*a*) The social and hygienic conditions under which the work is carried out, whether relative to the working conditions and to the means of prevention and protection against dust inhalation or to the welfare conditions of the workers, which are of such great importance in determining their physical resistance to disease in general and to pulmonary affections in particular.

(*b*) The intervention of the infectious tubercular factor. This factor constitutes in fact such a frequent complication as to leave the doctor almost constantly in doubt in regard to the gravity of the pneumoconiosis considered as a separate disease, since we do not yet possess sufficient criteria to enable us to effect a differential clinical diagnosis between *dust phthisis* and *tubercular phthisis* during the life of the patient, when the presence of the Koch bacillus in the sputum is lacking.

Another cause of doubt has recently been removed by the anatomo-pathological observations made by Mavrogordato, from which it would result that the large mononuclear endothelial cells, after phagocyting the grain of silica, are not destroyed, but thus conserve their vitality and acquire besides the capacity of assembling and forming pseudo-tubercles.

This observation evidently creates another remarkable difficulty in regard to the differential diagnosis between the two diseases, also on the *anatomo-pathological* side, so much the more so as the same author recognises that *all the fatal cases* of miners' phthisis at present encountered in the Witwatersrand are manifestly cases of tuberculosis. How is it possible to determine, we ask, the moment at which the siliceous granulation stops and the tubercular process commences, and how is it possible to distinguish the one from the other by clinical and radiological examination and perhaps also by *anatomo-pathological* examination ?

No one can but see how far these two facts—that is to say, the formation of granules due to silica, and, on the other hand, the total mortality due to tuberculosis—diminish the great importance attributed by some research students to miners' phthisis as a special clinical disease, considered capable not only of causing death to certain workers but of creating a very serious *mass pathology*.

In the Latin countries, as mentioned by the eminent research workers, Professor Martin, of Lyons, and Dr. Glibert, of Brussels, the various and complex symptomatology attributed to miners' phthisis in Anglo-Saxon countries and in Germany is practically unknown, and it would therefore be advisable to engage in a detailed study of silicosis and the other forms of pneumoconiosis in our countries also.

With the precise intention of collaborating as far as possible in developing the knowledge of this most important problem of occupational pathology, which affects the great mass of workers, there have been undertaken in Italy, since the Lyons Congress, certain researches into the pathology of workers in the slate, asbestos and marble industries, the results of which will be communicated to the Johannesburg Conference.

In this preliminary paper, it is intended merely to set forth the present-day state of the pneumoconiosis problem in general in our country as derived from laboratory experiments, clinical, anatomical and statistical data assembled from various research workers who have dealt with the question, or from special investigations covering certain working establishments.

Without going back to the clinical and anatomical observations made by Ramazzini, Morgagni and other authors in past centuries, it is easy to affirm that the study of disease due to dust affecting the respiratory organs has not been neglected in the revival of interest in the subject of occupational disease to which our research workers have testified about the year 1900. Many publications have been devoted to the study of general questions relative to pneumoconiosis. Others deal in particular with the pathogenic action of certain qualities of dust.

In the experimental field there should be recalled in the first instance the researches of Biondi (1906), who, by making animals inhale *metallic* dusts collected in the workings of the Sardinian mines, succeeded in producing in them more or less diffused bronchitis and small foci of bronchial pneumonia.

He carried out, moreover, experiments by means of the ingestion of inert dusts (non-metallic) and noted that these also produced a form of pneumoconiosis, but that grains of dust were not found, as in the case of pneumoconiosis, from inhalation in the bronchial tube and in the alveolar cavities, but only in the inter-lobular and inter-alveolar tissues and in the tissues between the inter-alveolar groups. Soon thereafter in order of time (1907) there appeared the study by Tommasi-Crudeli, chiefly anatomo-pathological in character, entitled " Destiny of the Dust Introduced into the Lung ". Feliziani (1906) and Romby (1908) directed their experimental researches to the study of the intestinal origin of pulmonary anthracosis, the first denying, and the second affirming the possibility, in confirmation of the observations made by Biondi.

The question of pneumoconiosis was moreover discussed by Ruata in 1908.

Guerra-Coppioli, in 1911, resumed the question of the intestinal origin of anthracosis, arriving at a negative conclusion and asserting, on the other hand, that the lymphatic ganglia of the mesentery constitute an almost insurmountable obstacle to the small corpuscles coming from the intestine with the lymphatic current.

The report of Devoto and Cesa-Bianchi to the third National Congress for Occupational Diseases (Turin, 1911) must be considered as a complete survey of the whole question relative to the pulmonary pathology of dust inhalation. These authors have emphasised the difficulty of provoking pathological phenomena in the respiratory apparatus in the case of guinea-pigs kept for eight to ten weeks and four to six hours per day in a very dusty atmosphere, and the facility, on the other hand, with which these arise as soon as the guinea-pigs are forced to exercise mouth breathing by closing the two nostrils or even one nostril. They have besides found alveolar lesions on microscopic examination of guinea-pigs which had inhaled cement. They have moreover studied the relation between pneumoconiosis and tuberculosis, asserting that the animals subjected to the inhalation of very fine limestone dust are less susceptible to tuberculosis than those which have inhaled silica dust.

In the same year, Moscati had stated at the Congress of Physiology that the prolonged experimental inhalation of starch dust was capable of producing evident connective peri-bronchial and subpleural sclerosis, though of a mild form. He saw, however, that the grains of flour undergo in the lung notable modifications which may presumably be interpreted as phenomena of hydrolysis or ptyalin digestion and finally become absorbed.

Tedeschi and Abbo have produced experimentally serious phlogistic processes of the respiratory organs of guinea-pigs by making them inhale for some time dust collected in grain silos (1914).

Recently Aiello has demonstrated that phrenicotomy favours the production of pneumoconiosis in animals subjected to dust inhalation (1929). Recently again Mazzitelli (1929) has felt justified in stating on the basis of some of his experiments that inhaled marble dust is subject, though only in part, to evident processes of transformation, absorption and elimination, whilst Bianchi has affirmed that it causes evident processes of reaction and inflammation in the lung.

As an offset to this important series of research contributions, numerous other studies of a clinical and anatomo-pathological character exist which have furnished important information on the ætiology and pathogenesis of the pulmonary diseases derived from dust.

There should be recalled in this connection the interesting studies of Devoto on the relations between pneumoconiosis and catarrh of the pulmonary apical zones (1913), on the non-tubercular lesions of the pulmonary apex (1914), on the relations between pulmonary affections due to dust and tuberculosis of the lung (1925) and on pneumoconiosis in its initial stages (1925).

Tedeschi also has described special non-tubercular lesions of the pulmonary apex (1914).

Highly interesting are, moreover, the histological and chemical researches of Boattini and Lo Faso on the essence of pulmonary anthracosis (1928), from which the said authors have drawn the conclusion that the particular colouring of the anthracotic lung is certainly due in part to the presence of iron, but that this fact does not afford justification for substituting siderosis for the conception of anthracosis, and that the anatomical and pathogenic conception of pulmonary anthracosis should not be in any way modified.

Ferrannini has measured the respiratory capacity of individuals engaged for many years in bagging flour, and who were decidedly free from tuberculosis (1911). In about half of these he found the pulmonary capacity to be more or less markedly reduced, that is to say, an indication of diminution of the respiratory surface due to encumbrance of the pulmonary alveoli. He was able, moreover, to demonstrate the presence of starch in the sputum of a few individuals, not microscopically but chemically, and also found there albumen, which he supposes to be derived from the gluten in the flour.

Another work of great importance has been completed by Bonanno (1928), who has studied from the clinical and radiological aspect eighteen cases of pulmonary silicosis in miners from the South African gold mines.

Meda also has completed some observations on the radiological picture of pneumoconiosis (1927). A few isolated cases of pneumoconiosis produced by different dusts are worthy of special attention.

Devoto and Cesa-Bianchi have reported the case of a glove maker, who during life had suffered from chronic bronchial catarrh and who, having died as a result of inter-current nephritis, showed during the pathological macro- and microscopical examination pneumoconiosis due to talc powder.

Ferrannini has studied a case of pneumoconiosis from cement, characterised by asthma and pulmonary emphysema in an individual whose occupation was handling cement (1928). His pupil, Sorrentini, had described a case of pneumoconiosis from flour (1923).

Fiori has moreover published particulars of a rare case of pneumoconiosis due to barium (1926).

Quite as numerous, and perhaps more interesting from the point of view of the discussions likely to take place in the international field in regard to dust pathology, are studies effected relative to the health conditions of groups of workers engaged in various dusty trades.

It would seem advisable to summarise rather fully the results of these investigations, since in them, rather than in clinical or anatomical findings pertaining to single individuals and laboratory experiments, we are likely to find elements useful in resolving the problems connected with the study of silicosis.

In a great many publications of various natures, clear indications are given not only of the incidence of the disease in question, but also of the high mortality rate from pulmonary diseases amongst workers engaged in the dusty trades of mining, quarrying or stonework. Mention shall, however, be confined here to recording a few of the more characteristic results taken from enquiries made on the spot.

Biondi (1906) had observed that amongst the miners in the mines of Sardinia the greatest damage due to the mechanical action of dusts occurs when the gangue of the mineral extracted contains silicates. He had moreover noticed that coal miners were almost all addicted to coughing and continued to expectorate an entirely black sputum even some time after they had quitted their occupation. In the workings of the mines of Bergamo, on the other hand (1907), he found minor injuries due to dusts, perhaps because the workers in these mines worked intermittently, the work in the mines alternating with agricultural pursuits. In a few miners, however, especially in the older men, Biondi met with cases of pharyngitis and bronchial catarrh with dark sputum due in great part to the black smoke of the candles used, and he observed that acute affections of the respiratory apparatus affected these workers more seriously and were of a more obstinate nature.

Frongia (1908), in twenty-six post-mortem examinations of miners from the Sardinia mines, effected with a view to studying pneumoconiosis, noted that the cause of death was in most cases an acute infection (pneumonia), but he found, nevertheless, very frequently amongst these workers serious and diffused arterio-sclerosis, emphysema and anthracotic foci, with more or less diffused softening of the tissues and presence of gangrenous foci containing a black broth-like matter, that is to say, the characteristic finding of black phthisis. On the other hand, foci of broncho-ectasia due to tubercular infection were only met with by him in five cases. Eighty per cent. of the fatal cases amongst the miners were not therefore cases of tuberculosis infection. Nevertheless, Frongia asserts that black phthisis would not represent the essential cause of death of the worker in any of the cases.

Pieraccini (1926) has noted amongst stonebreakers of fifty to sixty years of age (working on the roads), remarkable emphysematous conditions and ordinary forms of catarrh. Amongst the road-menders, however, he found many who showed a pronounced tolerance in the matter of resisting irritations due to dust.

Also in the sputa of these workers little addicted to coughing and who only suffered from time to time from catarrhal secretions from the nose and mouth, there was found dust in such quantity that it sufficed to take the secretion between the fingers in order to feel the presence of sand.

Pieraccini recalls that the working atmosphere in road-mending is one of the most dusty which exist (at least for many months of the year) and that the road dust which he examined was highly dangerous, since it contained amorphous silica to the extent of 22.47, with a content of aluminium and oxide of iron amounting to 4.45.

Evidently, however, the slight frequency of pulmonary affections among road-menders is due to the fact that they inhale the dust intermittently, and that for this reason it does not succeed in injuring the bronchial mucous membrane.

Vernarecci has studied mortality from respiratory diseases among *workers in some dusty trades* in Rome during the biennial period 1921-1922, and has established the following figures:

(*a*)	Macaroni makers and millers	tuberculosis = 16.66 per cent. of all deaths other pulmonary diseases = 33 per cent.
(*b*)	Stone masons and marble workers	tuberculosis = 14.80 per cent. of all deaths other pulmonary diseases = 14.15 per cent.
(*c*)	Carpenters and cabinet makers	tuberculosis = 18.6 per cent. of all deaths other pulmonary diseases = 16 per cent.
(*d*)	Masons	tuberculosis = 15.56 per cent. of all deaths other pulmonary diseases = 21.11 per cent.

The total mortality for all pulmonary diseases is therefore not excessive, since it averages about 30-36 per cent. of all deaths.

In a contribution relating to the injuries to health suffered by workers engaged in making vases (earthenware vases) in Sardinia, Marcello (1908) refers to the frequency of affections of the respiratory organs amongst workers engaged in turning.

Contradictory data exist relative to the incidence of pulmonary diseases amongst workers engaged in the cotton industry. Whilst Tassinari (1892) found amongst 100 weavers in the hospitals of Pisa in the years 1885-1890 a death rate of 2.07 from tuberculosis and amongst the other women in the hospital only 1.57, Pierotti during medical examinations effected in a cotton factory at Pontedera found:

(1) That amongst the male workers (comprising mechanics, firemen, cotton printers and finishers) there were found to be suffering from chest affections during the medical examination 15.5 per cent., or 10 per cent. affected with chronic febrile catarrh and 5.5 per cent. with tuberculosis (2.2 per cent. of which showed certain tuberculosis and 3.3 per cent. of which were doubtful).

(2) That amongst the women, on the other hand (all engaged in spinning, weaving and teasing), only 7.9 per cent. suffered from chest affections, more precisely 4.3 per cent. from chronic catarrh without fever, and 3.6 per cent. from tuberculosis (of which 1.61 per cent. revealed a positive diagnosis and 1.45 per cent. were doubtful).

Amongst workers in the alabaster industry, where for the most part work is carried out in narrow, badly ventilated workrooms unprovided with exhaust ventilation, and requires faulty posture on the part of the workman, who is obliged to inhale large quantities of dust (sulphate of lime), Pieraccini has found a certain incidence of catarrhal affections of the respiratory passages, but he has not given the proportion which these constitute of the deaths in the general population. De Hieronjmis and later De Guasta have found amongst these workers a high percentage of tuberculosis.

Besides these generic observations on the pulmonary pathology in a few dusty trades, we possess certain more extensive and important studies relative to certain special materials from mines and quarries generally regarded as involving greater risk for the health of the workers engaged in their extraction and subsequent manipulation.

Such materials are lime, cement and plaster, asbestos, slate, sulphur, marble and silica. On account of their interest and of the more accurate knowledge which we possess concerning them, it would seem advisable to give here a more detailed account of these.

Cement, Lime, and Plaster

Pesenti, at Alzano Maggiore, and Rota and Finzi, in Casale Monferreto and neighbouring districts, have contemporaneously (1906) dealt with the health conditions of workers manipulating lime, cement and plaster. Pesenti clearly affirms the high incidence of pneumoconiosis amongst workers in cement and plaster, but omits to provide proportional statistics. The conclusions which he draws from post-mortem examinations effected by him are, on the other hand, more explicit.

In one case he found that the process of pulmonary sclerosis had penetrated into the pleura, which was remarkably thickened and had lost all elasticity. In the lungs, disseminated amongst the sparse centres of normal parenchyma, were to be seen real connective islands thickened and hard, in the centre of which were found a nucleus of cement which grated under the knife. These were true pneumoliths. Similar alterations of connective neo-formations affected the lymphatic channels and the peribronchial tubes. A middle bronchial tube contained a broth-like mixture of cement; the mucous membrane of it was encrusted with pulverulent deposits; here and there were to be seen bronchial ectasia of varying dimensions.

The parenchyma free from incrustation showed the characteristic signs of vicarious emphysema.

In six other autopsies of workers in the cement industry, the author found sclerosis localised at a few points of the lung, circumscribed and nodular.

These forms of nodular, partial, broncho-pulmonary sclerosis follow, the author affirms, a slow evolution, and provide few subjective symptoms. He noted dyspnœa, loss of weight, night sweats, pleximetric and stethoscopic phenomena, and sputa similar to those of tuberculosis in the case of an individual in whom tuberculosis was not discovered, neither macro- nor microscopically, at the autopsy.

The case in question was only one of multiple nodular sclerosis of the lungs.

The author believes that the cement dust inhaled neither produces tuberculosis nor favours the evolution thereof, but he merely formulates this opinion as a hypothesis. These observations made by Pesenti are highly interesting, for they present very clearly the picture of the various forms of pneumoconiosis without tuberculosis, and also provide an idea of the varying nature of the clinical picture according to the gravity of the disease.

The study made by Rota and Finzi amongst workers in the cement and lime industry is predominantly clinical and statistical in character. They found that the morbidity and mortality rates for these workers (excavators, kiln workers, transport workers, crushing machine operators and baggers) are not higher than those of other workers. The diseases to which they are subject most frequently, however, are diseases of the respiratory apparatus, and besides, they often die at an early age. In fact, out of 63 deaths amongst the *permanent* workers engaged entirely in lime and cement work, 28 died before the age of forty and 11 under fifty. The cause of death was in 20 out of 63 cases due to pulmonary diseases, or, more precisely, in 9 cases to acute pneumonia, in 2 cases to pleuro-mediastinitis and in the other 9 cases to tuberculosis. The authors remark that there is no truth in the statement that lime-kiln workers enjoy a certain immunity from tuberculosis as averred by Halter. On the contrary, they found that the greatest toll to this disease was paid by the kiln workers. For instance, in the commune of Casale, 9 deaths of kiln workers out of 35 were due to tuberculosis.

During physical examination of 218 factory workers, Rota and Finzi found in 122 cases harsh respiration in the upper respiratory passages, due certainly, they assert, to an incipient pneumoniocosis or infiltration of dust in the peribronchial lymphatic channels. Harsh respiration was found more frequently in workers employed for a long time, and especially in those who had already worked for ten to twelve years. The proportions in which it was present were the following: 52 out of 128 workers engaged at the kilns, 18 out of 26 workers engaged in transporting stone, 43 out of 50 crushing machine operators, baggers and porters of sacks.

Many workers were also found to be emphysematous.

Asbestos

From an interesting statistical study made by Scarpa, it would appear that out of 30 workers (9 male workers and 21 women who had been engaged in manipulating asbestos in the mines or factory laboratories for weaving this mineral, and who were being treated in the department of the Turin Polyclinic under the direction of the author from 1894 to 1906), only one showed simple catarrhal lesions of the respiratory apparatus. The other 29 suffered from tuberculosis. All died in less than a year after the first medical examination, since the disease in a short time brought about destructive and ulcerative lesions of the lung. The author claims therefore that the asbestos industry is one of the most dangerous of those industries involving predisposition to pulmonary tuberculosis.

Slate

Already, in a communication dealing with the enquiry into conditions of factory workers completed in 1877 by the Ministry of Agriculture, Industry and Commerce, the sulphur mines of Sicily and the slate quarries of Liguria were designated as dangerous and liable to provoke special forms of ill-health in consequence of the nature of the work engaged in by the workers, as well as on account of the extremely heavy and trying work involved.

In a communication presented to the third National Congress for Occupational Diseases (Turin, 1911), Devoto and Cesa-Bianchi have stated that " in the district of Chiavari there has been observed a progressive loss of weight leading to premature death of workers (in the slate industry) without there being encountered, so it is affirmed, the tuberculosis bacillus ".

In *La Medicina del Lavoro*, 1929, No. 7, Devoto relates having found in the library of the Economic Society of Chiavari two monographs by Professor G. A. Mongiardini, of the University of Genoa

(1809 and 1812), and an Honours Thesis by Dr. G. B. Ravenna (1812), which illustrate the life of workers engaged in slate extraction in the quarries of Lavagna, and which contain many observations in regard to the diseases of the respiratory apparatus in question as well as many post-mortem findings. Also, a monograph by Dr. N. Della Torre, published in 1840 and entitled " Guide to the Quarries of Lavagna ", contains many clinical and sociological data relative to these workers.

Devoto himself records, moreover, that during the Congress of Italian Scientists, held in Genoa in 1846, there was discussed the pathology and hygiene of work in the slate quarries and that a priest, Giuseppe Ravenna, summarised all the medical and sociological studies on the subject in a publication dated 1879 and entitled " Memoirs of Lavagna ". All the elements furnished by this publication were co-ordinated in 1929 by Dr. Carlo Picchio, a pupil of Devoto, who made it the subject of his Honours Thesis.

The following are the principal data which have been extracted therefrom. Slate contains 25 per cent. of silica, 10 of aluminium, 35 of calcium and 30 of various other materials. About 1834 there existed in Monte-s.-Giacomo (Cogorno) seventy slate quarries, now abandoned, and the whole population of the region (about 4,000 persons) was engaged in working the slate, the men as excavators and cutters and the women as transport workers.

It would appear that the mortality was not high for that period, since Della Torre relates that from 1828-1837 there occurred in Cogorno only 422 deaths out of a population of 1,800 inhabitants (23.44 per cent.). It would seem, however, that males died prematurely, since from 1800 to 1816 more than half of them died before reaching fifty-five years of age, and in the period from 1780-1830 Della Torre found that only one man for each 10 women reached the age of seventy. Dr. Picchio, in scrutinising the death register from 1800 to 1816, noted that tuberculosis constituted a very frequent cause of death. Mongiardini also had drawn attention to the fact of the frequent incidence of pulmonary tuberculosis, and Ravenna had, moreover, written that the dust, being composed of " small particles, without doubt rough, hard, sharp, and having prominent points, calculated to wound and cut " when inhaled for a long time, could produce in the lungs changes sufficient to favour the outbreak of tuberculosis, which disease was commonest amongst the workers in question. Ravenna himself carried out a post-mortem examination of a quarryman and a stonecutter, and found only evidence of pulmonary tuberculosis without dust deposit.

The existence of true pneumoconiosis is demonstrated by the findings of an autopsy effected by Mongiardini on the corpse of a certain worker G. B. Binasco, aged fifty, an excavator at Cogorno. He found "the lungs fully more voluminous than the normal, of a dark red colour and variegated with blackish lines in the interior, similar to the colour of slate. There were multiple adhesions, especially of the left lung, which showed tophaceous concretions, and amongst these, a cyst as large as an egg, filled with ash-coloured pus. The back part was far more than half scirrhous, and almost stony and most difficult to cut into with a knife. The pleura and the right lung were sewn with tubercles, many of which were as big as a large hazel nut *(noce avellana)* and contained a blackish humour, others a very fine black powder which blackened the fingers and resembled wet and pulverised slate. The lung showed great hardness under the scalpel, which in cutting became toothed like a saw. Vesicules were found full of an earthy powder; many had coalesced, filled with the said powder, and seemed to form cysts."

The symptomatology presented by all the sick workers is described by Mongiardini, as well as Ravenna, in an almost identical manner—the state of denutrition more or less advanced to the point of approaching cachexia, dyspnœa, emphysema, chronic bronchitis. There is, however, some divergence between the views of the two authors as to the interpretation of the origin of the disease, since Mongiardini had at first denied and then (after the autopsy on Binasco) admitted the existence of dust in the atmosphere of the quarries, and Dr. G. B. Ravenna, on the other hand, admits that one of the principal causes of the diseases of quarrymen is the inhalation of slate dust, whilst he did not admit the existence of special diseases amongst the workers manipulating slate in the open, especially when protected against inhalation of the dusts.

Sulphur

In 1892, Dr. Giordano, of Lercara, described under the name of *theapneumoconiosis* a process of chronic broncho-pneumonia accompanied by abundant deposits of sulphur in the pulmonary tissue and in the peribronchial glands of sulphur miners. Giordano had had the opportunity of effecting a single autopsy on a miner, aged fifty-one, who had worked in the mines from the age of six and had died as a result of chronic broncho-pneumonia. In the lungs and in the bronchial glands there was found a great quantity of sulphur dust, but Giordano had also treated many miners suffering from chronic bronchial catarrh with rales, dyspnœa, cyanosis and emphysema, in the bluish-grey sputa of whom there was found a more or less extensive amount of sulphur dust accompanied or not by pus corpuscles, elastic fibres and bacillus of Koch, according as to whether tubercular infection had followed the pneumoconiosis or whether it was merely a question of pneumoconiosis in a pure form. He affirms, besides, having seen miners who had quitted their occupation still expectorating, not intermittently but constantly, pale bluish-grey matter two, seven and even twelve years later.

The observations of Giordano were confirmed by Lattuca at Casteltermini and by Ricevuti at Caltanissetta, all of whom, as a result of numerous autopsies on miners who had died by accident or had been killed, found in the lungs an emphysematous state, bronchial catarrh, greyish pigmentation, and besides, small nodules very compact and resistant, disseminated in the tissues, which grated under the knife and which varied in volume from the size of a grain of millet to a pea or larger, and which presented on section a surface of a blackish-grey colour.

Carapelle and Gabrielli, though not denying the existence of theapneumoconiosis, have expressed doubt as to its frequency; the first on a basis of theoretical considerations founded on the small quantity of fine dust daily inhaled by the miners, and the second, because, having had the opportunity of taking part in a number of autopsies on miners and having read the accounts of a number of other necroscopic examinations (in all eight cases), he felt unable to confirm the presence of infiltration of the lung by sulphur dust, whilst he found in all the cases a considerable extent of anthracosis. Giardina, however, has confirmed having observed in a sulphur worker who died of ankylostomiasis the complete findings accompanying *Zenker's pneumonoconiosis*, and he provides the following picture of the anatomical finding in the case of sulphur workers:

> The pulmonary tissue is rugged to the touch and grates under the knife; on the surface revealed in section there are bluish-grey stains and greyish nodules which extend to the size of a pea and are at times isolated or at other times grouped together round a caseified centre, or again surrounded by a more or less manifestly inflamed area. In the most serious cases, moreover, there are observed cavities in consequence of gangrene occasioned by compression exercised on the capillaries by the interstitial sclerosis. The bronchial tubes, here and there ectasic, are filled with muco-pus, and charged with a pigment recalling the fine dust of the mines. The alveoli have thickened walls and are moreover charged with purulent matter. The marginal areas of the lungs are emphysematous and the bronchial ganglia swollen and greyish in colour.

Numerous statistical data have moreover confirmed the frequent incidence of pulmonary diseases amongst sulphur workers.

Di Giovanni reported to the Congress for Occupational Diseases at Palermo (1907) that 47.4 per cent. of the sulphur workers examined presented chronic affections of the respiratory passages which ranged from chronic catarrh with emphysema to pneumoconiosis.

The Health Officer of Caltanissetta has reported in the years 1896 and 1897 the deaths of 250 sulphur workers, of which 199 (79.20 per cent.) were due to bronchial and pulmonary diseases. The Health Officer of Serradifalco has attributed to diseases of the respiratory passages 8 out of 19 deaths (42.10 per cent.) which occurred in 1898 amongst the sulphur workers of the commune. Dr. Ricevuti has, moreover, reported that of 739 deaths which occurred amongst the population of Caltanissetta as a result of pulmonary diseases in the triennial period 1896-1898, 308 (41.67 per cent.) were sulphur workers.

It is not, on the contrary, known precisely to what extent tuberculosis exists amongst this category of workers. Zampa has asserted that it is very rare amongst the sulphur workers of Romagna. Giordano, Burruano and others have said the same of the Sicilian sulphur workers.

Yet, as Giardina has justly observed, it is difficult to admit that sulphur dust is the almost exclusive cause of the extraordinary frequency of diseases of the respiratory apparatus occurring amongst sulphur workers, and that perhaps but little tuberculosis is diagnosed on account of the fact that the bacteriological proof is often neglected.

Marble

The pathology of marble workers is at present the subject of an interesting controversy. Fraschetti, subsequent to an enquiry on marble workers in Rome, had drawn attention to the fact that work of this nature predisposes the workers to contract pulmonary diseases, and Calderai had previously noted the very frequent incidence of these disease forms in the workers of Serravezza. During the years 1928 and 1929 there were published two works of greater importance which arrived at opposite conclusions from one another.

Dr. G. Bianchi, of Massa, as a result of clinical, radiological, anatomical, and statistical observations and animal experiments, has concluded that:

(1) The inhalations of fine marble dust cause alteration of the upper respiratory passages and disease symptoms (rhinitis, pharyngitis, bronchitis) such as to render null the protective function of these passages, which are no longer able to offer resistance to the penetration of the fine dust itself into the pulmonary alveoli.

(2) The fine dust, having arrived in the alveoli, gives rise to pathological processes such that the various defensive means possessed by the alveoli are weakened, if not abolished.

(3) The bacillus of Koch finds in the pulmonary tissue a ground favourable to its development and its pathogenic action.

The facts on which Dr. Bianchi bases his conclusions are as follows:

A group of rabbits kept for ten months in the marble laboratories presented bronchial and broncho-pulmonary symptoms, consisting in œdema, hyperemia, tumefaction, desquamation of the bronchial mucous membrane, casts composed of peelings of the epithelium and catarrhal secretions of the smaller bronchial tubes and the alveoli, intense vascularisation and production of new connective tissue in the interstitial tissues, obstruction of the ganglia of the hilum. Some of these rabbits, inoculated with the bacillus of Koch in various ways, developed tuberculosis of a much more serious and rapid evolution than others, which had not previously been subjected to dust inhalation.

Many workers showed the entire symptomology of forms of chronic bronchial catarrh and pulmonary sclerosis, and died of an insufficiency of the right ventricle or of acute complications which supervened, amongst the most frequent of which were tubercular infection.

Radiography of the respiratory apparatus has shown in the most simple forms of " marbloconiosis ", disseminated shadows, more dense towards the hilum, with an area varying from the size of a grain of rice to a small nut, and with peribronchial striae. In the cases complicated with tuberculosis, the specific tubercular foci develop preferably where the more intense shadows of pneumoconiosis are situated and evolve during a long time on the traces of already existent peribronchitis.

Further the cavitary lesions from the bacillus of Koch in pneumoconiotic subjects never assumed a considerable extension and rarely gave rise to large cavities. An anatomical, and pathological examination has revealed emphysema, sclerosis of the pulmonary tissue, the presence of hard nodules (pneumoliths) and other features of less importance.

Finally, statistical returns have demonstrated that the percentage of deaths from tuberculosis amongst marble workers is very high.

Dr. M. Mazzitelli, of Carrara, on the other hand, in studying the statistics of the causes of death of the population of Carrara, has observed that the tuberculosis mortality figures are very low amongst the marble workers since " out of 13,000 workers in two years there occurred 38 deaths, that is to say, 26 amongst workers in the open, in an atmosphere slightly or not at all dusty, and 12 amongst those daily subjected to dusty work in the laboratories ". He therefore concludes that marble dust is not an element which can cause tuberculosis, not to speak of causing predisposition to it. Besides he injected five times in succession, at periods separated by one month's time, 2 grammes of white marble dust (almost pure carbonate of lime) directly into the lower lobe of the right lung of a guinea-pig, and this animal not only remained free from any troubles but continued to gain weight and to multiply. Twenty-four hours after the fifth injection the lung of the guinea-pig subjected to radioscopic examination showed no opacity at the point of injection and the autopsy showed that the lungs were normal in form, volume and colour, and that their surface was smooth and glossy. The peribronchial glands were, however, well developed and firm. Microscopic examination revealed absolute absence of marble crystals, slight signs of an inflammatory process, with small infarcts, desquamation of the alveolar epithelium and infiltration of the septa. The other guinea-pigs inoculated, on the other hand, with dust from coloured marble, from granite, or dusts of mixed marble and granite, presented on post-mortem examination various lesions, such as adhesive pleurisy, degenerative processes, necrosis, etc.

A chemical analysis having been made of the lime in the lungs of the animals inoculated the smallest calcium content was found in the case of the guinea-pig injected with white marble dust and the largest in the case of that injected with dust from a mixture of coloured marbles.

From the results of this and other enquiries of less importance the author arrives at the following conclusions:

(1) Dust of Carrara marble is subject in the animal system to processes of absorption and elimination.

(2) A true dust pneumoconiosis from marble does not occur, at least as a usual phenomenon in consequence of work.

(3) Dust from Carrara marble cannot therefore be considered as phthisogenic.

It is difficult to pass judgment on these conclusions, which are in open contrast to those formed by Bianchi.

Silica

In regard to the importance of silica dusts as the cause of pneumoconiosis, we possess a single clinical study by Giglioli, carried out by a good method and, therefore, of much weight. Amongst the mercury mines of Monte Amiata there are some which have an argillaceous and damp gangue and one which has a siliceous gangue. Pieraccini had already remarked that amongst the workers who were engaged in the latter mine (Cornacchino) there occurred a high incidence of broncho-pulmonary affections and pulmonary tuberculosis, and an enquiry effected later by Drs. Puccinelli and Ginanneschi has confirmed the existence of this fact.

Giglioli found that in many of the miners at Cornacchino and in almost all those who worked at the top of the road, where the air is richer in silica dust, there occurred after two to three years of work broncho-pulmonary affections with coughing, breathlessness, emphysema, dusty but not hæmorrhagic expectorations, almost always without fever and without marked decline. In general, however, after a more or less lengthy period which may last even five years fever sets in, the expectoration becomes haemorrhagic, there occurs at times hæmoptysis and organic decline becomes evident. There appear, in short, all the signs of pulmonary tuberculosis. There is, consequently, almost always a well-marked pre-tubercular period, which may evolve slowly without tubercular complications and which corresponds to the so-called miners' phthisis as it has been precisely described in the Transvaal Rand Mines by the English Royal Commission of 1906.

More recently than Giglioli, Mazzi (1913), on the basis of animal experiments and clinical observations, has come to the conclusion that silicon (in the special form of silicates) causes chronic intoxication of the system and acts especially on the blood in exercising a general anæmia-producing action.

* * *

From this summary account of the studies effected in Italy in the last twenty-five years on the problem of pneumoconiosis confirmation is afforded of the fact that this question is well known amongst our research workers, who have examined it from the experimental point of view as well as the clinical and anatomo-pathological point of view and have availed themselves on various occasions of the means of proof furnished by semiology, radiology, histology and histo-chemistry in order to diagnose the disease or recognise its pathogenesis, in the same way as they have had recourse to statistics and to a study of the objective conditions in order to arrive at an idea of its social importance.

It is not our intention here to provide a reasoned and critical survey of the results at which they have arrived or of the conclusions which they have drawn, and still less to discuss the methods of enquiry which have been adopted in certain investigations.

We only wish to draw attention to a few points which seem to us to be the most interesting for those desiring to study pneumoconiosis and bring into relationship its pathogenesis in the individual with the social risk which it represents for certain categories of workers.

It seems evident, in our opinion, from the studies quoted that there exists the possibility of the manifestation of chronic broncho-pulmonary affections, more or less serious in character, amongst all the workers engaged in dusty industries, manifestations possessing clinical and anatomo-pathological characteristics analogous to the disease described by Zenker under the designation of "pneumonoconiosis". Almost all the research workers are in agreement in recognising that there exists a varying degree of harm in the various dusts which can be determined in accordance with their physical characteristics (hardness, insolubility, sharpness of the surface of the particles). Silica dust has always been recognised as the most harmful, but less hard and more easily absorbed dusts, such as, for example, flour dust, are also capable when inhaled for a long period in large quantity of overcoming the means of defence of the system and producing irritative phenomena or inflammatory symptoms, of penetrating into the structure of the tissues and there producing considerable lesions. But whether on the basis of studies completed in Italy or of those carried out in other countries referred to at the beginning of this paper, it seems to us that there still await solution certain problems of pathology which are amongst the most interesting from the point of view of hygiene. These points are: (*a*) the possibility of pneumoconiosis assuming the character of a disease with progressive evolution, that is to say, whether its evolution continues even after removal of the patient from the dusty atmosphere, and (*b*) the possibility of its assuming a severity sufficient to endanger life of itself, without infective complications and especially apart from tuberculosis.

Only after having thoroughly verified our data in regard to these fundamental questions shall we be able eventually to engage in a study of the reasons explaining why in a particular locality the *individual disease* assumes the character of a *mass infection* and becomes a menace to the whole community.

The key to the solution of these questions resides, in our opinion, in the capacity to diagnose pneumoconiosis during life and in being able to discriminate between it and other pulmonary diseases, especially between it and tuberculosis.

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APPENDIX

Professor Loriga, when showing his collection of radiographs, distributed to the Members of the Committee the following four short summaries describing the research engaged in by his collaborators. He distributed also a volume containing the original reports, presented by the Italian Ministry of Corporations.

PNEUMOCONIOSIS IN MARBLE WORKS

BY DR. GIACOMO BIANCHI,
DIRECTOR OF THE ANTITUBERCULOSIS DISPENSARY AT MASSA

In my capacity of Director of the Antituberculosis Dispensary of Massa for some years past I have devoted attention to the possible presence amongst the marble workers of a pneumoconiosis lesion. I have subjected to careful clinical and radiological examination a group of about 250 workers engaged in work in more or less closed workrooms, such as sculptors, rough hewers, modellers and workers in the grinding rooms.

There were excluded all cases of suspected syphilis and other chronic lesions, with the result that the study covered seventy-three workers engaged in marble, having no inherited disease or previous disease history and free from definite or suspected symptoms of affections of the respiratory passages which might come under the category of common infections.

Thus, as can be seen on the radiograms shown, radiography has revealed diffuse nodes of thickened tissue, spread over almost the whole respiratory surface. In these cases there can only be determined a slight percentage (20 per cent.) of functional alterations with symptoms of chronic bronchitis and equally of pulmonary emphysema.

I then engaged in experimental research by exposing several series of rabbits to marble dust inhalation in the workrooms and killing them after a long period; one series of animals was killed after exposure lasting over two years.

It was recognised that all the animals suffered from the broncho-pulmonary lesions described in the text, clearly revealed by the accompanying microphotographs of histological preparations which show in an evident manner the presence of marble crystals, in particular in the sub-pleural network, in the peribronchial connective tissue and in the lymphatic ganglions.

On the basis of these clinico-radiological examinations and experimental researches I have arrived at the following conclusions:

1. The marble dust inhaled during work by the men in marble workshops causes anatomo-pathological lesions characterised by diffuse foci of peribronchitis and interstitial pneumonia.

2. The above-mentioned lesions can be observed radiologically amongst workers exposed for several years to the dust and they are accentuated in proportion to the time spent in the workshops.
3. The anatomo-pathological lesions do not cause functional disturbances except in the case of a small proportion of the workers and it is not possible to deny that inherent constitutional factors are connected with the appearance of these functional disturbances.

PULMONARY ASBESTOSIS

BY DR. DOMENICO LOVISETTO

My investigations have dealt with workers handling pure asbestos, and asbestos mixed in very small quantities with cotton or other vegetable fibres. They relate to two distinct periods: the first extending from 1902-1912 and the second from 1912 to the present time. I have considered it advisable to keep the data relative to these two periods separate since the first relates to workers employed on the manufacture of asbestos under very unfavourable and unhealthy conditions as regards the industrial organisation, as well as the type of worker employed.

Very frequently workers suffer from forms of rheumatism, of bronchial pneumonia and some of them from tubercular affections. Patients suffering from chronic broncho-pulmonary forms of disease of a non-tubercular character were in general men and women who had worked for several years in the said establishment; the morbid process with slow but progressive evolution was characterised by absence of fever and spitting of blood. The initial symptoms affected the upper respiratory passages, with persistent cough particularly trying during the winter season with little or no expectoration.

In the most severe cases (workers engaged in the industry for many years in the most dusty workrooms) besides the above-mentioned symptoms there was noted diffuse broncho-pulmonary pneumonia especially at the basis of the thorax with symptoms of pulmonary sclerosis.

I have never known patients to die of these disease forms.

I also visited each year workers presenting manifest signs of tubercular lesions. A careful examination of these cases and a conscientious study of their case history led me to the conclusion that these tuberculous complications, almost always affecting young workers, only occurred in the case of workers with hereditary predisposition or who had suffered from lesions rendering them susceptible to tuberculosis prior to commencing work in the asbestos industry or again to those who had lived with tuberculosis patients.

At the end of this period my personal experiments led me to conclude that asbestos dust is dangerous on account of the irritation which it causes in the respiratory tract and that in proportion to the amounts of dust inhaled and the years spent under the conditions described, it may cause a clinical picture similar to that designated in English "pulmonary asbestosis"; on the other hand it cannot set up tuberculosis. Where this disease occurs it must be considered as stimulation of earlier latent tubercular foci or it is a question of causes other than inhalation of asbestos dust.

In the second period extending from 1912 to the present time and following on the erection of a factory construction complying with the most hygienic modern precepts, conditions amongst the workers have greatly improved and further the workers were only engaged after selection by thorough medical examination. It must also be remembered that the periodical medical examination reveals at the outset the presence of morbid symptoms even when these are still very slight.

A conscientious examination of all workers in the factory has led to the following conclusions.

Workers who have only worked with asbestos for two or three years generally suffer from redness of the throat and from frequent and violent coughing not, however, accompanied by expectoration; they show no other subjective symptoms.

On the other hand amongst workers who have been working upwards of five years in the factory and who by reason of the process on which they are engaged are exposed to the inhalation of dust in greater quantities, I have been able to note slight signs of pulmonary changes. During examination of the thorax I have often observed a slight limitation of inspiratory movement and on percussion more or less obvious dullness at the bases, more frequently to the right than left side with diminution of the respiratory murmur.

Amongst those with over ten years' exposure to the inhalation of asbestos dust I have noted in addition to the above-mentioned symptomatology, some generalised pleuritic rubs with very harsh vesicular rales. Amongst these workers the size of the heart especially the right side seems almost always considerably enlarged and the second pulmonary sound accentuated. There is neither fever nor night sweats. At times the patients suffer from gastric troubles though only to a slight extent. In more serious cases a certain degree of anorexia is noted which usually makes its appearance after the twentieth year of employment. An examination of the sputum of those patients suffering from expectoration disclosed almost always the presence of particles of asbestos.

Whilst radiographic examination of workers engaged for a few years only, and of those but little exposed to the inhalation of the dust is almost always negative, amongst the others on the contrary I found very frequently the presence of more or less intense and diffuse shadows particularly corresponding to the base with hilar markings and diminished chest expansion. A short rest is quite sufficient for rendering these patients once more fit for work.

During the five years three deaths occurred amongst workers in the factory and they were due: the first to arteriosclerosis, the second to broncho-pneumonia in the form of influenza and the third to tuberculosis, probably due to family infection.

Amongst all the patients examined during these last months, three only showed symptoms sufficient to warrant suspension of work.

It transpired from the history of these three patients that two of them (the first and the third cases) had worked on asbestos for about ten years, whilst the second had only followed the occupation for three years, and that though showing symptoms characteristic of those who inhale asbestos dust over a long period, they showed morbid phenomena of varying types modifying the characteristic asbestosis lesion.

In the first case there was anorexia, dyspnoea, intermittent fever, marked loss of weight, on examination of the patient: generalised pleuritic friction, diminution of the respiratory movement, more marked on the right side, dullness at both bases, with attenuated vesicular murmur and very harsh respiration at the bases. On radiographic examination there was noted considerable reduction of the transparency of the two lungs, especially of the lower lobes and at the bases, increase of radiographic density in the hilar regions with intensely opaque striation, which became thickened and irradiated in the pulmonary parenchyma. Dyspnoëa and anorexia are the symptoms currently noted amongst those workers who have for long years inhaled asbestos dust, but the fever has a different aetiology.

In fact the first patient at the age of twenty had suffered from sero-fibrous pleurisy, and a considerable decrease in weight (10 kg.) which occurred quite recently, fever, generalised friction of the pleura, diminution of the transparency of the right lung, point to the presence of a lesion, probably tuberculous, of the pleura and the right apical region.

In this case I think that a lesion, probably tuberculous with slow evolution, became superimposed on a fairly marked pneumoconiosis.

The same may be said of the second patient. In fact the case in question was one of an emaciated individual who at nineteen years of age had suffered from dry pleurisy and who last year had been spitting blood; morbid processes of the pleura are present and are still active. It should be noted that the aetiological factor " asbestos " assumes a lesser importance since the patient had been employed in the factory for nine years only and had been engaged on an operation which was almost free from dust production.

In the third case the patient in question was a woman who had lived for years with a tubercular husband and who had been working for ten years in a very dusty atmosphere manipulating blue asbestos, which, as is well known, contains the kind of dust which exerts the strongest effect. She showed besides a very advanced degree of pneumoconiosis and in addition pleurisy as demonstrated with proof by the radiographic examination which revealed in a clear manner the presence of pleurodiaphragmatic adhesions. The presence of blood-stained sputum likewise points to a pulmonary affection of another type.

Examination of the sputum has shown in the three cases the presence of asbestos fibres. The Koch bacillus test for tuberculosis was negative.

In conclusion, inhalation of asbestos dust in the long run causes pneumoconiosis; the period required for the manifestation of this pathological state is at least five years. There is a direct ratio between the quantity of dust inhaled and the pneumoconiosis; the higher is the dust concentration the less time is necessary for the manifestation of fibrosis. It can reach complete development after a period of seven to nine years and it can cause death after thirteen years on condition that the individual is continuously exposed to the risk in a very dusty atmosphere.

When the cause of the inhalation of the asbestos dust is withdrawn the pneumoconiosis process is generally arrested.

The functional injuries caused by the inhalation of asbestos dust occur very slowly and are characterised by dyspnoea on effort, and by a slight insufficiency of the right heart, the patient after being attacked may work for a long time with brief spells of rest.

It is very doubtful whether pulmonary asbestosis favours the occurrence of acute pulmonary affections though the anatomical conditions of the sclero-fibrous lung which cause a slowing down of the blood circulation in the lung (pulmonary stasis) may justify the supposition of a more ready development of the pathogenic germs in the respiratory passages.

Pulmonary asbestosis is a disease in itself which must not be confused with other diseases of the lungs; it is an occupational disease non-infectious and non-contagious. It is of slow progressive evolution but when the irritant action of the asbestos dust inhaled has ceased the fibrous process is generally arrested.

Cases with a fatal issue are rare and at the present time, with modern means of protection, with highly perfected exhaust and ventilation apparatus they should no longer occur.

Pulmonary tuberculosis is on the other hand an infectious disease of slow progressive and quite characteristic evolution; and the anatomo-pathological data and pathogenesis are likewise typical.

It may be conceded that the inhalation of particles of asbestos, by causing chronic irritation of the respiratory passages of the lung, may favour in a limited number of cases, installation of the Koch bacillus.

CLINICAL AND RADIOLOGICAL NOTES ON PNEUMOCONIOSIS DUE TO ASBESTOS

BY DR. GIOVANNI MUSSA

Dr. Mussa reports the result of examinations of workers employed in the Nola Canavese factory for the treatment of asbestos and india rubber.

All the workers who have worked for some time in the establishment show lesions of pneumoconiosis which can be recognised clinically and radiologically.

Very often previous case history provides no positive data and individuals showing lesions in a fairly advanced state do not feel any particular discomfort.

The first signs experienced subjectively are: breathlessness on slight fatigue, dry cough and later expectoration of small quantities of mucous.

Clinical examination reveals in many of the cases more or less accentuated dullness in the right infraspinous fossa of the scapula—region in which the vesicular rales are harsher and the vocal and tactile tremor more accentuated.

There is sometimes cardiac transversal dilatation; the apex beat is displaced a little beyond the nipple line; the second sound more accentuated at the base, sometimes with duplication of the aortic second sound.

The radioscopic examination reveals: marborisation distributed bilaterally in the hilar and perihilar zones which in the most advanced cases considerably reduces transparency. Sometimes there is infiltration of the bases. The apices are almost always free and motile. Examination of the sputum has not revealed the presence of asbestos crystals.

No case of association of pneumoconiosis with tubercular lesions was met with.

RADIOLOGICAL AND CLINICAL STUDIES EFFECTED AMONGST THE CARRARA MARBLE WORKERS

BY DR. LUIGI TURANO

DIRECTOR, INSTITUTE OF RADIOLOGY, CIVIL HOSPITAL, CARRARA

I have examined 105 workers in regard to each of whom, subsequent to clinical examination, and wherever possible, examination of the sputum, radioscopic and radiological examinations were made. I have examined workers employed in marble grinding and in other workshops where there was intense grinding, taking care to examine workers of all ages, with all grades of working experience (in point of time—maximum fifty years) and from all kinds of work: sculptors, rough hewers, sawyers, polishers.

I have met with pleuritic lesions (remains of basal pleurisy, interlobular hyperplasia, etc.) in a proportion of about 10 per cent. and these in view of their extent I am tempted to connect with the effect of dust inhalation, for though the dust does not become accumulated on account of its facility for becoming dissolved in the respiratory parenchyma it nevertheless produces very probably pleuritic reactions by reason of the continuous irritation which it sets up.

I must state that in all those cases in which I found alterations of the pleura there were no tubercular antecedents (with the exception of two cases), but on the other hand as will be seen later there were clearly noted changes in the radiograph of the lungs.

I only found 4 per cent. of cases of calcification, a percentage which it will be agreed is too low and which rules out of account the possibility of carbonate of lime—inhaled, even in a continuous and intense degree as is the case for workers in the marble industry — becoming localised and accumulating in the pulmonary tissues.

The fact which struck me next was, however, that of having found in 28 per cent. real changes in the radiograph of the lung, consisting in a very marked reinforcement of the latter, in an arborescent aspect and a thickening of the vessels themselves.

Now if all the radiographs shown be examined this strongly reticulated aspect of the vascular network, the alterations in which may be due to the following causes, will be clearly seen:

(1) either the vessels are affected by the thickening process (very probably phenomena of endoperiarteritis) as found in the case of workers subjected to dust inhalation, as has been clearly demonstrated by pathological anatomy;
(2) or there are phenomena of actual lymphangitis, as shown by certain radiographs;
(3) or the vascular network which in many cases stands out against the great transparency of the pulmonary field may be interpreted as a change of slight extent due to emphysema which reaches a high incidence rate among the workers.

However that may be, the facts which I have just mentioned provide such ample evidence, that it is unnecessary to insist further on the fact; on the other hand I can merely advance hypotheses relative to the interpretation of the symptoms, since it is evident that only verification by post-mortem examination can reveal the truth.

The above-mentioned alterations correspond to what I had noted with regard to the initial stage of pneumoconiosis, for they are lesions of slight importance. In no case did I find distinctly diffuse nodular pictures as are usually met with in pneumoconioses and especially in those produced by silica and by iron.

On the other hand, the observations which I have made in regard to radiographs of tubercular marble workers established bacteriologically are interesting.

In the case of five workers who showed the Koch bacillus in the sputum and who had a previous tubercular history the radiological examination provided strange pictures as will be seen on the relative plates. In one of them is seen opacity of the medial region of the left lung with dissemination of small shadows certain of which show blurred outlines, others clear outlines, whilst the apical and subapical regions are perfectly free.

In another case on the other hand there is seen (fig. 4)[1] in correspondence with the lower region of the right lung an opaque patch as large as a tangerine with blurred outlines, whilst the remaining parts of the lung and in consequence the apices and the subclavicular regions are perfectly free.

It is unnecessary for me to stop to demonstrate the fact that such radiological pictures are very rare, I might even say atypical in proportion to the ordinary aspects of pulmonary tuberculosis, which we have the opportunity of observing. Yet this atypical character, these strange forms of tuberculosis which occurred in the case of two workers—sculptors who had been working one for 27 years and the other for 5 years on white and coloured marbles—are due according to available evidence to associated tuberculosis and pneumoconiosis; that is to say, that the silica dust contained even in very slight quantity in the marbles, in particular in the coloured marbles, had in my view, on account of conditions which we are unable to detect, encountered special predisposition suitable to its fixation and association with tuberculosis, thus rendering possible pulmonary tuberculosis in sites which are atypical for this disease.

I must in closing recall that studies particularly of a statistical nature conducted by the Director of the Health Bureau of Carrara, Dr.Mazzitelli, have clearly revealed the fact that tuberculosis at Carrara does not show special gravity as revealed by the mortality rate for workers. Yet this infection does not however on the other hand, as erroneously believed by some, follow a particularly benign course, first because the marble dust becomes dissolved in the pulmonary tissues and consequently the tubercular lesions are not influenced by inhalation of marble dust.

In conclusion the changes met with amongst Carrara marble workers may be classed in the initial stage of pneumoconiosis, that is to say comprising the least serious forms of the disease, such as the very marked reinforcement of the pulmonary outline, due as demonstrated by the personal observations just quoted, to the processes of arteritis and lymphangitis, and in certain cases equally to conditions of emphysema usually present amongst those workers.

I have also found frequent pleuritic changes which can be related to inhalation of marble dust, but never however lesions of the pulmonary parenchyma.

The radiological aspect of pulmonary tuberculosis amongst the workers examined is on the other hand highly important, since it shows an atypical picture on which are noted lesions with unusual sites and apical and subclavicular regions unaffected. It is this fact which has led me to admit the probability of a combination of pneumoconiosis and tuberculosis.

Finally statistical as well as radiological data justify absolute exclusion of the theory of a particular benign or malignant course of tuberculosis amongst marble workers, as likewise of any kind of predisposition to the said specific disease.

[1] This refers to the radiographs exhibited by Dr. Loriga, which are not reproduced here.

SILICOSIS IN THE NETHERLANDS

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Introduction

Our knowledge of silicosis is based chiefly on information obtained through the introduction of the Stonemasons Act and the medical examinations of adult workers in the stonemasons' industry established in pursuance of that Act.

Previous History

" Stonemasons' disease " was for many years classified with tuberculosis, where at the present time it would in many cases be more accurately diagnosed as pseudo-tuberculosis. This is not a matter for surprise when it is considered that, in the light of our present knowledge, the symptoms of this disease may take a form similar to those of lung tuberculosis, and when the statistics of that time are studied.

According to Sommerfeld[1], on a medical examination of 2,013 stonemasons in 1899, 169 were tuberculous, while 10.8 per cent. were noted as strongly suspected of tuberculosis.

The higher death-rate than in less unhealthy occupations, which was to be expected from the bad health conditions among stonemasons, appears from two Dutch statistical returns relating to death-rate according to occupation calculated for various age-groups for ninety-six occupations and combinations of occupations.

During the years 1891-1896 the death-rate among stonemasons

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[1] *Verhandlungen der Deutschen Gesellschaft für öff. Gesundheitspflege zu Berlin, Sitzung vom 26. März 1900.*

calculated for all men between eighteen and fifty years of age was greater than in any other occupation and the same was the case in the period 1896-1900. Even such injurious occupations as compositor, cigar maker and diamond cutter show a considerably lower death-rate.

It is noteworthy that in the age-group 18-24 years the death-rate differs little from the average for all occupations, while the highest death-rate is to be noted in the age-group 36-50 years. The difference in the mortality figures increases with the length of employment in the occupation. In the statistics covering the same period of five years relating to causes of death according to occupation and age, the mortality from diseases of the respiratory organs in the age-group 18-50 years is seen to be considerably higher among stonemasons than the average for all occupations.

In the period 1886-1898 Sommerfeld mentions that out of 952 stonemasons [1] dying in those years, 87 per cent. died of diseases of the respiratory organs, in connection with which it should be remembered that in Germany a great deal of sandstone is worked, as was formerly the case in the Netherlands, while in Belgium a large quantity of limestone from the local quarries is worked.

Enquiries preceding the Introduction of the Stonemasons Act, 1911

Various important enquiries into the life and health of stonemasons in the Netherlands were carried out which, as a result of the indisputable evidence of the unfavourable health conditions, led to the introduction of this Act.

In the annual reports of the Factory Inspectorate for 1903 and 1904, a detailed and carefully prepared report was published by the then assistant factory inspector, C. J. P. Zaalberg, relating to conditions and evils in the stonemasons' industry.

In 1906 177 stonemasons were examined by Dr. Elias [2] in Rotterdam, but without an X-ray examination. As a result of symptoms agreeing with those in tuberculosis, 22 stonemasons were considered as suffering from tuberculosis and a number of others as more or less suspect.

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[1] Workers in stone, not quarry workers.

[2] S. Elias: *Iets over steenhouwers en hun vak.* Rotterdam, Immig & Zn., 1909.

In the same year a Commission [1] was appointed, on the proposal of the Directorate of the Social-Technical Association of Democratic Engineers and Architects, to carry out a more thorough enquiry into the injurious effects of stonemasons' work and the necessary measures for remedying the evils. With the co-operation of various doctors 356 stonemasons were medically examined, with the result that 52 were found to be obviously suffering from lung tuberculosis and 62 suspected of this disease. No sufficient grounds were found for the high death-rate from tuberculosis in the use and abuse of alcohol, fatiguing labour, or the vibration of the chest from the stroke of the hammer.

The microscopic structure of various kinds of stone dust examined confirmed the impression that granite and sandstone constituted a danger owing to the fine texture of the dust and the small cohesion of the dust particles. Even then the question was discussed whether the inhaling of particular kinds of dust prepares the ground for the tubercle bacillus.

Various data given below are taken from the report of this Commission.

Kinds of Stone

Natural stone is worked in the Netherlands for various purposes in a great variety of kinds and is for the most part imported from abroad.

Natural stone is only found in the Netherlands itself in certain places in the south of the country; limestone in the Pieters Mountain near Maastricht in South Limburg; sandstone and limestone near Kunrade. A kind of freestone is used on a large scale in the Netherlands for engineering works and in domestic building, which is generally known to stonemasons as " blue stone " and which is a natural limestone obtained from a number of Belgian quarries. In addition to this limestone other kinds of limestone are employed, such as Morley, Roche d'Euville and Savonnière, from the quarries in the north and north-east of France, and marble from Italy, Belgium and Greece. Granite is imported from Sweden, Norway, Germany and Scotland. The dust both from the Belgian limestone and the French limestone is regarded by stonemasons as less troublesome than sandstone dust. The use of sandstone is chiefly confined to monumental buildings and to decoration, while

[1] STEENHOUWERSARBEID EN STEENHOUWERSZIEKTE: *Rapport.* Rotterdam, 1910.

building proper is carried out with brick. In addition to the above-mentioned sandstone quarried in the country, sandstone from Teutoburg, Oberkirchen, Bentheim, Gildehausen, Bremer and now also Nivelstein sandstone, imported from Germany, and Bollendorf, Pilsen, La Rochette, Udelfangen and Borne sandstone from Luxemburg are worked.

As the result of many years' experience the Dutch stonemasons regard the Teutoburg as the most injurious to health of all kinds of sandstone, the Oberkirchen, Bentheim and Gildehausen, among others, as somewhat less injurious, while the Bremer sandstone is also considered as among the dangerous kinds. The Udelfangen and Borne sandstones are less feared and are assimilated to such limestones as d'Euville, Morley, etc.

It has been shown in a remarkable way by a chemical analysis for determining the lime content of various kinds of stone, carried out by the chemical engineer De Voogt in his laboratory, on the proposal of Sleeswijk [1], of Delft, that a parallel exists between the estimate of the dangerousness of particular kinds of stone from sandstone to limestone and the presence or absence in greater or less degree of lime.

The following table gives a summary of these results:

Sandstone free from lime	Limestone, Belgian limestone, and lime sandstone containing lime
Oberkirchen Bentheim Gildehausen Red Bremer	Udelfangen sandstone contains 13 per cent. lime. Roche d'Euville limestone 16.7 per cent. Hard Morley limestone 17.9 per cent. Soft Morley limestone 27.2 per cent. Belgian limestone 20.4-21.4 per cent. Shell limestone 25.7 per cent.

The mixture of lime seems to exercise a favourable influence on the dangerousness of sandstone. The same appears to apply to clay and coal dust [2].

Collis and Gilchrist [3] however observed in coal-heavers after several years' work " signs similar to those widely regarded as characteristic of silicotic fibrosis ".

[1] *Bedrijfshygiënische vraagstukken Tijdschr. v. Soc. Hyg.*, 19th Year, 1917, No. 4.

[2] HEFFERMANN and GREEN: *Journal of Industrial Hygiene*, Vol. X, 1928, No. 10, p. 272.

[3] *Journal of Industrial Hygiene*, Vol. X, 1928, No. 4, p. 109.

Stonemasons' Tools

The tools most in use in stone working are illustrated in figs. 1, and 2. Nos. 1-7 (fig. 1 [1]) are chisels of various kinds and weights which are manipulated by means of a wooden hammer varying in form and weight; the pointed chisel (3 and 4) is used for cutting away larger protrusions on the stone; the Bouchard chisel (7) is used for obtaining an equally rough pointed surface. All these tools, in the working of stone, give rise to dust. The fact of the toothed chisel (6) becoming blunt and consequently unuseable has led to the invention of a handle provided with a slot in which an inset piece with teeth of various kinds is inserted (6*a*), which has proved economically more advantageous.

In addition to the chisels, the tools shown in fig. 2, Nos. 10, 11, 12, 13 and 14, are in use.

The Bouchard hammers (10 and 11), heavy iron hammers with wooden handles, are chiefly used in the working of Belgian limestone. On sandstone the point of the hammer soon becomes blunt, which is uneconomical. The stonemason's beam (13 and 14) is used for the same purpose as the Bouchard hammer and consists of from ten to seventeen pointed chisels placed side by side and fixed by a wedge in an iron frame with an iron handle. These tools are much heavier and consequently much more fatiguing to work than ordinary chisels, while the creation and dispersion of dust is considerably greater.

Working Position

It is obvious that the chance of inhaling dust is influenced by the position of the stonemason while cutting. The cutting of the stone is the dangerous work which is generally carried out in a sitting position, in connection with which a crouched position is to be condemned. (See fig. 3.)

Age of Commencing Work

In the enquiry by the Commission into the age at which stonemasons commence work, it was found that formerly even children of ten, eleven and twelve years of age in not inconsiderable numbers (106 out of 356 stonemasons examined) chose this dangerous occupation as their calling.

[1] The illustrations (figs 1-4) are given after p. 534.

Hours of Work

The hours of work varied from 10 to 13 per day. Piecework led to great over-exertion owing to the desire to earn a great deal in a short time.

Housing Conditions and Workplaces

The housing conditions were not worse than with other classes of workers. Workplaces were generally in a miserable condition, lacking sufficient ventilation, too low and too small. The lack of open spaces and open sheds for outdoor work in fine weather were among the defects noted.

Abuse of Alcohol

Irregular living and abuse of drink are commonly regarded as causes of the outbreak of " stonemasons' disease ". As regards the abuse of drink, this was certainly considerable, especially among pieceworkers, although it is well known that a noticeable diminution is observable in this respect.

Conclusions

The conclusions of this important report are, briefly stated, the following: tuberculosis among stonemasons should be regarded as an occupational disease. The health conditions of stonemasons in the Netherlands are very unsatisfactory, the death-rate from lung tuberculosis and diseases of the respiratory organs abnormally high. Stone dust, and particularly the dust arising in the working of many kinds of sandstone, must be regarded as the primary cause of the abnormal sickness and mortality figures. The working of Belgian limestone and other kinds of limestone is less prejudicial to health. The introduction of a law for the combating and prevention of " stonemasons' disease " is considered as urgent.

Measures for Protection

The following are considered as measures for the protection of health: preliminary medical examination of young workers before entering the occupation, not earlier than sixteen years of age, followed by periodical re-examination; removal from the occupation of cases of incipient tuberculosis, and at the same time the assimilation of this occupational disease to an industrial accident; limitation of hours of work to eight hours a day, with regulation of rest periods; strict regulations relating to the arrangement and use of workplaces; the requirement that certain kinds of stone should be worked in a moist condition; prohibition of the working of certain kinds of sandstone, together with prohibition of their importation, and prohibition of the use of the stonemason's beam.

The wishes expressed on the basis of this report, and the minimum demands made for measures for the protection of stonemasons, led in a short time to the introduction of the desired legislation.

THE STONEMASONS ACT, 1911-1921 [1]

This Act, containing regulations relating to the special risks to safety and health connected with the work of stonemasons, came into force in 1913 [2] and was amended in 1921 [3].

Its principal provisions are summarised below.

The employer must see that the workplaces and their accessories and the methods of work comply with certain regulations [4]. The distance between the chisels used by persons doing stonemason's work on different pieces of work must be at least 70 centimetres, when working sandstone on one and the same block 1½ metres, in the case of stone other than sandstone at least 1 metre except in the case of fine work. Stones worked, being sandstones or other stones, which absorb water without involving any serious difficulty in working, must be kept moist. The use of the stonemason's beam in such work is prohibited and also the use of the Bouchard hammer, where the same weighs more than $3^1/_4$ kilograms, except in working granite. An open space for working in the open air must be available in the workplace. The hours of work per day, which were originally limited to nine for workers over seventeen years of age and seven and a half for young workers under seventeen years of age, have since the amendment of the Act in 1921 been fixed at eight hours a day and forty-five hours a week for workers over eighteen years of age and seven and a half hours a day and forty-two hours a week for workers under that age. The rest period after three and a half hours of work must be at least half an hour. Piecework is prohibited for young persons under eighteen years of age. Employment in stonemason's work is prohibited for young persons under fourteen years of age.

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[1] *Staatsblad* 315, Act of 7 October 1911.
[2] 1 March (sections 2 and 4 on 1 May).
[3] 11 Nov. 1921, *Staatsblad* 1167.
[4] *Steenhouwersbesluit* 1913, *Staatsblad* No. 38, amended 1923, *Staatsblad* No. 297.

Compulsory Medical Examination

Every stonemason under twenty-one years of age must be in possession of a stonemason's card, which is issued to him after medical examination carried out free of charge, if it does not appear that the performance of stonemason's work will give rise to any special danger to his health. If the examination took place before eighteen years of age, the stonemason's card ceases to be valid after one year and a fresh examination must take place. A person to whom a card is refused may, within fourteen days of the date borne by the notification of such refusal, apply to the Minister of Labour, Commerce and Industry for a re-examination, for which one or more medical practitioners are designated.

The compulsory examination of adult stonemasons, that is to say, at twenty-one years of age and over, was introduced for the first time after the amendment of the Act in 1921. A stonemason's card is issued irrespective of the result of the examination. If at the date of the examination the stonemason is eighteen years of age or older, the card ceases to be valid after the expiry of three years from that date. Before 1921 an adult stonemason could be medically examined free of charge voluntarily with a view to ascertaining whether the performance of stonemason's work would involve special danger to his health.

Compulsory Examination of Stonemasons under Twenty-One Years of Age [1]

Medical examinations before and after entering the occupation are at present carried out by five medical practitioners in permanent service belonging to the Central Service of the Factory Inspectorate and by private medical practitioners appointed in accordance with a specified scheme. Examination has in certain respects a preventive effect, in so far as it dissuades persons of weak constitution from choosing the stonemason's trade, in the anticipation that they will be rejected. Examination has resulted in the weeding out of young persons with defective lungs. During the first years after the Act came into force not a few young persons were rejected. Thus in 1913, out of 266 examined, 29 were rejected; in 1914, out of 254 examined, 23 were rejected; while in 1924 and 1925 only one person was rejected out of 120 and 146 respectively examined.

[1] Departmental Committee for the Diagnosis of Silicosis: Home Office, London, 1929. (Cf. "The Value of Initial and Periodic Examination.")

The grounds for rejection are various: mostly lung defects, also general debility, kidney diseases, curvature of the spine, chronic otitis media, insufficient nasal respiration, etc. It has not been possible up to now to take X-ray photographs of the lungs of young persons between fourteen and eighteen years of age.

Compulsory Examination of Adult Stonemasons

The compulsory medical examination of adult stonemasons, that is to say, at twenty-one years and over, is based on section 3, subsections (1) and (8) of the Stonemasons Act, 1921. The periodical examination takes place at the expiration of three years from the time when a stonemason's card was issued irrespective of the result of the examination. There is no question therefore of rejection, as in the case of stonemasons under twenty-one years of age. If the result of the examination so requires, the examining medical practitioner gives the stonemason instructions as to the precautions to be adopted in connection with his work and the manner in which he should live in order to avoid injury to his health, so far as possible.

Co-operation of the Factory Inspectorate with the Public Health Inspectorate and the Consultation Offices for Tuberculosis

This co-operation has made it possible to obtain a considerable number of X-ray photographs of stonemasons examined in the Consultation Offices for tuberculosis in various localities in the Netherlands. The supplementing of clinico-physical examination by an X-ray photograph has proved of great importance for forming an opinion of lung affections due to the inhaling of stone dust.

Medical Examination of Stonemasons

As a general rule every stonemason is examined, in accordance with a uniform scheme for the whole country, by two medical practitioners, one a medical officer in the Factory Inspectorate and one an examining medical practitioner of the Consultation Office for Tuberculosis. Where this is not possible, the examination is carried out by two medical officers of the Factory Inspectorate. The stonemason is summoned to attend for examination at a specified centre by the district chief of the Factory Inspectorate.

The first general examination of adult stonemasons took place in 1923, the second in 1926 and the third in 1929, so that it has been possible, although not in a large number of cases, to compare with each other the clinico-physical condition of the lungs of the same person at the three dates and three X-ray photographs.

The subjoined table gives a survey of the total number examined and the X-ray photographs taken in the above-mentioned years.

Year	Number examined	X-ray photographs [1]	
		Total taken	With positive results
1923	963	274	232
1926	889	111	97
1929	799	69	57

[1] In addition a number of X-ray examinations were made without photographs being taken.

How indispensable X-ray examination is as a supplement to clinico-physical examination for the purpose of judging the state of health may be seen from the subjoined table taken from the first general examination of 1923.

CLINICAL AND X-RAY EXAMINATION OF 274 CASES, CLASSIFIED ACCORDING TO THE NUMBER OF YEARS OF EMPLOYMENT IN THE OCCUPATION

Lung Affections noted in 1923

	Years of employment							Total examined
	0-5	5-10	10-20	20-30	30-40	40-50	50-60	
Clinical, affection; X-ray examination, no affection	—	1	1	4	2	1	—	9
Clinical, no affection; X-ray, affection	—	8	41	50	24	11	1	135
Clinical, affection; X-ray, affection	—	4	17	34	30	8	4	97
Clinical, no affection; X-ray, no affection	—	1	12	17	3	—	—	33
	—	14	71	105	59	20	5	274

From the above figures it will be seen that in nearly half the number of cases the X-ray examination gave more information than the physical examination. In a corresponding statement on 69 cases from the general examination in 1929, lung affections are not shown clinically in 19 cases, but are shown in the X-ray examination, and in 38 cases both clinically and by X-rays.

Subjective Complaints and Objective Phenomena

It is noticeable that in the general examination of stonemasons in 1923, 1926 and 1929, few complaints were received as to the state of health of the patients; most of them felt quite well, though a certain number complained of shortness of breath when moving. Here and there men complained of coughs with little or no sputum, which explains why altogether an examination of the sputum was made in only 48 cases, with positive results as to the presence of tubercle bacilli in 11 cases. After inhaling stone dust for many years, complaint was made of irritation in the throat and a stifling feeling in the breast, with relative shortness of breath, an inclination to cough and expectoration, especially on rising in the morning. Generally speaking, percussive irregularities are few and auscultatory phenomena more striking: rough, heightened or weakened respiratory rustling, lengthened or jerky breathing in one or both apices or other places, also cracking and dry snoring noises, varying in strength and area, seldom damp or crapitating. Coughing and sputum which is not characteristic often only occur when bronchitis appears as a complication.

The X-ray picture [1] of pneumonoconiosis, due to the dust of various kinds of stone, does not differ in its various degrees from those given for silicosis by various investigators [2]: (1) enlarged hilus-shadow, increased appearance of the retiform tissue and linear shadows; (2) increased appearance as in (1), and the appearance over a wide area of stippled shadows (mottling), and (3) appearance as in (2) and nodular shadows, large close mottling.

The question of the mutual relations between pneumonoconiosis and tuberculosis, whether the tuberculosis only appears in later years as an infection on a foundation of silicosis—tuberculo-silicosis —or the silicosis is secondary to tuberculosis latent in youth and manifesting itself later—silico-tuberculosis—appears to be more

[1] Out of 274 cases radiologically examined, 42 showed no affection. For information as to the special cases (139) of silicosis, reference should be made to the reports on this head concerning stonemasons employed for many years in the occupation in the medical examinations of the Factory Inspectorate in 1923. Not all cases are summarised, where there are similar cases with insignificant differences. (*Centraal Verslag der Arbeidsinspectie over 1923.* Algemeene Landsdrukkerij, 1924.)

[2] Jarvis, Sutherland and Bryson. Irvine includes incipient mottling in the first stage.

and more answered in this sense [1], that each of the two processes favours the development of the other, and that the tubercle bacillus, appearing as a secondary factor, often seriously threatens health and life. In this connection the case is noteworthy of a stonecutter forty-seven years old who, on a clinical and X-ray examination, showed an affection of the apex of the right lung without exhibiting radiologically any degree of silicosis after thirty-four years' work on sandstone.

A concise critical survey of the position of the question of silicosis and tuberculosis appeared in connection with the proceedings of the Fourth Meeting of the Permanent International Committee for the Study of Occupational Diseases at Lyons in 1929 under the signature of Böhme in *Klinik und Silicosis II*, which also contained a study by Mavrogordato on the ætiology of silicosis.

The clinical distinction between tuberculo-silicosis and silico-tuberculosis [2], as Watkins-Pitchford justly remarks, makes no essential difference to the fundamental pathological processes.

Since 1923, 16 stonemasons have died, of whom 9 died from pulmonary tuberculosis; only in 2 cases was it possible to confirm the clinico-radiological examination by a post-mortem examination. Dutch stonemasons generally die at home and not in a hospital, so that a post-mortem examination rarely takes place. That in a number of cases the triad—clinico-physical examination, X-ray examination, and post-mortem examination—is necessary for the definitive judgment of the process is obvious. On a post-mortem examination of a stonemason sixty-six years old, numerous permanent foci were found in both lungs, and here and there caverns with secondary tuberculosis of the wall, although the X-ray photograph had not sufficiently demonstrated this. The man died of hæmorrhage from a cavern as large as a fist.

Dust Content of the Air in Working Various Kinds of Stone

A certain number of analyses of air for determining the dust content were made by the factory inspector, Scholte, close to the mouth of a stonemason. When working moist Oberkirchen sandstone the results were 45.8, 99 and 109 mg. per cubic metre of air;

[*Text continued on page 526.*]

[1] Böhme and Lucanus: *Deutsche Medizinische Wochenschrift*, 53rd Year, No. 38, p. 1604.

[2] Watkins-Pitchford: *Journal of Industrial Hygiene*, Vol. IX, No. 4, April 1927.

	In 1923		Kinds of stone worked in order of working from youth onward before 1923	Clinico-physical results		
	Age	Years in occupation		1923	1926	1929
1	38	26	Belgian limestone, sandstone, marble	—	—	Snoring sounds 2 apices
2	37	25	Belgian limestone, sandstone (not much)	Percussion dull left upper	—	—
3	44	32	Belgian limestone	—	—	—
4	34	21	Belgian limestone	—	—	—
5	35	23	Belgian limestone, sandstone (not much)	—	—	—
6	62	50	Belgian limestone, marble (not much)	—	Snoring sounds	—
7	53	40	Sandstone, Belgian limestone, granite	—	—	Bronchial breathing right
8	45	33	Sandstone, Belgian limestone, granite	Snoring sounds	Snoring sounds	—
9	52	32	Belgian limestone	—	Snoring sounds	—
10	34	20	Belgian limestone	—	Snoring sounds	Weak breathing right
11	27	14	Belgian limestone, granite, sandstone	Percussion dull left upper	—	As in 1923
12	38	26	Sandstone, Belgian limestone	Snoring sounds	—	—
13	46	33	Belgian limestone, marble (very rarely)	—	Percussion dull left	Heightened breathing
14	39	27	Belgian limestone, sandstone	—	—	—
15	57	43	All kinds of stone	—	Snoring sounds	Snoring sounds right.
16	36	23	Belgian limestone, marble, sandstone	Snoring sounds, weak breathing	—	Weak breathing
17	34	21	All kinds of stone	Snoring sounds	—	Percussion dull, right upper
18	31	19	Belgian limestone, sandstone	Snoring sounds	—	—
19	30	15	Belgian limestone, sandstone (rarely)	—	—	—
20	33	21	Belgian limestone, sandstone (rarely)	—	—	—
21	31	18	Sandstone, Belgian limestone	—	—	—
22	35	21	Belgian limestone, sandstone	—	—	—
23	40	26	Sandstone, Belgian limestone	—	—	—
24	38	20	Marble, Belgian limestone, sandstone (seldom)	Snoring sounds	Snoring sounds	Heightened breathing left upper
25	53	41	Marble, Belgian limestone, sandstone (seldom)	—	—	—

[1] First stage: hilum shadows and linear shadows (and reticular).
[2] Second stage: mottling.

X-ray results 1923	1926	1929	Various observations
—	Stippled lung [2]	Snowstorm lung [3]	1926-29, marble worked
—	—	1st stage (incipient)	1923-29, Belgian limestone worked.
—	1st stage (incipient) [1]	Stippled lung	Same kinds of stone as before 1923
—	—	Stippled lung	Same kinds of stone as before 1923
—	—	Stippled lung	Same kinds of stone as before 1923
—	1st stage (incipient)	Same	Same kinds of stone as before 1923
1st stage (incipient)	Same	Same	1923-29, Belgian limestone; cough
1st stage (incipient)	Same	Same	1923-29, Belgian limestone, marble worked
1st stage (incipient)	—	—	1923-29, Belgian limestone
1st stage (incipient)	Same	More linear shadows	1923-29, Belgian limestone, sandstone
1st stage (incipient)	Same	Same	1926-29, Belgian limestone, not much sandstone
1st stage (incipient)	Same	More linear shadows	1923-29, no stone cut
1st stage (incipient)	Stippled lung	Same	For 2½ years short breathing, same kinds of stone
—	—	1st stage	1923-29, same kinds of stone
Stippled lung	Same	Same	1923-29, Belgian limestone, sandstone
Stippled lung	Same	Same	{ 1923-26, Belgian limestone and marble; 1926-29, sandstone }
Stippled lung	Increase	Same	1926-29, Belgian limestone worked
Stippled lung	Same	Same	Same kinds of stone as before 1923
Stippled lung	Same	Same	In 1926 left more linear shadows, same kinds of stone
Stippled lung	Same	Same	Same kinds of stone as before 1923
Stippled lung	Same	Same	1926-29, all kinds worked
Stippled lung	Same	Increase stippled lung	1926-29, sandstone worked
Stippled lung	Same	Same	1923-29, sandstone, Belgian limestone
Stippled lung	Same	Same	Same kinds of stone as before 1923
Stippled lung	Same	Same	1926-29, Belgian limestone, marbled worked

[3] Third stage: shadows as first and second stage and nodular shadows, large close mottling.

	In 1923		Kinds of stone worked in order of working from youth onward before 1923	Clinico-physical results		
	Age	Years in occupation		1923	1926	1929
26	42	29	Belgian limestone, much sandstone	Weakened breathing apices	Same	Same
27	36	21	Sandstone (much)	—	—	Percussion dull right upper
28	61	49	Marble	Snoring sounds	Percussion dull both apices	Snoring sounds
29	43	27	All kinds of stone	—	Snoring sounds	Snoring sounds left lower back and weakened breathing
30	47	33	Belgian limestone, not much sandstone	Snoring sounds	—	—
31	44	32	Belgian limestone, sandstone	Snoring sounds	More snoring sounds	Snoring sounds and percussion dull
32	61	48	Belgian limestone, sandstone	Snoring sounds	Same	Percussion dull upper
33	56	42	Sandstone, Belgian limestone, marble	Weakened breathing	Same	Same
34	40	26	Much sandstone	—	—	—

with dry stone 58.7 and 87.3 mg.; in working dry Belgian limestone, 58.5 and 159.4 mg. per cubic metre of air.

Teleky [1] reports a typical case of silicosis ("snowstorm lung"), notwithstanding that the stone was worked in a moist condition, affecting a stonemason, who had worked on moist sandstone for fourteen and a half years.

Kinds of Stone Worked according to Quartz Content

It has already been mentioned that the stones worked by stonemasons in the Netherlands are sandstones free from lime, sandstones containing lime and limestones with varying lime content, including Belgian limestone and marble, and also granite.

On the first general examination of stonemasons in 1923 it was found that the working of sandstone had gradually diminished, on the two later periodical examinations that Belgian limestone was chiefly worked, and also marble and granite, and to a lesser extent,

[1] TELEKY: *Reichsarbeitsblatt*, 1929, No. 26, III, p. 229.

X-ray results			Various observations
1923	1926	1929	
Snowstorm lung (incipient)	Same	Increase	1923-26, sandstone, half year, 1926-29, Belgian limestone
Snowstorm lung	Increase since 1923	Increase	1923-29, no stone worked
Snowstorm lung	Increase	Same as in 1926	Short breath, habitual cough, no sputum, only marble
Snowstorm lung	Increase	Increase	1923-26, much sandstone; 1926-29, all kinds, short breathing, cough
Snowstorm lung (incipient)	Same	Same	1923-29, Belgian limestone and granite
Snowstorm lung	Same	Increase	1923-26, sandstone 1 year; 1926-29, all kinds of stone; before 10 years sandstone
Snowstorm lung (incipient)	Same	Same	1923-26, sandstone
Snowstorm lung	Increase	Increase	1923-26, Belgian limestone and marble; 1926-29, Belgian limestone and sandstone; cough, short breath
Snowstorm lung	Same	Same	Percussion over both lungs slightly dull; 1923-29, sandstone

sandstone. A new kind of sandstone worked in recent years is the Nivelstein [1] sandstone already mentioned, in which the quartz grains are held together by a quartz-like cement and not by lime, clay, iron oxide, glauconite, or other cements [2]. The Netherlands sandstone from Kunrade is very rich in quartz. An analysis showed sand and insoluble silicates 54.17 per cent., calcium carbonate 39.6 per cent., clay and iron oxide 4.8 per cent., and traces of magnesium carbonate. No special experience as to the danger of the working of this kind of stone exists as yet. The hardness of sandstone is determined by the size of the granules and the nature of the cement. If the injurious agent in the various morbid changes in lung tissue presenting the clinico-radiological character of silicosis is held to be quartz, SiO_2, it is important to know the quartz content of the kinds of stone in use in order to form an

[1] Onderzoek Technische Hoogeschool, Delft.
[2] THIELE and SAUPE: "Die Staublungenerkrankungen der Sandsteinarbeiter". *Schriften aus dem Gesamtgebiet der Gewerbehygiene*, Neue Folge, 1927, No. 17.

opinion as to the danger to health in working these various kinds of stone. This applies to the various kinds of Belgian limestone, other limestones, and also to marble and various kinds of granite.

The following analysis is given of limestone of Belgian origin: $CaCO_3$ 95.67 per cent., SiO_2 2.56 per cent., and small quantities $MgCO_3$ and Fe_2O_3.

The Maastricht limestone (Netherlands) already mentioned contains, according to a three-fold analysis, chiefly calcium carbonate and also SiO_2 in quantities from 0.38 to 2.25 per cent. The Kunrade limestone also contains only small quantities. Shell limestone, a limestone with pipe clay as cement, is practically speaking free from quartz according to German analyses [1].

Marble [2] may contain quartz, according to an analytical examination by Riddell and Rothwell of the dried lungs of a marble worker; the ash contained on analysis 2.34 per cent. quartz, while that of the lungs of town dwellers contained 0.60, 1.28 and 2.67 per cent.

Granite [3] from the Fichtelgebirge (Germany) contains 30 per cent. quartz without cement, the quartz being found between the other constituents.

Comparison of the X-ray Photographs in a Number of Cases of the Same Stonemason Examined in 1923, 1926 and 1929

For the purposes of this comparison thirty-four cases have been selected which present a compendious picture. The X-ray photographs were taken in the same consulting offices for tuberculosis in Amsterdam, The Hague and Utrecht. The medical examinations were conducted by the same doctors.

The number of years in the occupation varies, as shown by the subjoined table, from fifteen to fifty years. From the above-mentioned report of 274 X-ray photographs taken in 1923, it appears that affections of the lungs demonstrable by X-ray examination only appear after five years' stonemason's work, and between the fifth and tenth years, and in increasing degree up to thirty to forty years' work in the occupation.

In the column indicating the kinds of stone worked these are mentioned in the order in which they were worked from youth onward.

[1] *Ibid.*
[2] *Journal of Industrial Hygiene*, May 1928, p. 147.
[3] Koelsch and Kaestle: *Die gewerbliche Staublungenerkrankung 1929.* Supplement No. 15 to *Zentralblatt für Gewerbehygiene*, p. 72.

The particulars of the clinico-physical results give a compendious statement of the relatively few phenomena in general.

From this table it will be seen that before 1923 2 out of the 34 stonemasons had worked sandstone alone all their lives, 4 had worked successively sandstone and Belgian limestone, 16 Belgian limestone and sandstone, 4 Belgian limestone only, one Belgian limestone and marble, 1 marble only, and 6 sandstone, Belgian limestone and granite.

In the period 1923 to 1929, the number of sandstone workers increased to 4, the number of Belgian limestone, limestone and marble workers together from 6 to 11. The increase of silicosis from 1923 to 1929 appears from the following:

Year	No affection	Stage I	Stage II	Stage III
1923	6	8	11	9
1929	–	9	15	10

Out of 6 stonemasons (Nos. 1 to 6) with no signs of affection in 1923, No. 1 worked from 1926 to 1929 on marble alone, before that chiefly on Belgian limestone, and to a small extent on sandstone, and in 1929 was shown to have a snowstorm lung. Stonemasons Nos. 3 and 4 worked before and after 1923 on Belgian limestone only, and in 1929 each had a stippled lung, while stonemason No. 5 showed practically the same symptoms after a large amount of work on Belgian limestone and a small amount on sandstone both before and after 1923. Out of the above 34 cases, not one appears to have improved, even where, as in cases 12 and 27, no stonemason's work was carried out for as long as six years. On the contrary, a change for the worse is observable in case No. 27, who had previously worked considerably on sandstone, notwithstanding that he worked no stone at all from 1923 to 1929, while in case No. 28, who had worked all his life exclusively on marble, and in 1923 already showed signs of a snowstorm lung, an aggravation was observable in 1926. Altogether, 18 out of the 34 cases are shown to have become worse either in 1926 or in 1929.

Stonemason No. 22 shows in 1929 an aggravation of his stippled lung after working on sandstone from 1926 to 1929 and previously on sandstone and Belgian limestone, while No. 32 shows similar phenomena, at least to the eye, and the same is the case with No. 34, who had worked largely on sandstone all his life. It is worthy of remark that out of the 9 stonemasons presenting the typical phenomenon of snowstorm lung, 1 had never worked on sandstone, 2 only on sandstone, and the other 6 sometimes Belgian limestone and sometimes sandstone, and, to a small extent, granite.

Influence of Various Kinds of Stone

From the X-ray photographs taken in connection with the general examination of stonemasons in 1923, a number have been selected relating to stonemasons who in the course of their lives had worked on certain kinds of stone and others who had worked on more than one kind of stone, for comparison of the condition of the lungs in connection with the number of years' employment in the occupation [1].

KINDS OF STONE WORKED AND NUMBER OF YEARS' EMPLOYMENT IN OCCUPATION

Condition of the Lungs as shown by X-Ray Examination

Years in occupation	Sandstone				Belgian limestone				Marble				Sandstone, Belgian limestone, granite			
	No affection	Stages I	II	III	No affection	Stages I	II	III	No affection	Stages I	II	III	No affection	Stages I	II	III
10-20	–	–	1	–	9	7	1	–	2	–	–	–	1	12	3	–
20-30	–	–	2	5	9	14	5	–	1	1	–	–	3	15	20	5
30-40	1	1	1	1	4	9	3	–	1	–	–	–	1	8	6	4
40-50	–	1	2	–	1	5	2	1	–	–	–	1	–	3	3	6
50-60	–	–	–	1	1	2	–	1	–	–	–	–	–	–	–	–
	1	2	6	7	24	37	11	2	4	1	–	1	5	38	32	15
	16				74				6				90 [1]			

[1] Among these 90, there are 3 cases of silicosis + tuberculosis (sputum positive).

From the above table it appears that out of 16 sandstone workers, 2 were already in the second stage and 5 in the third stage of silicosis after twenty to thirty years' employment in the occupation, as compared with the Belgian limestone workers, among whom, out of a total of 74 stonemasons, after the same number of years' employment in the occupation, only 5 were in the second stage and none in the third stage. Among the 90 stonemasons who worked various kinds of stone, thus including sandstone, the pro-

[1] These photographs are reproduced after p. 534.

portion is more unfavourable than in the case of the Belgian limestone workers, taking the third stage as the test, although relatively favourable in comparison with the sandstone workers.

A striking fact is the large number of Belgian limestone workers (18) showing no affection after ten to thirty years' employment in the occupation, as against only 4 stonemasons working on all kinds of stone.

The third stage of silicosis is found among Belgian limestone workers in smaller numbers (2) after forty to sixty years' employment, and therefore after a greater number of years' employment than in the case of sandstone workers (7).

One question that arises is: why, in a particular case, the working on sandstone only produces no silicosis, and the working on Belgian limestone, with a low quartz content and much lime, does produce it ?

Workplace and Manner of Living

The condition of workplaces, although improved in many cases, still leaves much to be desired.

The stonemason's manner of living, compared with an earlier period, twenty to thirty years ago, has changed for the better, especially as regards abuse of alcohol. The irregular life of a stonemason working at piecework in company with others of youthful years, away from their homes, with insufficient rest at night, and abuse of alcohol, has injured the health of many for the rest of their lives. At the first general examination in 1923, 194 of the 963 stonemasons examined stated that they had drunk a great deal of alcohol in their youth.

A number of stonemasons have died during or shortly after work in the restoration of churches and other monumental buildings in which large quantities of sandstone are worked.

Dust Goggles and Respirators

Dust goggles or respirators are seldom used and certainly not regularly.

The wearing of a respirator while engaged in strenuous work becomes burdensome in the long run. By way of experiment a stonemason wore a respirator every day for a month during his work. After a certain time, the pores were stopped up with stone dust clogged together with the moisture from breathing.

Instruction of Stonemasons

Under section 9 of the Stonemasons Act, 1921, provision is made for instructions respecting the nature of the dangers to which stonemasons are exposed, and in regard to which precautions are to be taken; the printed instructions must be affixed in the workplace and a copy on a smaller scale delivered to the stonemason personally. In addition to this, since 1923, in most of the large towns lectures have been delivered and discussions held by the medical adviser and the medical practitioners attached to the factory inspectorate.

The use of sandstone alone as little as possible remains of great importance.

Assimilation to Accidents for the Purposes of Compensation

Preparations are being made for the assimilation of this occupational disease to an accident in pursuance of section 87 (*a*) of the Accident Act, 1921, as amended in 1928 [1].

Conclusions

The introduction and application of the Stonemasons Act has led to a clearer insight into the character of the " stonemasons' disease " and a more intelligent procedure in combating it by the improvement of the working conditions and personal hygiene of stonemasons.

The preliminary medical examination and annual re-examination of young stonemasons to a considerable extent prevents persons suffering from lung tuberculosis entering upon and continuing in stonemasons' work.

The periodical (three yearly) medical examination of adult stonemasons has shown the indispensability of X-ray examination for forming an opinion of lung affections.

The working of sandstone alone must be regarded as more injurious to the lungs than the working of limestone alone. The working of sandstone alone does not always lead to symptoms of silicosis and, on the other hand, the working of limestone alone (Belgian limestone, marble) does not prevent silicosis in a serious

[1] *Staatsblad* No. 223, 1928.

form. The working of sandstone and limestone alternately appears to produce less serious results in the same period than the working of sandstone alone.

Compulsory medical examination both in the form of preliminary examination and periodical re-examination should be introduced for sand-blowers as well as for stonemasons.

Silicosis as an occupational disease of stonemasons should be assimilated to an accident for the purposes of the application of the Accident Act.

APPENDIX

Silicosis and Sand-Blowing

Considerable use is now made in industry of the sprinkling of quartz sand (river sand) on metal objects for the purpose of cleaning and in the etching of glass. Sand-blowing is carried out by blowing fine dry sand [1] from a pipe under air pressure, the pipe being directed by hand on to the piece of work and the worker standing in a closed room with his eyes and face protected by a dust helmet into which fresh air is introduced from without by a tube at the back. In cleaning smaller objects the latter are carried in a closed box with a glass front along the stationary blow pipe, while the worker outside the box directs the pipe on to the object to be cleaned, his hands and arms being placed in leather or rubber gloves with armpieces attached to openings in the front of the said box.

The dust helmet is burdensome when working for a long time continuously at blowing and is therefore frequently taken off, when the continued scattering of dust by other workers in the same room leads to unavoidable inhalation. The wearing of a suitable respirator for a short time might be used as a remedy for this. A forty-four-year-old sand-blower in an engineering works died after three years' employment on such work. On the post-mortem examination silicosis was found to be present in an advanced stage, but there were no signs of tuberculosis. The man had frequently worked without a helmet. In the blowing of sand on metal objects it is beaten to a fine powder and the raising and dispersion of dust is enormous. It is well known that serious lung affections [2] in the form of silicosis in its various stages arise also among this class of workers. In a cycle factory in the Netherlands an X-ray photograph was taken of a worker who complained of shortness of breath and the result showed the characteristics of snowstorm lung, although the man had inhaled no dust during the last few years but had previously done so in considerable quantities.

[1] Steel granules are not used (*Centraal Verslag der Arbeidsinspectie Nederland*, 1925).

[2] *Zentralbl. für Gewerbehygiene*, May 1928, p. 149.

The quantities of SiO_2 that a lung can contain appear from an analysis of the dried lungs of a sandblower by Riddell and Rothwell [1], in which 16.83 per cent. SiO_2 was found.

There has been no regular medical examination of sandblowers in the Netherlands, nor yet in Germany [2].

In the work already referred to, *Das Sandstrahlgebläse*, the measures for preventing the injurious effects arising from the use of sandblowing apparatus are particularly described.

On a lesser scale than in industry sandblowing is used in the cleaning of the fronts of buildings. By this process brick, sandstone and limestone are restored to their natural colour. To prevent the dispersal in the surrounding space of the dust from the powdered sand, a large awning is suspended from 1 to 2 metres from the front, so that the worker who remains for a long time in a thick cloud of dust is insufficiently protected by his mask. In this case also signs of pneumonoconiosis in a serious form are found.

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[1] *Loc. cit.*

[2] *Das Sandstrahlgebläse: Schriften aus dem Gesamtgebiet der Gewerbehygiene*, 1928, Neue Folge, No. 21, p. 45.

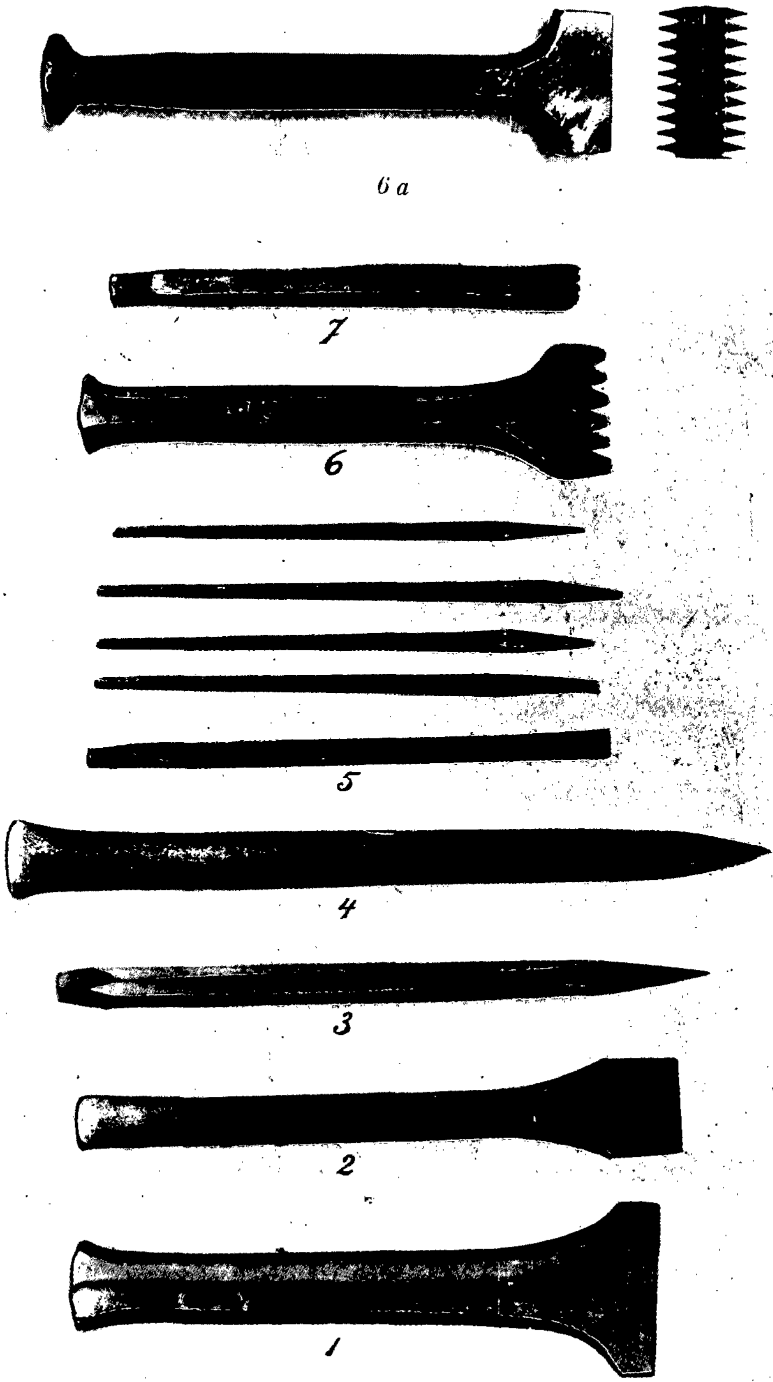


FIG. 1.

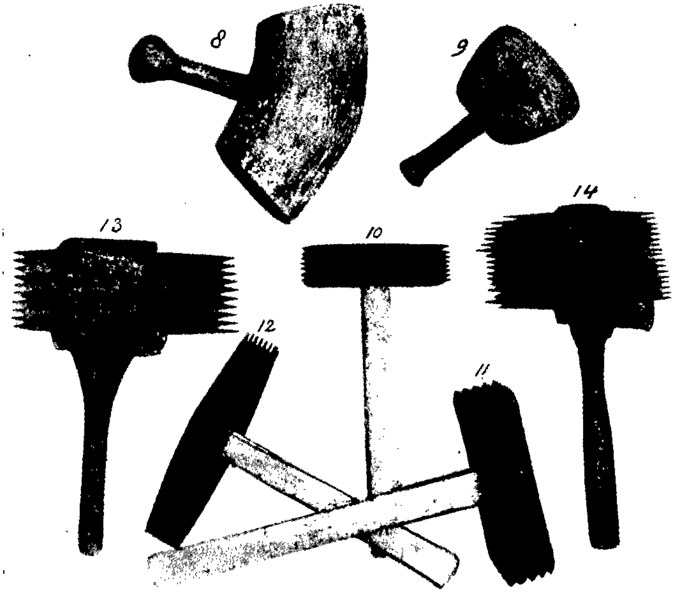


Fig. 2.

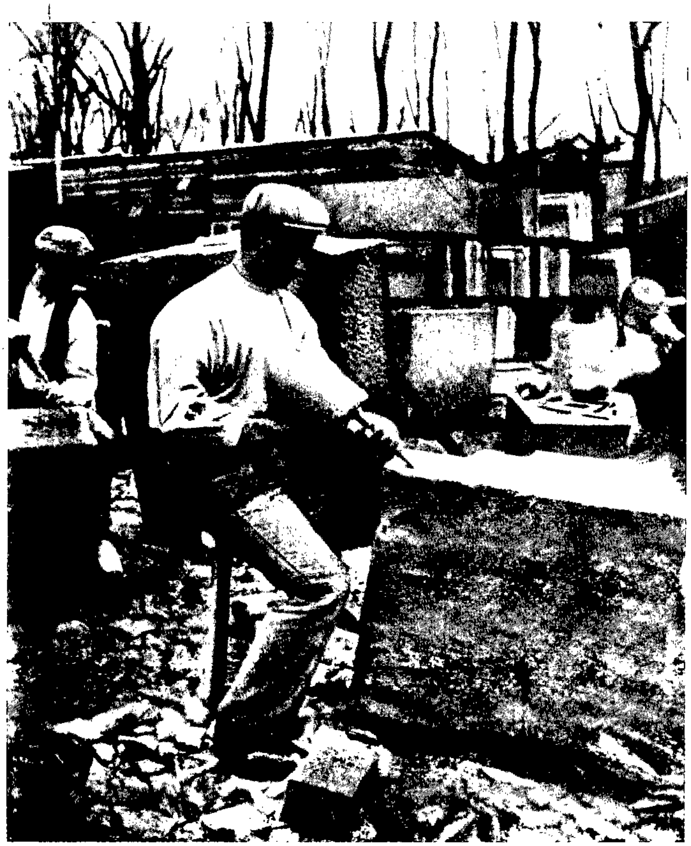
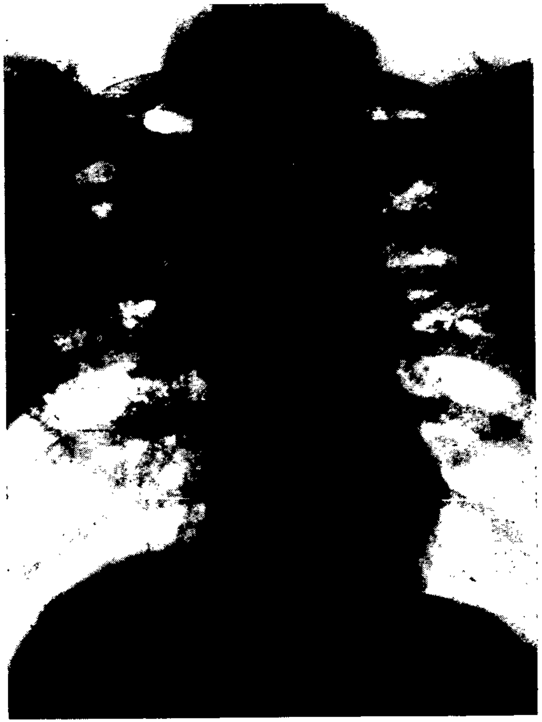


Fig. 3. — Stonemason at work (in good sitting position).



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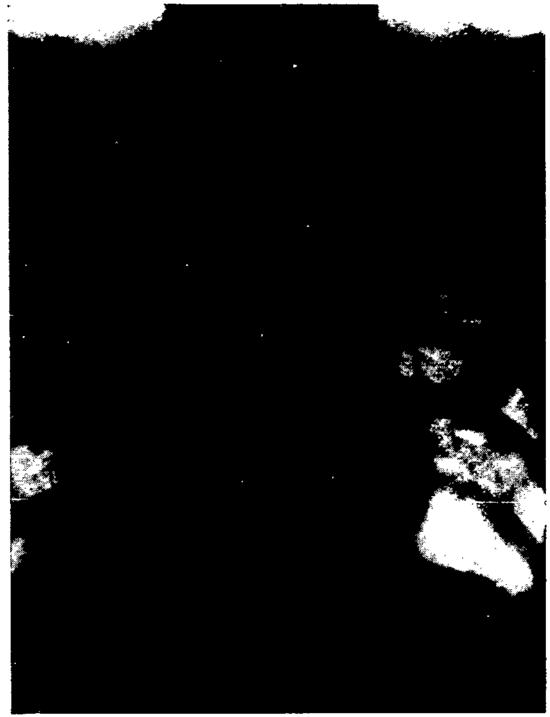
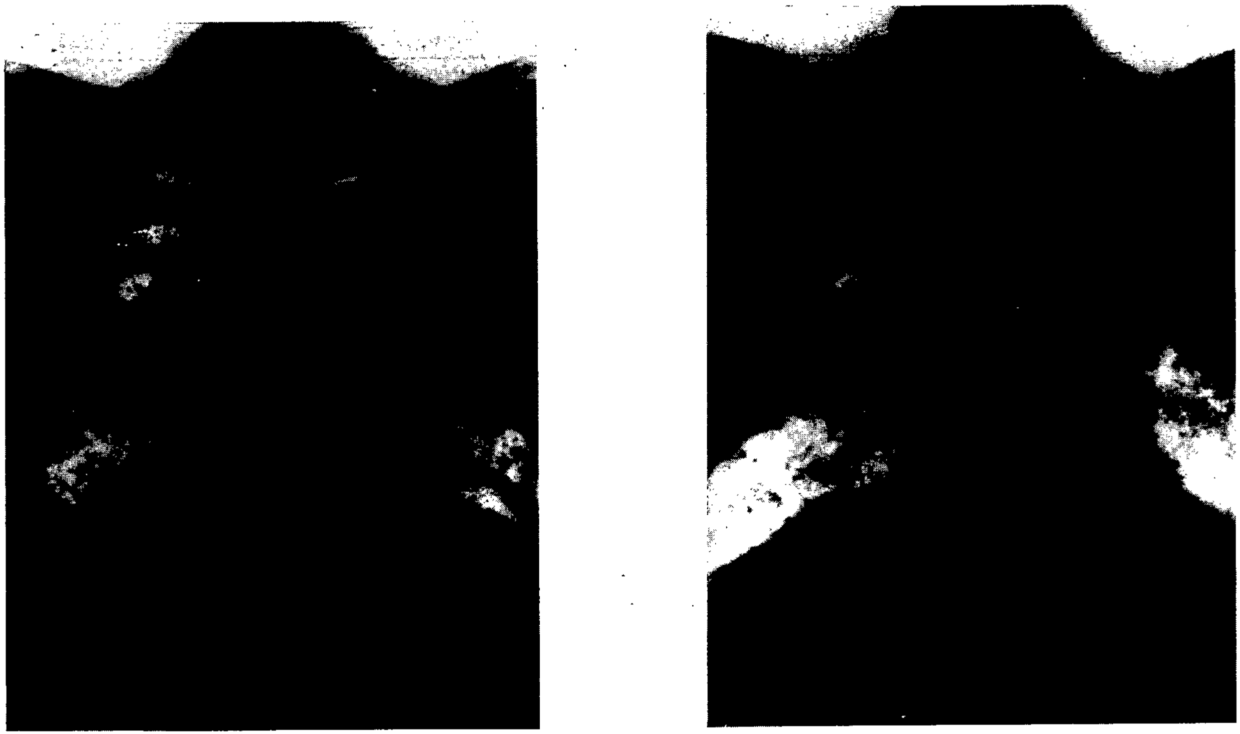


III

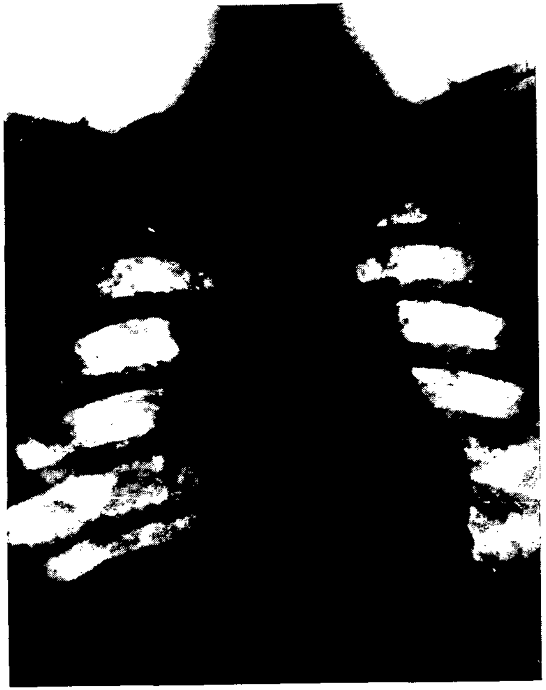
D. J., No. 29: 43 years of age; 27 years stonemason in 1923, before and after that date worked all kinds of stone.

X-ray photo. I: snowstorm lung, 1923. III: snowstorm lung, 1929, increased.



II III

Ph. G. M., No. 27: 36 years of age; 21 years stonemason in 1923; before that date much sandstone; from 1923 to 1929 did not work in stone, nevertheless increased.
X-ray photo. II: snowstorm lung, 1926, increased. III: snowstorm lung, 1929, increased.



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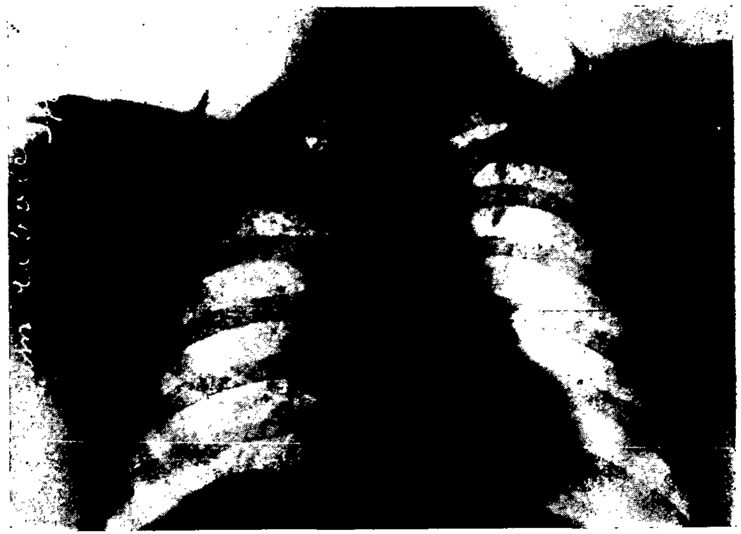
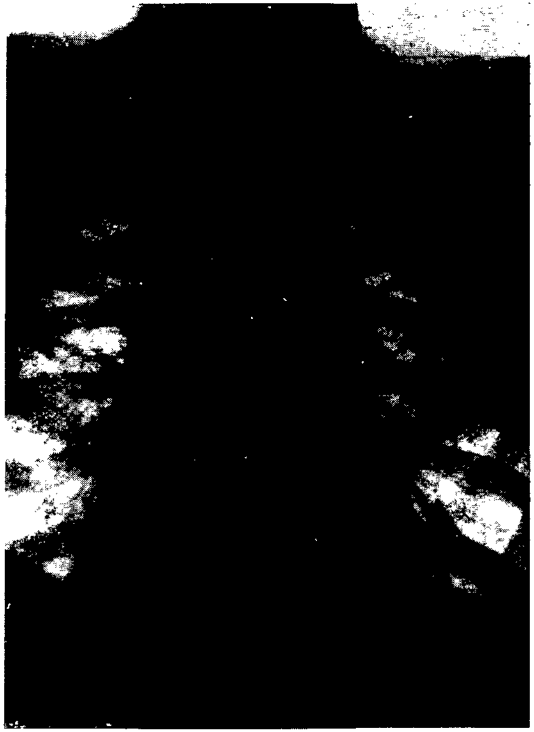


III

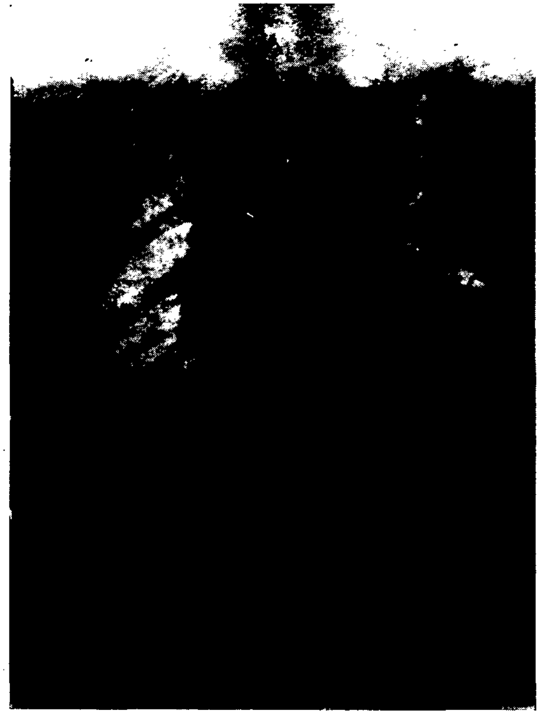
A M., No. 23: 44 years of age; 30 years stonemason in 1923. Before and after, sandstone and Belgian limestone. X-ray photo. I: stippled lung 1923 (2nd stage). III: stippled lung 1929, remained the same since 1923.



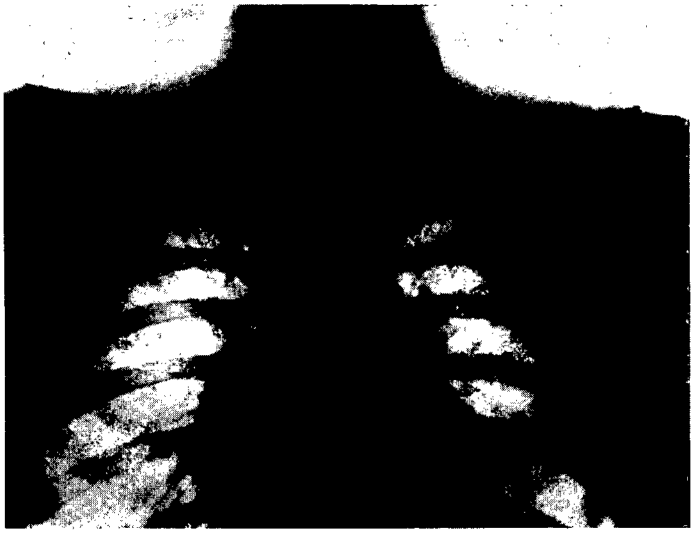
A. V., No. 11: 27 years of age; 14 years stonemason in 1923; before then all kinds of stone; after then not much sandstone.
X-ray photo: incipient fibrous lung (1st stage) 1926, the same as in 1923 and 1929.

J. F. S.: 44 years of age; 32 years stonemason in 1923, before then all kinds of stone; died 1925. On post-mortem = silicosis + tuberculosis.
X-ray photog.: silicosis (3rd stage), right more than left.

J. J. W.: 64 years of age; 52 years stonemason in 1923; before and after, Belgian limestone only.
X-ray photo: snowstorm lung.



P. V.: 61 years of age; 49 years stonemason in 1923, before and after, marble only.
X-ray photo: snowstorm lung 1926, increased after 1923, and remained the same in 1929.



F. v. B.: 44 years of age; 30 years stonemason in 1926, before and after, only sandstone.
X-ray photo: no affection.

SILICOSIS IN THE UNITED STATES

BY DR. ALBERT E. RUSSELL,

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INTRODUCTION

Silicosis is rather widespread in the United States: it has been found to exist with a rather high incidence in a number of industries. There are other industries in which only a few workers are occasionally exposed to siliceous dust, but in which the effect of the exposure in these few dusty occupations is great enough to produce silicosis in a moderately advanced condition in a short time.

The principal industries in which silicosis occurs in its greatest incidence are enumerated below. It is not implied that all the workers in these industries are exposed to excessive amounts of dust.

Mining:
- Anthracite coal
- Bituminous coal
- Gold
- Silver
- Zinc
- Lead
- Copper

Quarrying:
- Granite
- Sandstone
- Limestone
- Slate
- Flint
- Rock crystal (quartz)

Stone (finishing):
- Granite
- Sandstone
- Building stone (various grades)

Pottery:
- Emery wheels
- Carborundum

Abrasive:
- Sand
- Sandpaper
- Grinding

Glass

Mineral earth:
- Silica flour
- Sand

Spray coating:
- Plumbing materials

Refractories:
- Silica bricks

Construction:
- Railways
- Highways
- Tunnels
- Rock drillers in general

A number of occupations in industries are productive of dust, while the general nature of the industry in which it is carried on might not indicate that any dust hazard was prevalent. These are enumerated here:

Sand-blasting	Buffing
Moulding (ores)	Cleaning
Grinding	Polishing

There are numbers of dusty industries and occupations in the United States which do not necessarily present silica hazards, but they have an excess of dust, and in most of them silica is found in a small percentage, and no doubt plays its role in causing an excessive morbidity from respiratory diseases. Some of these are enumerated here:

Cement	Graphite
Marble finishing	Coal cleaning

Smelting:

Steel
Copper
Lead
Zinc

Textiles:

Cotton
Woollen

Grain elevators:

Wheat
Oats and other grain

Construction:

Building
House wrecking

Studies on the problems of dust removal are being made in laboratories at Harvard, Yale, and other universities. Much valuable work in this direction has been done by the U.S. Bureau of Mines at laboratories in Pittsburgh and in mines. The manufacturers of exhaust and ventilating equipment have also contributed greatly by study and experimentation to the improvement of dusty conditions in industry.

A very valuable experiment is being carried on in mines in Oklahoma. The Bureau of Mines, the Metropolitan Life Insurance Company, and the State of Oklahoma have combined to study the effects and remedies of the dust hazards encountered in mining.

The United States Public Health Service has made studies of certain industries to cover the various types of dust:

1. The cement industry, representing calcium dust.
2. Silver polishing, representing metal dust.
3. The granite industry, representing silica dust.
4. The coal industry, representing carbon dust.
5. The cotton industry, representing vegetable dust.
6. Street sweeping, representing municipal dust.

These studies have been completed and two have been published; others are in p ocess of preparation.

Some of the industries wheıe silicosis has been found in excess are briefly reviewed here.

Mining

Mining is one of the largest industries in the United States. It is widespread, being carried on in some measure in practically every State. Silicosis is a hazard which seems to be common to most mining operations. Its incidence and severity vary according to the variety of dust encountered and its concentration.

The efficiency of exhaust systems throughout the different mines varies greatly. Many companies are keenly interested in providing exhaust systems, and others give more attention to other problems.

The principal groups of mines in the United States are those producing the following ores:

Coal	Iron
Copper	Aluminium
Lead	Gold
Zinc	Silver, etc.

During recent years there has been much more machinery employed in mining than formerly, most of which is impelled by compressed air or electricity. These newer methods have increased the dust hazards to an appreciable degree. The coal miners, for instance, are reputed to have more pneumonoconiosis in recent years than in the days when mining was accomplished by older methods.

The United States Bureau of Mines has been a very valuable agency in assisting in the alleviation of dust and other hazards in mines. The Bureau maintains a very excellent laboratory at Pittsburgh and at experimental mines near by. The Bureau workers have co-operated with mine operators and other agencies and are rendering a service which would otherwise be unobtainable. The chief surgeon and other medical personnel of the Bureau of Mines are supplied by the United States Public Health Service.

Coal Mining

Coal is produced in thirty of the forty-eight States and in Alaska. Six of these States produce less than 100,000 tons annually.

There are two varieties of coal produced in the United States, viz. anthracite and bituminous.

Anthracite Coal

Anthracite coal is produced in Pennsylvania. There are other deposits of anthracite (or near-anthracite), but these are not great enough to produce in paying quantities. There were 157,743 wage earners in the anthracite coal industry in 1923 (U.S. Census). These were located in three counties in Pennsylvania.

Anthracite coal occurs in Pennsylvania in large veins and at varying depths. In earlier days there were out-croppings, which were mined with steam shovels in pit mines, but at present the mines are all underground. The mine shafts and tunnels are large and afford good opportunity for general ventilation. Anthracite coal has been produced on a large scale longer than bituminous coal.

The rock which is associated with anthracite coal contains 31 per cent. of free silica, and the possibilities of the occurrence of silicosis are obvious. The following table gives the percentage of silica in several industrial dusts which we have studied.

TABLE I. — CHEMICAL AND PETROGRAPHIC ANALYSIS OF THE DUST IN EACH STUDY

	Total silica (Percentage)	Quartz (free silica) (Percentage)
Silver polishing:		
Hollow-handle making room	22.2	1.7
Wet pumice (two samples averaged)	70.5	Less than 0.5
Brass foundry	73.3	19.0
Cement:		
Pack house	21.2	Less than 1.0
Crusher house, raw mill, stone house	16.8	6.5
Soft coal (bituminous):		
Coal dust	?	1.2
Rock dust	High	54.0
Hard coal (anthracite):		
Coal dust	?	1.5
Rock dust	High	31.0
Granite:		
Average	70.0	35.2

The anthracite miners develop acute bronchitis and, later, emphysema and miner's asthma. These chronic conditions, together with the effect of some rock dust, make it very difficult, even for those who are specialised in tuberculosis, to diagnose pulmonary tuberculosis. Obviously, tuberculosis is easily overlooked among coal miners. Routine sputum analysis will often give information as to whether or not a tuberculous infection is present.

The dust counts made in the anthracite mines studied by the

Public Health Service showed that the dustiness encountered by workers in the various occupations averaged as follows:

	Million particles per cu. ft.
Miners and mine labourers	124.2
Rock workers	81.9
Drivers and runners	36.5
Others	2.3

It was shown by petrographic analysis that a sample of coal dust from the anthracite mines contained 1.5 per cent. of crystalline silica as quartz.

The incidence of tuberculosis among coal miners has been a much debated subject; we found among those included in our study that tuberculosis did occur. In considering the causes of deaths from 1906 to 1926 in Wilkes-Barre, Pa., located in the heart of the anthracite region (deaths from all external causes were excluded, also data of the epidemic years), it was found that the cause of 11.4 per cent. of the deaths of coal miners was given as tuberculosis, while 6.5 per cent. of the deaths of other adult males in the same area was stated to be due to this disease (see figs. 1 and 2).

The earlier workers in anthracite coal mines in Pennsylvania were principally from Wales and Cornwall, England. At present, however, these people are in the minority, and Slavs and Southern Italians compose the greater numbers. The morbidity records which we have for a group of these miners show that alcoholism was a frequent cause of absence from work.

Bituminous Coal

Bituminous or soft coal is found in larger quantities in the United States than anthracite and is distributed over a much greater area. The deposits are usually in " drifts ", for which reason the plan of the mines is different from those of anthracite coal. Most of the bituminous mines are entered horizontally, usually from a mountain side. The overlying stratum is of sandstone in some of the larger areas, schists and other varieties of stone in others. The drifts are low in many places, and necessarily the chambers and tunnels are small. This fact augments the dust hazards of bituminous mining. There were 545,798 wage earners in bituminous coal mines in 1919 (U.S. Census). Much of the coal is cut with machines and then loaded with shovels. Coal-loading machines are being introduced—their use lessens the amount of dust. Rock drilling is supposed to be done when the other operations are not in progress. (From a previous table it may be seen that analysis shows that some of this rock (sandstone) contains 54 per cent. of quartz.)

The following figures show the extent of dustiness to which each one of these workers is exposed.

	Million particles per cu. ft.
Coal cutter (machine operators) . .	112.3
Coal loader	112.3
Rock driller	78.1

The pneumonoconiosis of the bituminous coal miners is quite different from that of the anthracite miners, whose X-rays have been shown herein. The bituminous miners have not had asthma in the same incidence as the anthracite miners. In fact, miners' asthma among bituminous miners is considered to be rare.

The incidence of tuberculosis, likewise, has not been shown to be as great among bituminous miners as among anthracite miners.

It will be seen from the accompanying prints[1] that the pneumonoconiosis of these workers is apparently not so severe as that of anthracite miners (film 3).

The coal is carried out of the mines usually by a small electric train. The silica hazard in these mines is augmented by the use of sand on the tracks of the coal trains; the sand becomes pulverised and the motion of the trains fans it into the air. In many of these mines (especially the smaller ones) ventilation is accomplished through the same tunnel, increasing the silica hazard by the diffusion of this dust. Conditions could be alleviated by the use of a material other than sand to increase the friction of the car wheels on the track.

From the accompanying print it may be seen that the motormen on these coal trains developed silicosis. No doubt the pneumonoconiosis of the other mine workers is influenced by this sand dust (film 4).

Gold Mining

Gold is mined in California, Colorado, Nevada, South Dakota, and Utah. It occurs in other States, also, but is not mined extensively in those States. The mining is accomplished in California partly by hydraulic methods which eliminate the silica hazard; but as a rule there is a silica hazard in all the gold mines in the United States.

Gold is invariably found deposited in quartzite rock, the percentage of quartz, however, varying in different localities. Silicosis is known to occur in excess at most of the mines.

[1] These prints are given after p. 562.

It is said to occur with less frequency in the Colorado mines, which are moist, and naturally less dust is created in the mining process. The ore is found combined with volcanic rock which contains more than 20 per cent. of quartz. The altitude of these mines is above 10,000 feet, and belief is held by some that the cases of silicosis eliminate themselves because of dyspnoea, the affected workers seeking lower countries before diagnosis is made.

In Utah the mines are hot, and cooling air must be supplied for the comfort of the workers. The heat dries the mines, thus augmenting the dust hazards. The workers in these mines are reputed to have a high incidence of silicosis.

One of the oldest and largest gold mines in the United States is located in the Black Hills of South Dakota. The sick-benefit association of this mining company has reported the illness (eight days or longer) of its members to the Public Health Service over a period of five years. When the rates of illness among these gold miners are compared with those of other sick-benefit associations, it is found that the miners have 2.5 times as many respiratory attacks as the other groups. When the comparison is made in regard to each condition, it is found that influenza and grippe are 3.7 times as great among the miners. The outstanding condition, however, is pulmonary tuberculosis, which has an incidence 8.7 times as great as that of the other groups. This finding was to be expected, since we know that the workers are exposed to excessive amounts of a highly siliceous dust. No doubt these cases of tuberculosis are complications of silicosis, although we have no examinations of X-ray prints to furnish proof of this opinion.

Granite Manufacturing

The granite industry is one of the largest in the United States in the production of stone. It is excelled only by the marble, limestone and sandstone industries as to amount produced. Granite is used in monumental work principally, while marble, sandstone, and limestone are used more extensively as building materials.

The manufacturing of granite into monuments requires more manual labour than that of other stone, because of the extreme hardness of granite. The softer stones (marble, sandstone, and limestone) are easily manufactured with machinery, and much of the dust hazard is thereby eliminated.

The large granite centres in the United States are located in

Vermont, New Hampshire, Maine, Massachusetts, Connecticut, Rhode Island, New York, Minnesota, Wisconsin, and Georgia. There are numerous other localities where granite is found, but production is not carried on extensively in these places.

The hazard from granite is based upon its free silica (quartz) content, which ranges from 25 to 35 per cent.

A report of a study made by the United States Public Health Service of the dust hazard in this industry has recently been published—Public Health Bulletin No. 187. In this study it was shown that the workers engaged in finishing granite were exposed to dust in the concentration of 40 to 65 million particles per cubic foot (i.e. particles less than 10 microns in diameter). The general plant atmosphere averaged 20 million particles per cubic foot.

TABLE II. — CLASSIFICATION OF OCCUPATIONS INTO DUST COUNT GROUPS

Group	Occupation	Number of men	Average dust count. (Million particles per cubic foot)	
A	Hand pneumatic tool operators	565	59.8	More than average plant dustiness
	Carvers; letterers	24	37.0	
	Others	25		
B	Surface machine operators	68	44.0	
	Tool grinders	20	27.1	
	Others	16		
C	Lumpers			
	Boxers			
	Polishers [2]			
	Cranemen			
	Bedsetters	146	20.2	Average plant dustiness
	Tool carriers			
	Mechanics			
	Labourers			
D	Polishers [2]	17	9.0	Less than average plant dustiness
	Sand blast operators	4	6.2	
	Sawyers	10	4.6	
	Blacksmiths	10	2.5	
	Others [3] (no specific dust count, but low)	66		

[1] Hand pneumatic tool cutters during most of their time in granite, but before or later were in other occupations.
[2] All in Group C, except in one plant (where they had a separate shed).
[3] Occupations were: derrickmen (22), engineers (10), machinists (9), foremen, manufacturers (9), etc.

The workers were grouped according to the intensity of exposure and are considered throughout the morbidity and mortality study in these groups. Groups A and B were exposed to averages of about 27 million particles per cubic foot, and the average for some in this group reached 60 million; Group C averaged about 20 million particles; Group D averaged 10 million or less. Table II explains this classification.

Each part of the study (X-ray, physical examination, sickness records, and mortality) showed a direct relation to the extent of dust exposure and damage to the lungs and the extreme likelihood of final superimposition of a fatal tuberculosis.

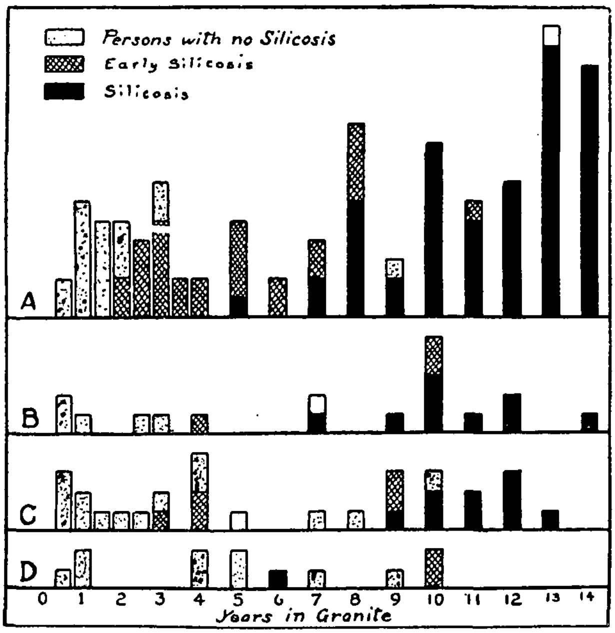


FIG. 1. — Persons with and without silicosis in the four dust count groups, by length of service.

The physique of the granite cutters was every good, and they usually remained in the industry after apprenticeship. Their wages were good ($8-$20 per day), and they worked forty hours a week for one half of the year and forty-four hours a week for the other half. The living conditions were usually very good.

Pleurisy (dry) was a common finding among the granite workers. The pulmonary disability (silicosis and tuberculosis) varied directly with the length of exposure. There was a tendency for patients about to break down with tuberculosis to have more respiratory diseases than they had had before this period. Silicosis was found among many of the workers, in groups A and B after two years' service; after longer exposure silicosis occurred among them almost universally. Fig. 1 explains the incidence of silicosis among the various groups by length of service.

The amount of sickness from all causes showed a direct relation to intensity of exposure to dust. The following graph shows that length of service and intensity of exposure caused an increase in the incidence of sickness in Groups A and B (fig. 2).

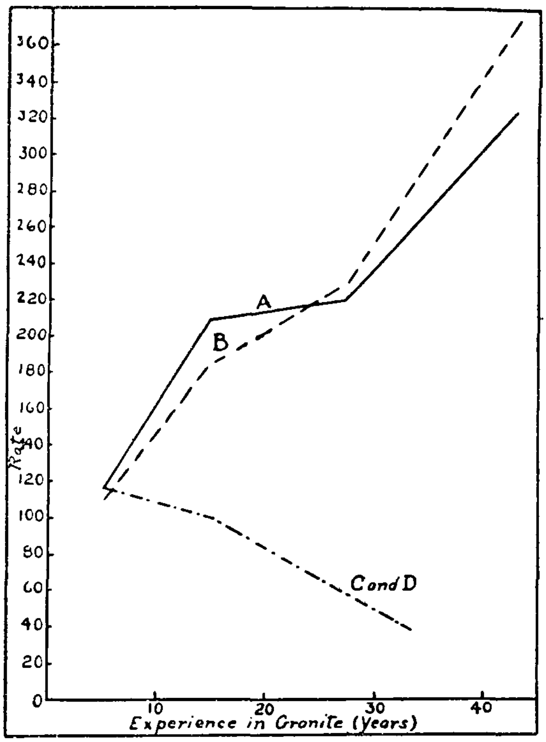


FIG. 2. — Incidence of sickness from all causes in the four dust count groups by length of service. Eight days and more (rate per 1,000).

The following graph compares the frequency of sickness of granite workers with that of certain other industrial groups. The group " General Sick Benefit " is given to represent more or less average industrial workers. From this graph it will be seen that the workers in dusty trades have a much greater incidence of all respiratory conditions (fig. 3).

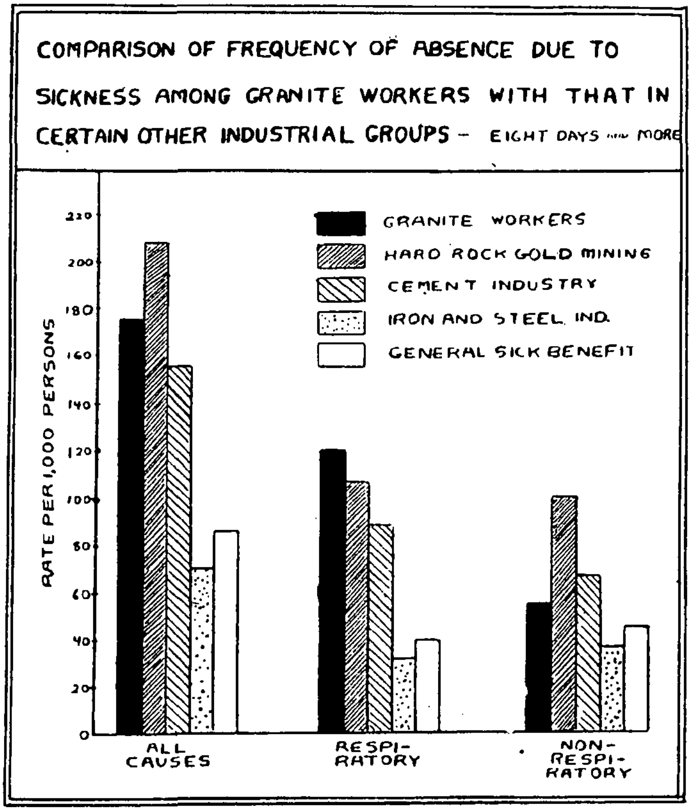
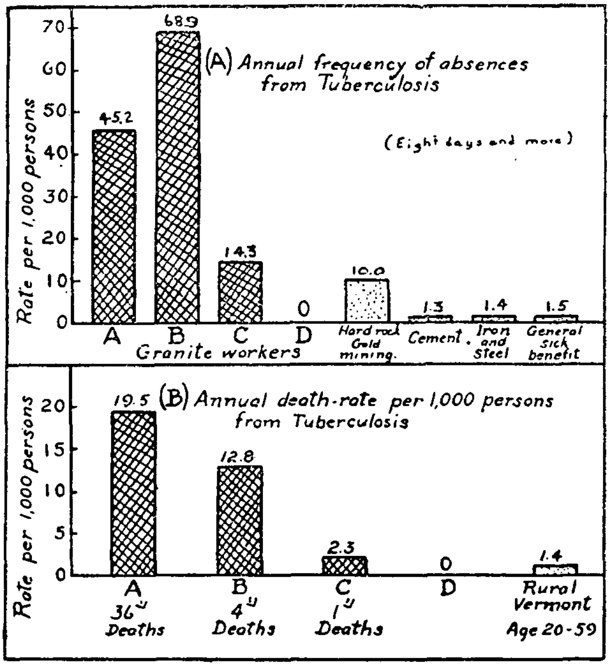


FIG. 3.

The sickness rates from tuberculosis (superimposed on silicosis) is next compared with those of other industries. Here we see the great preponderance of the incidence of tuberculosis. In the same graph the death rates of the various groups are compared with those of adult males in rural Vermont. It should be noted that the hard-rock gold miners used herein had not been in the industry as long as the granite workers (figs. 4 and 5).

When tuberculosis became a complication of silicosis, it usually made a rather sudden onset and pursued an unremitting course to a fatal ending. None of the cases became arrested. The age at death of these workers averaged 49 years, which included a few who indoubtedly had a latent tuberculosis on entering the trade, in which instance the disease resembled tuberculosis not complicated by silicosis; these latter cases, however, were few. It was difficult



[1] From beginning of study to working up of report—about three years—among 972 workers: A, 614; B, 104; C, 146; D, 108.

FIG. 4. — (A) Annual frequency of absences from tuberculosis (eight days and [.] more); (B) Annual death rate per 1,000 persons from tuberculosis.

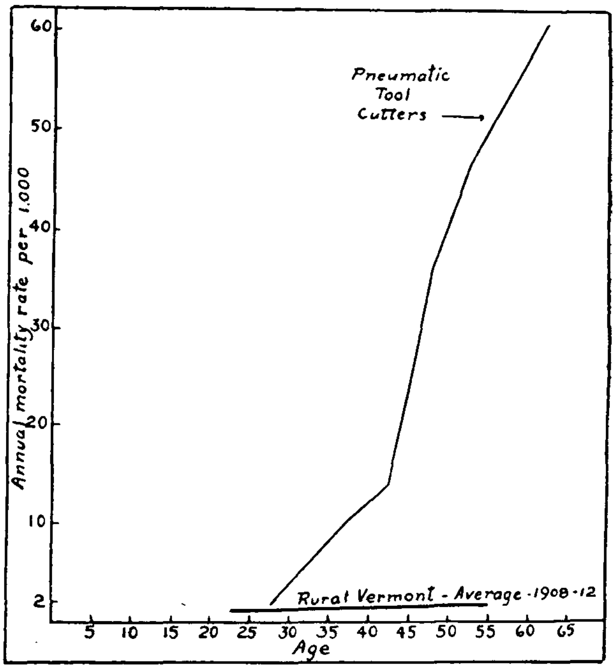


FIG. 5. — Age curve of mortality from tuberculosis among hand-pneumatic tool cutters and in rural Vermont (males).

to obtain specimens of sputum for analysis, but when the sputum was examined, it was usually found that the first specimen contained tubercle bacilli in great numbers. The length of a case of tuberculosis among these workers was usually about fifteen months, and termination was always death.

Tuberculosis occurred in the families of granite workers, but perhaps less frequently than in general practice, because of the excellent hygienic conditions of their homes; and also, the disease came on at an age (about fifty) when the children were no longer little, many of them being either grown up and at work or away at school.

Pneumatic tools were first employed in the granite industry about the beginning of the present century, and the tuberculosis rate has increased rapidly with their use. It is doubted if the maximum rate of tuberculosis has been reached. Since the introduction of the pneumatic method the rate has risen in proportion to the length of time for which they have been used, as follows:

1.5 per 1,000 . .	1890-1894
10.8 ,, ,, . .	1910-1914
19.5 ,, ,, . .	1924-1926 (period of study)

Studies were made of many of the exhaust and ventilating systems in use in the local plants, and in no instance were they found to be adequate. A plant in another city was found to have an excellent system, by which, if it were properly maintained and operated, a safe atmospheric condition could be obtained. A paper on "The Efficiency of Dust-Removal Systems used in Granite Cutting" was presented in Public Health Reports, 18 October 1929. This paper gave specifications for exhaust and ventilating systems, together with dust counts found under varying conditions.

The accompanying X-ray pictures show silicosis and tuberculosis complicating it in granite workers. Tuberculous lesions in the base of the lung (usually right) were found as a rule among these cases. (See bulletin.) (Films 5 and 6.)

Granite Quarrying

Much of the quarrying of granite is accomplished by a wet process, and very little dust is generated. The worker is able, too, to stand away from the pneumatic drill, which is attached to a stand. After being removed, the stones must be split into smaller sizes, and some dust in encountered here, but perhaps not in quantities sufficient to produce marked silicosis, and quarry workers in granite are certainly not reputed to have a high incidence of tuberculosis.

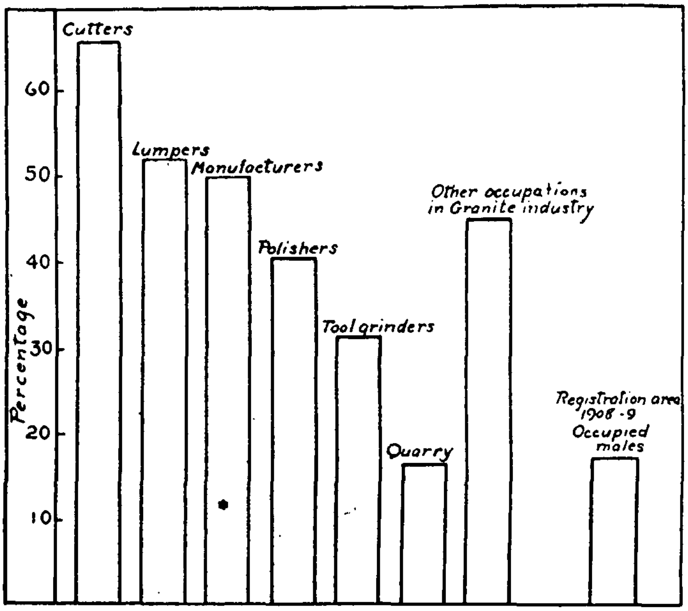


FIG. 6. — Proportionate mortality from tuberculosis [1] in specific occupations of granite industry compared with data for occupied males. Registration Area, 1908-9.

[1] Many were previously granite cutters.

The precaution taken to keep down dust in granite quarries is the provision of hose and water to keep the drill moist during the cutting operations. The splitting of the blocks is accomplished out in the open and usually after the stone has been removed from the quarry pit.

Sometimes a stone finisher will change his occupation to quarrying, and should he develop silicosis, its background might be his former occupation. A careful occupational history is necessary before silicosis can definitely be accredited to the occupation which the worker followed immediately before his illness. Although the quarry worker in granite handles siliceous materials, it is thought that the hazard from dust is small.

It may be seen from the graph on page 548 (fig. 6) that the deaths of quarrymen from tuberculosis were less than those of occupied males in the registration area in 1908-1909.

MARBLE

Vermont, Georgia, and Tennessee are the principal marble producing States. Vermont was the pioneer in production of large amounts. Marble dust contains about 1 per cent. crystalline silica, with about 98 per cent. calcium. No silicosis has been shown among these workers. The Vermont State Sanitarium for Tuberculosis is only a few miles from one of the largest marble works, and according to its records, marble workers (unless they have previously worked in granite) are seldom admitted to the institution for treatment. Dr. E. J. Rogers, physician in charge of institutions and clinics for tuberculosis in Vermont, states that these workers rarely have tuberculosis. The calcium present in marble dust may be a factor in causing such a low incidence of tuberculosis among this group of workers. Tuberculosis has likewise not been reported to be in excess at other (newer) marble centres.

(Vermont marble must not be confused with Vermont granite.)

SANDSTONE

The sandstone industry in the United States centres in and around the States of Ohio and Indiana. The contact of the worker with the stone in quarrying and finishing is not so close as in the case of granite. Sandstone is less resistant and can be made into fiinished products by machinery much more easily than granite. Therefore it would not be supposed that workers in sandstone would be exposed to as much dust as granite workers. Certainly they are exposed to much less dust than miners, since much of their work is accomplished above ground and in the open.

A study which was made in one of these quarry sections was reported in the *Journal of Industrial Hygiene* in September 1929 (Vol. II, No. 7). Of 919 workers, 409 were found to be negative for silicosis. The median age, however, of this negative group was twenty-seven years, and the average time of exposure to dust was less than four years. It was shown that by the time the workers were thirty-six years old and had had an exposure to dust of 7.41 years that 238 had " increased fibrosis ". The incidence of silicosis increased with age and length of exposure, and the number of cases of tuberculosis also increased likewise. If these findings exemplify the silicosis hazard in the sandstone industry, we see that this hazard constitutes quite a health problem. The incidence of tuberculosis as a complication of silicosis in sandstone workers is much less than in the granite stone industry, being obviously a matter of intensity of exposure. There were no dust counts made in this study of sandstone, but from the nature of the occupations in this industry it is certain that the granite workers are exposed to much greater quantities of dust than this group of workers.

Spray Coating

The number of workers in this occupation has greatly increased in the United States in the past few years. There has been greater demand for plumbing materials, incident to the construction and modernising of homes, and the spraying of paints has in many instances replaced the older methods of brushing. The tremendous growth of the automobile industry has necessitated rapid methods of painting.

A committee on spray-coating selected by the National Safety Council recently studied the situation. Evidently lead is the main hazardous material encountered in the spraying of paints, but siliceous materials are occasionally employed. In the manufacturing of plumbing materials (bath-tubs, wash-basins, etc.), silica is frequently encountered. Erroneous ideas have prevailed as to the safety of " wet dust ", but such dust has been shown to be capable of producing extensive silicosis. Vitreous enamel is stated to contain 43 to 47 per cent. of silica (much of which is evidently in the form of silicates). The committee recommends the use of a bisilicate of lead, which would lessen the hazard from both silica and lead. The committee also urged adequate exhaust systems for the spray booths and showed that with a poor ventilating system the air contained 445 million particles per cubic foot and that with exhausts of a better variety the counts showed only from 5 to 24 million particles per cubic foot.

Sand Blasting

The use of sand blasting in the industries has become very widespread in the United States within a very short time. Many large manufacturers find use for sand blasting in some of their processes, whereas they have no other dusty trades.

From my own observations, I am convinced that sand blasting, unless done under proper conditions, is capable of producing silicosis more quickly than almost any other trade carried on in the United States. The sand-blasting machinery producers have taken cognisance of the great hazards of the trade and have instigated research towards instituting methods of control. Equipment for dust alleviation is available, but its efficiency depends upon its design, its proper installation, and its maintenance. Recently, blasting with steel grit has been tried, and obviously much less dust is produced with this medium, but the result is not the same as when sand is used; instead of a cut surface, more of a hammered effect is obtained. More recently carborundum has been used and with success. I believe that in time carborundum or other silicon carbide products will replace the use of sand or fine pebbles.

There are more than 10,000 workers in the United States employed in sand blasting, and as the labour turnover in this trade is great, many more people are exposed. Because of the delayed effect of silica dust in the lungs, it would be impossible to estimate the role which sand blasting plays in mortality from tuberculosis and other respiratory diseases.

Sand blasters nearly always use masks or helmets to protect them from dust. In some cases the operator does not wear a mask, but stands outside the cabinet and looks through a window and operates the hose through an aperture covered with burlap. The inadequacy of such equipment is great and cannot be too strongly condemned.

The Public Health Service and the National Safety Council have undertaken co-operative studies of sand blasting in the United States. The complete report of this work will be published jointly and will be available for distribution next year. The findings, although not yet complete, show that the dust concentration in two of the rooms in which counts were made reached 1,706.6 and 1,171.2 million particles per cubic foot. Helmets with positive air pressure were worn by operators, and samples of air taken from under the helmets contained 17.3 and 13.3 million particles per cubic foot, respectively. This is above the standard set for granite, which is 10 million particles; also, sand contains a higher percentage of silica than granite. That these are dangerous amounts is quite evident, and forced ventilation of the sand-blast rooms is obviously very necessary. The accompanying X-ray print and history are from a patient who wore a helmet while at work (film 7).

The influence of positive pressure may be seen from the following statements. The air of one of the sand-blast rooms contained 894.7 million particles and the air from under the helmet with positive air pressure contained 8.4 million particles per cubic foot. A test was made in which the helmet was used without air supply. The room dustiness in this instance was 1,568.0 million particles, and the air under the helmet contained 437.7 million particles per cubic foot.

Case of silicosis in a sand-blaster. Patient wore a mask.
W.M.: aged 46 years; Mulatto.
Sandblaster 7 years.
History of past health showed no diseases of any importance. No history of tuberculosis in family. Five years after this X-ray was made, patient died of tuberculosis (tubercle bacilli in sputum). (Film 7.)

Rock Drilling

Rock drillers are exposed to rock dust, which dust is produced in great quantities, by the pneumatic drills with which their work is accomplished. Moreover, the workers are usually labouring in " rooms ", tunnels, or pits where natural ventilation is of little assistance.

Rock drilling is done extensively in the construction of highways, railways, tunnels, and excavation for buildings. An engineer engaged in inspection of construction work stated recently that on the island of Manhattan (New York City) alone there were 20,000 rock drillers. The rock in which these 20,000 drillers are working contains over 50 per cent. of quartz. This means that, when the labour turnover is considered, over 20,000 persons a year are exposed to dangerous amounts of silica. A study was made of rock drillers engaged in subway construction on Manhattan island and was reported in the *Journal of Industrial Hygiene*, February 1929. Fifty-seven per cent. of the workers examined were found to have silicosis, and tuberculosis was found (by X-ray) to be present in 9 per cent. of the cases examined.

Because of the insidious nature of silicosis the incidence of both silicosis and tuberculosis will no doubt greatly increase among these workers, inasmuch as they have undergone intensive exposure to rock dust in recent years.

Attention is being given to methods of dust prevention, but the nature of the work and its frequent use in isolated situations, as in foundation work, construction of highways (rural), etc., make the problem of the prevention of dust more than difficult.

The Abrasive Industry

In the abrasive industry, which manufactures a number of products, sand is invariably used. In some instances natural sand constitutes a large part of the abrasive material.

E. R. Hayhurst and other writers state that "during the last fifteen years of observations in the State of Ohio, there have appeared few reports of silicosis and these usually from the abrasive industries" (*Journal of Industrial Hygiene*, Sept. 1929, Vol. XI, No. 7).

I saw a worker suffering from moderately advanced silicosis who described his exposure to silica dust as occurring when he dumped sand on hot electric elements to be burned with other substances to produce abrasive material. He stated that great clouds of dust arose from the hot furnace and remained in the air for several hours. X-rays of a number of workers in this industry show that there was definite silicosis present, although in the early stages. These workers change their occupations frequently and do not have as many years of exposure as workers in a more skilled trade.

In a number of abrasive industries a silica hazard exists without, perhaps, attaining a degree sufficient to produce the great excess of tuberculosis that is found in other dusty trades.

Grinding is an occupation in the abrasive industry in which silicosis is known to occur in excess and with such severity that tuberculosis is a frequent complication. From the following table it will be seen that the workers in this occupation have an excessive death rate from tuberculosis.

TABLE III. — MORTALITY FROM TUBERCULOSIS OF THE LUNGS IN A CONNECTICUT AXE FACTORY, 1900-1919

	Death rate per 100,000
State of Connecticut	150
State of Connecticut (male population)	170
Axe factory district (3 towns, entire population)	200
Employees of axe factory (all)	650
Employees of axe factory, polishers and grinders	1,900
Employees of axe factory, others	160

This table was prepared by Professor C. E. A. Winslow, of Yale University, and Sanitary Engineer Leonard Greenburg, U.S. Public Health Service.

Copper Mining and Smelting

The mining and refining of copper in the United States requires the services of over 60,000 persons. The largest copper mines are located in Arizona, Utah, Montana, and Michigan, the producing being indicated by the order given. Copper miners are reputed to have a high incidence of tuberculosis, and it is known that silicosis is quite prevalent among them. The incidence and severity of the condition depends on the variety of rock dust encountered and its concentration. The latter is better controlled in some localities than in others. Some of the big copper producers have installed elaborate ventilating systems and have incidentally been able to salvage enough ore to pay for the cost of operation of the exhaust system.

The smelting of copper also involves silica hazards; and inasmuch as arsenic is frequently found in connection with copper, a hazard from arsenic is also frequently encountered.

Sand

The use of sand seems to increase in America with each year. In 1921 845,008 tons of sand were produced in the United States, and greater quantities are used at present. The following industries use it in their processes of manufacturing:

Glass	Refractories
Foundries	Abrasives
Paving	(1) Grinding
Filter	(2) Polishing
Ballast	(3) Cleaning
Sandblast	

Sand varies in its content of free silica, but the amount present in it is always so great that the variations do not make much difference. As a causative agent of silicosis, sand rates very high.

The harmful effects of sand are well illustrated in the following quotation from a personal letter to me from one of the most eminent X-ray men in the United States:

> We have just completed the examination of a few interesting cases. These men have been engaged as labourers in a plant where sand is pulverised to be used in the manufacture of sand soaps and other articles where pulverised sand is the essential part of the goods produced. It has been noted that a mottling, such as we have designated as the second stage of silicosis, is present in some of the men as early as

three months after starting the occupations. Massive consolidations were present within a year, and equal to those seen in hard rock miners of several years. In other cases, there was the conglomerate mottling indicative of the third stage, occurring in less than a year.

The men stated that the sand, before pulverisation, was heated to a high temperature, and when it escaped upon their skins, it would burn them, and it would take at least two weeks before their skins became sufficiently tough to handle the sand. We were wondering whether this hot sand, when in the finely divided state, was at a sufficiently high temperature to destroy the cilia in the lower air passages, because of the very quick presence of fibrosis.

We thought this group of individuals might be of interest to you to present at South Africa.

Pottery Industry

Ohio leads in the United States in the number of pottery workers, employing almost 14,000 wage earners in this industry. New Jersey is second, with over 6,000 wage earners, and New York has about 3,000.

Silicosis has been known to occur among potters for a number of years, the silica dust being encountered in the glazing of pottery with silica flour. There are a few other occupations in which dust is generated, but these are of minor importance.

The silicosis of potters is of such severity that tuberculosis is a frequent complication; the tuberculosis does not usually occur, however, until about middle age or later. Newer methods are being employed in this industry and will no doubt lessen the amount of dust and consequently the incidence and severity of silicosis and tuberculosis among potters. One of the leading pottery companies in the United States has recently completed a very modern plant, during the planning and construction of which attention was given to the elimination of dust hazards.

Lead poisoning is also a hazard in this industry.

The print shows early silicosis in a potter (see film 8).

Compensation for Silicosis in the United States of America

There are two groups of compensation laws in the United States of America—federal laws and State laws.

The Government of the United States pays compensation for silicosis under the Act which refers to civil employees of the United States and to persons whose employment entails movement from one State to another, as in the case of transport workers. An instance here is the Longshoremen's Act.

Silicosis is not directly named in a law allowing compensation in the United States, but the language of the laws is sufficiently broad to cover occupational diseases in general, and silicosis is clearly included.

When a civil employee of the United States develops silicosis, he must file a claim; and quite unlike many of the States, the Federal Government sends a physician to examine the patient, and consider the case, which is then presented to the Employees' Compensation Commission where the award is made. Everything is accomplished without expense to the patient. He need not employ lawyers to present his case for him.

The case is considered as an injury produced by the inhalation of harmful dusts. The interpretation of the word " injury " includes not only accidental injuries, but also " such occupational disease or infection as arises naturally out of such employment " (section 40, Longshoremen's and Harbour Worker's Act, 1927). Specific occupational diseases such as silicosis are not defined, but the interpretation given above has been used to include silicosis, and compensation is paid the worker or his relatives.

The following States have legislation, as outlined below, which permits compensation within the confines of their own boundaries:

California	New Hampshire
Connecticut	New Jersey
Maine	Ohio
Maryland	Rhode Island
Minnesota	Wisconsin

The other States have no definite laws whereby the worker may obtain compensation. Some manufacturers in these other States feel morally obligated for silicosis and there have been instances in which a voluntary compensation has been paid. The amount paid varies, of course, according to circumstances, such as length of service, financial condition of the plant, etc. A number of plants in these States carry insurance on the workers which covers occupational diseases.

California

Article 20 of the State's Constitution has permitted statutes to be made covering workmen's compensation and insurance. Under a certain section the term " injury " is defined as follows: " The term ' injury ' as used in this Act, shall include any injury or disease arising out of employment . . . "

Under the Statutes of California an industrial accident commission, which is composed of three members, has been constituted, and has complete jurisdiction over injuries covered by this Article, in regard to treatment, compensation, etc.

Connecticut

The physicians in Connecticut are required by law to report occupational diseases in the same way in which contagious diseases are reported. Section 2146 of the General Statutes of 1918 reads as follows:

Every physician having knowledge of any person whom he believes to be suffering from poisoning of lead, phosphorus, arsenic, brass, wood-alcohol, mercury or their compounds, or from anthrax, or from compressed-air sickness, or any other disease, contracted as a result of the nature of the employment of such persons, shall, within forty-eight hours, mail to the Commissioner of Labour and Factory Inspection a report stating the name, address and business of his employer, the nature of the disease, and such other information as may reasonably be required by said Commissioner [1].

Section 5388, dealing with compensation of workmen for injuries, states that the word " injury " shall be construed to include any disease which is due to causes peculiar to the occupation and which is not of a contagious, communicable, or mental nature. It is evident that silicosis is covered. The Act states further: " If an injury arises out of and in the course of employment, it shall be no bar to a claim for compensation that it cannot be traced to a definite occurrence which can be located in point of time and place. "

Under authority of this Act, five commissioners are appointed in Connecticut to hear such cases and are given power to make decisions granting compensation and to do other things necessary in the administration of the Act.

Maine

In the State of Maine, silicosis is not compensable. The State requires its physicians to report cases to the State Board of Health. No doubt the collection of data on occupational diseases will be very important in obtaining a law for compensation of disabled workers.

[1] Obviously silicosis would be included in reportable occupational diseases under the heading of " any other disease, contracted as a result of the nature of employment by such person ".

Maryland

The same statements apply to Maryland as to Maine.

Minnesota

The physicians of Minnesota are not required to report silicosis. The workmen's compensation law does not include silicosis in its schedule, but according to section 67 (10) of the Statutes, claims for the compensation of silicosis may be made.

Nothing in this Act shall affect the rights of an employee to recover compensation in respect to a disease to which this section does not apply, if the disease is an accidental personal injury within the meaning of other provisions of this Act.

New Hampshire

The physicians of New Hampshire are required to report certain occupational diseases which are listed for them, and also " any other ailment or disease contracted as result of the nature of the patient's employment ".

New Jersey

Silicosis is not compensable in New Jersey. The Compensation Act schedules a number of occupational diseases, but leaves out silicosis and adds: " Compensable occupational diseases shall not include any others than those scheduled. "

New York

In the State of New York, again, we find the words "injury" and " personal injury " coming to the aid of silicotic patients. The law in this State does not specify that silicosis is a compensable disease, yet compensation is allowed because of the injury silica dust has done to the lungs.

Section 2, paragraph 7, of the Statute reads: " ' Injury ' and ' personal injury ' mean only accidental injuries arising out of and in the course of employment, and such diseases or infection as may naturally and unavoidably result therefrom ".

While silicosis is not mentioned, it is certain that it comes under the heading of an " injury ", and still more emphatically so when it is complicated by tuberculosis. The phrase " diseases or infection as may naturally and unavoidably result therefrom " would make silicosis compensable. Further, section 48 of the Act makes the matter a bit clearer: " Nothing in this section shall affect the right of an employee to recover compensation in respect to a disease to which this section does not apply, if the disease is an accidental personal injury within the meaning of sub-division 7 of section 2 ".

Five industrial commissioners are appointed by the Governor and are charged with the administration of the provisions of the Act and with the care of the State insurance fund, which is a State fund created for the purpose of insuring its employees against liability and of assuring the persons entitled to compensation. The fund consists of premiums, and employers and employments are prorated in collecting these premiums, in accordance with the difference in the extent of industrial hazards in their establishments.

The physicians in New York State are required to report industrial poisonings according to a list; silicosis does not, however, appear on the list.

Ohio

Ohio, like many other industrial States, requires the reporting of occupational diseases, but omits silicosis from the list of such diseases. The Compensation Act does not specially mention silicosis, but the term " occupational disease " automatically includes it in the list of compensable conditions.

Section 35 of the Act reads as follows:

For the purpose of providing compensation to workmen and their dependants, for death, injuries or occupational disease occasioned in the course of such workmen's employment, laws may be passed establishing a State fund to be created by compulsory contribution thereto by employers, and administered by the State, determining the terms and conditions upon which payment shall be made therefrom. . . . Such compensation shall be in lieu of all other rights to compensation, or damages, for such death, injuries, or occupational disease, and any employer who pays the premium or compensation provided by law, passed in accordance herewith, shall not be liable to respond in damages at Common Law or by statute for such death, injuries, or occupational disease.

Rhode Island

In Rhode Island the physicians are required by law to report occupational diseases according to a list which is provided them, and silicosis is not included. The list carries this phrase, which obviously includes silicosis: " Any other ailment or disease as a result of the nature of the patient's employment."

Wisconsin

The physicians of this State are likewise required to report occupational diseases from a list which omits silicosis.

The Act (Compensation of Workmen), under section 102, paragraph 34, states that the provisions include in addition to occupational injuries, all other injuries, together with occupational diseases growing out of and incidental to employment. Thus silicosis is included as a compensable disease.

An industrial commission, as in many other States, administers the intentions of this Act. Appeals are also heard by this commission, and if further recourse is necessary, may be taken to the Supreme Court.

Other States have legislation pending and several have attempted to pass a Silicosis Act which would specifically make silicosis compensable.

The great difficulty in obtaining compensation for silicosis is due to the fact that the disease is so insidious in its development that the patient may have changed from a dusty occupation before his illness becomes manifest. In such instances it is not a simple matter to tie up the disease definitely with the former occupation. Labour turnover is greatest in dusty occupations and in other hazardous trades. The great incidence of tuberculosis as a complication and usually as the immediate cause of disability, together with the inability of the medical profession, as a rule, to differentiate between silicosis and tuberculosis or to recognise their co-existence, makes the workers' chances fewer for obtaining compensation, even when the law allows compensation for silicosis.

Statistical studies of silicosis in the United States have been made by Frederick L. Hoffman, L.L.D., of the Prudential Life Insurance Company, and were published by the Bureau of Labour Statistics, Department of Labour, Bulletin No. 231, *Mortality from Respiratory Diseases in Dusty Trades (Inorganic Dusts)*, and Bulletin No. 293, *The Problem of Dust Phthisis in the Granite Stone Industry*.

Among the earlier studies that included the clinical consideration of silicosis was that made by Dr. A. J. Lanza, then of the United States Public Health Service, on the occurrence of silicosis among workers in zinc mines in Missouri. His work was published as U.S. Public Health Service Bulletin No. 85, and U.S. Bureau of Mines Bulletin No. 132.

Dr. L. U. Gardner has contributed materially to the knowledge of the pathology of silicosis by his animal experimentation, using different kinds of dusts. His studies were published in the *American Review of Tuberculosis*.

Other studies of lesser magnitude have been made and have been published in current journals.

The report here presented is by no means inclusive as regards the incidence of silicosis in the United States, but rather covers briefly the industries in which this disease is most common. Silicosis, being so very insidious in its onset, unless the exposure is overwhelming, goes unrecognised in many instances for this reason. Other reasons for the non-recognition of silicosis are the fact that disability *per se* comes late in the disease, and the fact that when tuberculosis complicates it, the superimposed disease overshadows the silicosis. With the increase of study of industrial diseases we may hope that silicosis will be more easily recognised and that more definite data will be available concerning its occurrence.

Uses of silica	*Types of silica used*
Abrasive uses:	
In scouring and polishing soaps and powders.	Quartz, quartzite, flint, chert, sandstone, sand, tripoli, and diatomaceous earth; all in finely ground state.
In sandpaper	Quartz, quartzite, flint, sandstone, and sand; coarsely ground and closely sized.
In sand-blast work	Quartz, quartzite, sandstone, and sand, crushed into sharp angular grains uniform in size.
Metal buffing, burnishing and polishing .	Ground tripoli and other forms of ground silica.
For sawing and polishing marble, granite, etc.	Sharp, clean sand graded into various sizes.
As whetstones, grindstones, buhrstones, pulpstones, oilstones, etc.	Massive sandstone from very fine to moderately coarse grained.
Tube-mill lining	Chert, flint, and quartzite in dense, solid blocks.
Lithographers' graining sand	Medium to fine sand or rather coarsely ground silica and tripoli.
Tube-mill grinding pebbles	Rounded flint pebbles.
In tooth powders and pastes	Various forms of pure silica finely ground.
Wood polishing and finishing	All forms of silica ground to medium fineness.
Refractory uses: In making silica fire brick and other refractories.	Fairly pure quartzite known as gannister; not less than 97 per cent. SiO_2 nor more than 0.40 per cent. alkalis, tightly interlocking grains desired.
Metallurgical uses:	
In making silicon, ferrosilicon, and silicon alloys of other metals, such as copper.	Moderately pure sand, massive crystalline quartz, sandstone, quartzite, or chert.
As a flux in smelting basic ores	Massive quartz and quartzite.
Foundry-mold wash	Ground sandstone, quartz, and tripoli.
Foundry parting sand	Fine sand and ground tripoli.
Chemical industries:	
As a lining for acid towers	Massive quartz or quartzite.
As a filtering medium	Massive diatomaceous earth and tripoli, sand, finely granular quartz or quartzite, finely ground tripoli, diatomaceous earth, and other forms of silica.
In the manufacture of sodium silicate . . .	Pure pulverised quartz sand, pure tripoli, and diatomaceous earth.
In the manufacture of carborundum	Pure quartz sand.
Paint: As an inert extender	Finely ground crystalline quartz, quartzite, and flint; also finely ground sandstone, sand, and tripoli.
Mineral fillers: As a wood filler	Finely ground crystalline quartz, quartzite, flint, tripoli, and other types of ground silica.
In fertilisers	
In insecticides	
As a filler in rubber, hard rubber pressed and molded goods, phonograph records, etc.	Finely ground silica of all types.
In road asphalt surfacing mixtures	
Ceramic uses: In the pottery industry as an ingredient of bodies and glazes.	Flint, tripoli, and chert, and other amorphous silica preferred; also all other forms of very pure silica, all finely ground.
In the manufacture of ordinary glass . . .	Pure quartz sand.
In the manufacture of fused-quartz chemical apparatus, such as tubes, crucibles, and dishes.	Very pure massive quartz preferred.
Decorative materials: In the manufacture of gems, crystal balls, table tops, vases, statues, etc.	Rock crystal, amethyst, rose quartz, citrine quartz, smoky quartz, chrysoprase, agate, chalcedony, opal, onyx, sardonyx, jasper, etc.
Insulation:	
Heat insulation for pipes, boilers, furnaces, kilns, etc.	Massive and ground diatomaceous earth.
Sound insulation in walls, between floors, etc.	Do.
Structural materials: Sand-line brick . . .	Moderately pure, sharp, angular sand, preferably finer than 20-mesh, together with a small percentage of finely pulverised silica.
Optical quartz: For the manufacture of lenses and accessories for optical apparatus.	Clear, colourless, flawless rock crystal or massive crystallised quartz.

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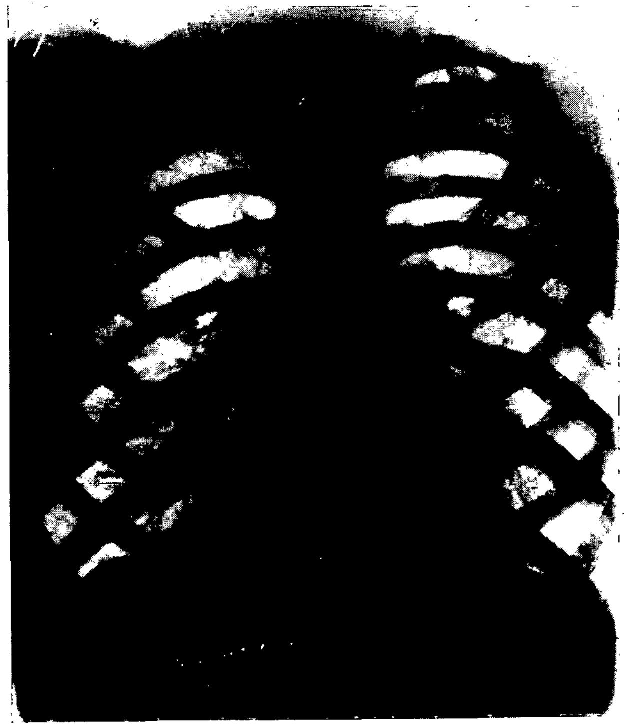
[To face p. 562.]

FILM 1.— Anthracite coal miner for thirty-five years.

FILM 2.— Anthracite coal miner for twenty-eight years. Tuberculosis and anthracosis. Sputum contained tubercle baccilli.

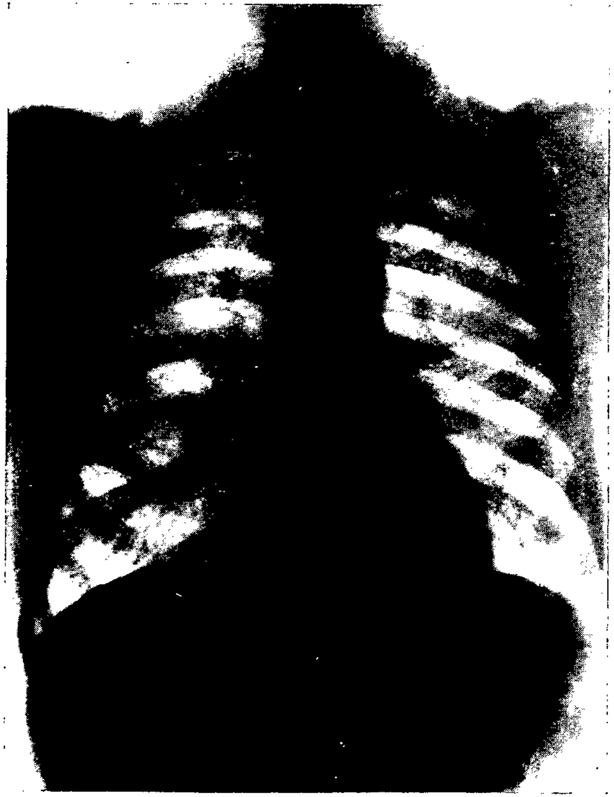
FILM 3. — Coal (bituminous) miner for eighteen years.



FILM 4. — Motorman (coal train) for seven years. Exposed to dust from sanding the tracks.

FILM 5. — Silicosis in a granite worker. An early tuberculosis is in evidence in the base of the right lung.

FILM 6. — Silicosis and tuberculosis in a granite worker. Tuberculosis lesion in base of right lung. Cavitation present. Tubercle baccilli were found in sputum. Basal tuberculosis was common among these workers.



FILM 7. — Sand blaster. Silicosis (tuberculosis two years later).

FILM 8. — Silicosis in a pottery worker.

APPENDIX

INHALATION OF ASBESTOS DUST: ITS EFFECT UPON PRIMARY TUBERCULOUS INFECTION

BY LEROY U. GARDNER AND DONALD E. CUMMINGS

The following is a summary of a preliminary report on the experimental investigation of inhaled asbestos dust, dealing with the reaction in normal and tuberculous animals. The complete report will be submitted for publication in the Journal of Industrial Hygiene.

Guinea-pigs have been exposed for eight hours daily for periods as long as two and a third years to an atmosphere containing approximately 35 million particles of asbestos dust (Canadian chrysotile) 1.5 μ and less in diameter. Rabbits and albino rats have been likewise exposed for shorter periods (330 days).

The experiments demonstrate that fibrous structures at least as long as 200 μ can pass the protective mechanism of the upper respiratory tract and enter the lung. Anatomic evidence of injury to this mechanism is wanting.

Inhaled asbestos dust does not penetrate to the terminal alveoli of the lung as is the case with a particulate substance like quartz. The major portion is held up in the respiratory bronchioles. There phagocytosis takes place, and there the material remains localised, at least for a period of two and a third years. Phagocytes containing asbestos particles migrate into the lateral alveoli given off from the walls of the bronchioles, and considerable numbers ultimately penetrate into the adjacent connective tissues. In the guinea-pig, transportation of dust particles to intrapulmonary and mediastinal lymphoid tissues is so slow that changes in these structures play little part in the early development of asbestosis. In the rabbit, dust cells begin to appear in the lymphoid tissues of the lung within sixty days after starting the inhalation; thereafter, they are found in increasing numbers.

In the guinea-pig, fibrosis in the walls of the respiratory bronchioles and their lateral alveoli is first manifested after 500 days' exposure. Thereafter this type of reaction progressively increases in intensity and extent. The resulting atelectasis is responsible for a gland-like appearance, which is due to the contraction of the included alveoli and a consequent compression of the epithelial lining cells. In the rabbit sufficient time has not yet elapsed for fibrosis to be expected.

In the lungs of guinea-pigs, asbestosis bodies, apparently identical with those described in the human being, have developed after an exposure of approximately seventy days. In the rabbit these structures have not been discovered after exposures as long as 330 days. In the albino rat they are very rare. Only two small typical forms have been discovered in one animal exposed for seventy days. The prevalence of chronic infections of the lung in all members of this series is possibly responsible.

Asbestosis bodies apparently fail to form in the tracheobronchial lymph nodes. They may be transported in small numbers to these tissues and to areas of chronic pleurisy. They have not been discovered in the peritoneal cavity 100 days after injection of dust. In the subcutaneous tissue of the groin, typical forms were found 102 days after the injection of 3 milligrams of dust.

Asbestosis bodies are not present in asbestos dust previous to contact with animal tissues. They are produced by oxidation and hydrolysis of the chrysotile molecule. The formation of these structures is the first direct evidence that the body is capable of effecting chemical changes in inhaled silicate particles. The chemical processes involved have been discussed *in extenso.* Attempts at artificial production of asbestosis bodies *in vitro* have been partially successful; solutions of ferric chloride and sodium silicate have been made to combine in the presence of a fibre to produce more or less typical forms. The asbestosis body is therefore analogous to the well known " silica garden ". Attempts to produce asbestosis bodies *in vivo* by the injection of dusts containing iron salts and silicates have thus far failed. The failure to produce them in tissues other than the lung and subcutaneous of guinea-pigs and man has not been explained.

Comparison between the localisation and the reaction to asbestos and other types of inhaled dusts has been shown. The points at which inhaled dust is localised in the lung or lymph nodes vary with the type. Granite remains within the pulmonary air spaces and produces no local reaction of fibroblasts for several years. In the tracheo bronchial lymph nodes characteristic silicotic nodules develop within two years. Carborundum likewise has failed to affect the stroma of the lung even in four years, but fibrosis in the lymph nodes has been observed. Quartz is rapidly concentrated by migrating phagocytes in the pulmonary and mediastinal lymphoid tissues. In these places it provokes an early and rapid multiplication of fibro-blasts. Asbestos, as it is inhaled, is concentrated in respiratory bronchioles and their lateral alveoli. Phagocytes carry it into the walls, where fibroblasts are stimulated.

Lymph stasis plays little part in early asbestosis; the structure of this dust tends to localise it within the lung from the start. Lymph vessels are dilated in the absence of detectable obstruction. The dilatation may be a direct result of pulmonary irritation.

Primary tuberculous infection is influenced only to a limited degree by inhaled asbestos. This effect has been tested by inhalation infection of attenuated tubercle bacilli (strain R_1). One group of guinea-pigs was infected at the outset of dust inhalation; a second group, two years after beginning dust exposure. In normal guinea-pigs such infection produces tubercles in the lung and tracheobronchial lymph nodes comparable to the primary complex in man. The lesions caseate and the pulmonary foci heal by resolution. Spread of the infection with macroscopic disease in other viscera is very rare. In the first asbestos group infected, 32.2 per cent. of the animals showed some evidence of spreading tuberculosis. New disease was sharply localised to areas where dust reaction had occurred. Rarely small cavities developed in such secondary foci. The tendency to healing by fibrosis was marked; at autopsy 40 per cent. of the cases showed healed fibrosis tuberculosis; macroscopic disease in the spleen and sometimes the liver was common. Dissemination appeared to begin in primary tubercles contiguous to foci of dust reaction. The contrast with animals similarly infected but exposed to quartz dust is marked. In them every exposure longer than five months resulted in generalised chronic tuberculosis of the lungs and other viscera.

For the second asbestosis group infected, the record is not yet complete. In them the localisation of the infection was atypical. Many bacilli were trapped in foci of dust reaction. Some produced local tubercles; others immediately entered the dilated lymph vessels and were transported to the tracheobronchial lymph nodes. Tuberculosis in these nodes sometimes occurred without involvement of the lung. Early diseases in the spleen and hepatic lymph nodes was the rule. The ultimate outcome of infection in this group has not yet been observed.

The combined action of asbestos dust and tubercle bacilli in the lung produced more fibrosis than did either agent acting independently.

THE MEDICAL EXAMINATION OF NATIVE LABOURERS ON ENGAGEMENT AT THE GOLD MINES OF THE WITWATERSRAND

BY A. I. GIRDWOOD, M.B., CH.B. (EDIN.), CHIEF MEDICAL OFFICER, WITWATERSRAND NATIVE LABOUR ASSOCIATION, LTD., JOHANNESBURG

There are approximately 200,000 natives working on the gold mines of the Witwatersrand. A little more than half this number is drawn from areas within the Union of South Africa, of which the largest portion consists of the Xosa, Fingo and Pondo tribes of the Transkei (Cape Province), and the smallest portion comprises tribes drawn from Zululand and the Northern Transvaal. Basutos, Bechuanas and Swazis come from the three British Protectorates, and constitute the second largest portion.

All these natives are known as British South African natives.

The balance of the natives is obtained from Portuguese East Africa south of Latitude 22° South, and are known as East Coast natives.

Methods of Recruitment and Terms of Service

British South African Natives

Almost one-half of these natives are not " recruited ", but voluntarily come to the Witwatersrand and seek employment on the mines. The remaining natives engage through the representatives of the Native Recruiting Corporation stationed in the native territories, who advance the natives money to provide for the needs of their families and for the train fare and food to Johannesburg.

The non-recruited native on his arrival on the Witwatersrand selects a mine and engages himself for a period of service mutually agreed with the mine authorities, sometimes on a monthly basis.

The recruited native nominates a mine on attestation, and in the majority of cases is required to contract for a period of nine months.

In botb cases the agreement of service is ratified by the issue to the native and the employer of a service contract prescribed by the Government.

Service beyond the registered period is terminable by the giving of seven days' notice on either side.

East Coast Natives

All these natives are dealt with by the Witwatersrand Native Labour Association.

Those seeking mine employment voluntarily make their way to one of the many camps maintained by the Association in Portuguese East Africa. From these camps the natives are drafted, either by steamer, railway or motor transport, to the Association's centralising depot at Ressano-Garcia, within five miles of the eastern border of the Union. The natives are forwarded twice weekly by rail from Ressano-Garcia to the Association's main distributing depot at Johannesburg.

East Coast natives are initially contracted for 313 shifts worked, but, in terms of the Convention recently concluded between the Portuguese and Union Governments, may re-engage for a further period or periods not exceeding 156 shifts worked, upon the completion of which the native may be called upon by the Portuguese authorities to return to Portuguese territory.

Medical Examination in the Native Territories

The British South African non-recruited native naturally has no medical examination prior to reaching the Witwatersrand; but all British South African recruited natives, with the exception of a few from areas where medical officers are not available, are examined by the local medical officers—usually Government district surgeons.

For the guidance of these medical officers a schedule has been drawn up by the Transvaal Mine Medical Officers' Association, and in it special attention is directed to diseases of the lungs.

The East Coast native has no searching medical examination until his arrival at the Association's depot at Ressano-Garcia, and only natives who are obviously ill or diseased are eliminated at the various camps.

At Ressano-Garcia, where the Association has a large depot and hospital, the Association's medical officers (one whole-time and one part-time) examine and (where necessary) re-vaccinate the natives, comprising gangs of 300-400 twice weekly, and those deemed fit for mine work are forwarded to Johannesburg.

At the request of the Tuberculosis Research Committee these natives have, during the last eighteen months, been given an intradermal tuberculin injection immediately prior to their departure for Johannesburg, and the reaction is recorded on their passports twenty-four to forty-eight hours later, on their arrival in Johannesburg, and the medical histories followed up during the period of the natives' stay on the mines.

Medical Examination on the Witwatersrand

All natives for employment on gold mines, non-recruited as well as recruited, and from whatever areas, are given a strict medical examination at the Witwatersrand Native Labour Association's central depot at Johannesburg, before being registered to the various mines.

After registration the natives are again subjected to a further medical examination by the mine medical officer on their arrival at each mine, and any who are considered to be unfit to commence work are returned to the W.N.L.A. depot for re-examination —clinical and radiographic—and possibly for detention in the depot hospital.

The only difference in the methods followed for the examination of the non-recruited and the recruited natives is that, in the case of the former, the mine examination takes place first, upon the native applying for employment.

Details of Medical Examination at the Central Depot

There are usually about 170,000-180,000 recruits examined annually at the W.N.L.A. central depot, and the numbers presented for examination daily vary from 300 to 1,200.

A staff of six whole-time medical officers perform these examinations.

On arrival at the depot, every native takes a bath and is given soft paraffin soap with which to cleanse himself. His clothes are deverminised in a steam disinfector. These precautions are necessary owing to the prevalence of typhus fever in the native territories.

After the clothes have been dealt with the natives are drafted in batches to the examination rooms, where they are first taught to breathe properly by trained native orderlies, i.e. in a manner suitable for auscultation. This may appear unnecessary, but in practice it is found to be essential and saves a great deal of time, for some of the natives are very nervous and apprehensive.

The boys are then lined up naked, in rows of about twenty-five, before each medical officer, who carefully auscultates the chest, front and back, and a mark is made on the boy's chest on the detection of any abnormality, however slight. He is thereupon removed to a special examining room for re-examination by one of the medical officers, whose whole time is thus occupied. If considered necessary, the native is detained in hospital and X-rayed; his medical and labour history are enquired into, and a bacteriological examination is made of his sputum.

On the completion of auscultation of each row, an inspection is made of the limbs, eyes, glands and for the presence of any venereal disease, and those passed fit are sent to the depot Pass Office for registration.

A medical officer, when he has become accustomed to doing this work and has developed the power of concentration, is able to examine about sixty natives per hour, but requires a break of about half an hour after two hours' work. To many it may appear impossible to examine such a number with any degree of accuracy, but it must be realised that all that is demanded of the medical officer is the detection of an abnormality and not a diagnosis of the condition. After doing this work for several years the W.N.L.A. medical officers have naturally become proficient in the use of the stethoscope.

Occasionally defects are missed at this examination, but this is more likely to occur at the close of a heavy day.

It is on account of this possibility that a second examination is carried out by each mine medical officer, where the natives arrive on the mines in smaller numbers.

Every day, in spite of the schooling, there is always a number of natives who will not, or cannot, breathe suitably. It has been found necessary to X-ray the chests of such natives, for experience has proved a large proportion to have tuberculosis or silicosis. In many cases the poor breathing is done wilfully, the native hoping to escape detection by so doing.

Disposal of Unfit Natives

Natives found unfit at the central depot, including those returned after the examination by medical officers on the mines, are dealt with as follows:

1. Natives who are ill are put in hospital and treated, and if the disease has been of a serious character are repatriated on convalescence.

2. Natives who are out of condition or merely "train-weary" are weighed and detained, under medical supervision, in the depot for a fortnight or longer. During this time the natives are periodically examined and only passed out when sufficiently improved for underground mine work. Those natives who do not improve to any extent are usually put on light surface mine work and not allowed to work underground until passed as fit therefor.

3. Natives with chest abnormalities are detained in hospital for investigation and treatment. Natives found to be non-tuberculous are discharged from hospital and afforded mine surface work.

All tuberculous cases, incipient or otherwise, are repatriated to their homes and warned not to return for mining employment.

Silicotic or tuberculo-silicotic cases are transferred to the miners' phthisis wards for examination by the Miners' Phthisis Medical Bureau, a body of medical men appointed by the Government to examine mine natives with pulmonary tuberculosis or silicosis with a view to determining the degree for compensation in terms of the Miners' Phthisis Act. Such natives are repatriated when fit to travel to their homes.

General Remarks

An attempt has been made to give a brief résumé of the medical examination, as conducted on the Witwatersrand, of natives engaged for employment on the gold mines.

It is realised that this examination, thorough as the time-limit permits, is by no means definitely conclusive, but the whole problem is an extremely important and difficult one. It is felt that, whatever other method the circumstances may allow, it would still lend itself to criticism.

From the foregoing it will be realised that one of the chief difficulties is the large number of natives who have to be dealt with daily, and their examination completed, as far as possible, on the same day.

A stethoscopic examination alone (which is all that time permits) has its limitations. Early silicotic and early hilus tuberculous cases are missed, and obviously it is impossible to subject every native to a radiographic examination.

A radioscopic examination was undertaken, and over 2,000 natives were screened, but without the success hoped for. Obvious tuberculous or tuberculo-silicotic cases were detected, but all early conditions were not made apparent.

Another great difficulty is that a population which is extremely susceptible to tuberculosis has to be examined; many have the disease in a latent, undetectable form which, under their pastoral home conditions, would remain quiescent, but which, after the increased stress and strain of a few months' mining work, develops into an acute tuberculosis.

Statistical Table

The subjoined table gives the numbers dealt with and the causes and percentages of rejections at the W.N.L.A. central depot from January to December 1928:

Class	Total examined	Total rejected	Causes of rejection			Percentage of rejection
			Tuberculosis	Defective lungs	Other causes	
						Per cent.
East Coast recruits	44,668	3,782	272	960	2,550	8.69
East Coast re-engagements	14,642	217	39	112	66	1.48
British South African recruits	50,921	2,429	118	836	1,475	4.66
British South African non-recruited	40,525	1,011	34	368	609	2.49
British South African re-engagements	14,348	225	14	116	95	1.56
Contractors' natives	2,946	5	4	1	0	—
Total	168,050	7,669	481	2,393	4,795	4.56

SANATORIUM TREATMENT OF MINERS' PHTHISIS PATIENTS

BY A. D. PRINGLE, M.B., CH.B., M.D., MEDICAL SUPERINTENDENT, TRANSVAAL MINERS' PHTHISIS SANATORIUM

Provision for Hospital Care and Treatment

The number of cases of miners' phthisis occurring in the early days of mining on the Rand with a considerable number of deaths drew the attention of the industry to the necessity of making some hospital provision for the treatment and care of such persons.

In 1908 negotiations took place with the Government, and in 1910—the Government contributing a site of 20 acres with a small building thereon—the Chamber of Mines erected and equipped the Springkell Sanatorium at a cost of some £50,000. To this Sanatorium were admitted all cases, whether of silicosis only or of silicosis complicated with tuberculosis.

In 1916 it was suggested that the purely silicotic cases should be housed in an institution quite separate from that in which there were cases of pulmonary tuberculosis, and with this end in view, in 1917, the Estate of the Wedge Farm was purchased by the Chamber of Mines, where a large and commodious country house was converted and adapted for use as a recuperative hospital much on the same lines as some of the earlier sanatoria in Scotland. Of course additions were necessary but in the end suitable provision was made for fifty beds. The entire cost of building and equipment in this instance was borne by the industry. Both these sanatoria are situated within a few miles of Johannesburg and are easy of access. Considerable provision is made for the free transport of patients and also for their relations and friends who wish to visit them.

In so far as Springkell is concerned, the annual cost of upkeep is in the neighbourhood of £20,000; with the exception of a £5,000 grant from the Government, this is borne by the Chamber of Mines. Since 1920, a limited number of paying cases have been admitted from the Military Pensions Department and from the Municipalities.

In respect of Wedge Farm the annual cost of upkeep is in the neighbourhood of £7,000 per annum—all provided by the industry.

When first opened, Springkell had accommodation for seventy-two patients; this has since been increased to a hundred.

The maximum accommodation at Wedge Farm is for fifty patients.

Climatically, the situation of both these institutions is ideal from a sanatorium point of view. Springkell has a northern aspect, situated in well-wooded country, with a hill on the south side protecting it from the occasional cold winds of the winter months. The Wedge Farm Sanatorium is situated on an estate well sheltered with trees. On the High Veld generally, and particularly within a few miles of the northern side of Johannesburg, the climate is ideal; with an altitude of just under 6,000 feet it is never very hot in summer, and only occasionally is it uncomfortably cold in winter. The protective quality of the Witwatersrand ridge can be felt immediately a short journey is made to the south. In winter it is very much colder in Johannesburg, and the winds are more persistent and constant. Sunlight we have practically every day of the year. I do not suppose that we have more than three days out of the 365 when the sun does not shine for the greater part of the day. Our rainfall averages about 20 inches per annum and is precipitated within the limited period of the summer months, and then almost invariably at night—occasionally in the late afternoon.

The grounds of both institutions are suitably laid out, and with the surrounding open country provide plenty of scope for exercise. There is a remarkable absence of dust.

The administration of both institutions is in the hands of what is known as the " Miners' Phthisis *Sanatorium* Board "; its functions are purely of a hospital nature. (This Board must not be confused with the Miners' Phthisis Board, which deals with financial matters, principally in respect of the compensation of silicotic and tubercular ex-miners.) The Sanatorium Board consists of representatives of the gold mining industry and of the Government, one of the latter's representatives being selected with particular reference to looking after the interests of the miners.

The cases admitted to either institution come from the body of men who have left the mines.

Type of Disease

Those conversant with the literature of silicosis are well aware of the changes that have taken place in the type of the disease, as advance has been made year after year in controlling the dust underground. Only the earlier practitioners on the Rand could correctly describe both the clinical and pathological conditions that obtained in the early days. The names of Dr. Louis Irvine, the late Dr. Macaulay, Dr. Loeser and Dr. Andrew Watt are well known in this respect. Dr. Andrew Watt was in an unusually strong position, in that he made himself an expert radiographer to assist him in diagnosing the large number of cases that came to him. All experienced physicians on the Reef agree that the former cases of massive fibrosis caused by dust are no longer seen—nowadays, the silicosis is much more patchy in its distribution and the tuberculosis element predominates. Among post-mortems that I have done at Springkell, this change in the type of disease is confirmed, and among outstanding features one would mention the very patchy distribution of dust, the tendency for deposit at the posterior margins of the lungs, and particularly in some cases tough, hard fibrosis round the roots of the lung. The last mentioned has an important clinical significance in that where this condition arises early in the mining career of the individual, incapacitation soon results, an incapacitation out of all proportion to the amount of dust in the general structure of the lung. Clinically, these cases early exhibit marked short-windedness, and an attack of bronchitis in these cases quickly develops further into emphysema, and, before long, involvement of the heart.

Treatment

With the tendency in latter years for the tuberculosis element to be more pronounced, it cannot be expected that the treatment of cases of tuberculosis complicated with silicosis is much different from the main principles of routine treatment adopted in hospitals and sanatoria for pure pulmonary tuberculosis in other countries. In so far as cases of pure silicosis are concerned, a great deal depends on the amount of dust a patient may have in his lungs and whether he is free or not from secondary infections of the pneumococcal and streptococcal varieties.

We may take it, then, that in so far as the ante-primary or primary stage silicotic individual is concerned, institutional treatment is required solely as a recuperative measure in general, and in particular for any accidental affection he may have, such as bronchitis, asthma, and troubles of this type.

But with respect to the cases of miners suffering from pure tuberculosis or silicosis complicated with tuberculosis, the routine treatment that is adopted for pulmonary tuberculosis in every hospital and sanatorium obtains, with the reservation that in some respects particular attention is given to some outstanding symptomatic and objective conditions.

Cough

With this symptom the great majority of cases do not differ from the purely tubercular, but in a few the cough is of a markedly paroxysmal nature, so severe as to cause vomiting, loss of wind and collapse. The usual well-known sedative cough mixtures are exhibited, and in a limited number the simple remedy of black currant infusion; a glass of hot milk will alleviate a cough that keeps the patient awake.

Dyspnoea

The pure tuberculosis patient has this complaint, but the miner with a lot of dust has it aggravated. The attacks come with lightning suddenness and cause the patient great alarm and distress. When it threatens to be dangerous, and particularly when it is so bad as to render the patient almost helpless, the quickest and most satisfactory treatment is a hypodermic injection of $^1/_6$ grm. of morphia. Probably, before one reaches this line of treatment, turpentine stupes, cough mixtures and stimulants are tried. They help a little, but the good effect does not last.

Apart from the two above-mentioned troublesome conditions, treatment resolves into general hospital care and discipline, and the exhibition of such special forms of medication as are advocated from time to time.

General

All patients sleep on open verandahs, balconies, shelters, or open-air wards. The principles of constant rest in bed for some cases and graduated exercise for others are observed. Meals are taken at regular hours, with rest before and after. Special attention is directed to try and meet the vagaries of a patient's appetite. I mention this, because at Springkell this feature stands out. It requires at times a lot of personal attention to detail, and certainly makes ward work heavier.

The preparations of malt and cod liver oil, pure cod liver oil, and emulsions cannot be freely given in a locality where the atmospheric temperature is uniformly mild and warm. As a matter of fact, my experience among tubercular patients is that where the appetite is good and the ordinary meals satisfactorily taken, these "extras" are of little avail. There is a limited number of individuals who do benefit by these preparations, but the general routine use of cod liver oil is contra-indicated here, as in such a number of cases patients appear to contract dyspepsia and become "liverish" (patients' word).

Of the more direct methods of attack on the disease, we have tried here during recent years, amongst others, Bruschettini's Vaccine, Sodium Morrhuate, Dreyer's Diaplyte Vaccine, and Sanocrysin. These have been extensively tried in Europe, and there is no need to discuss them fully. Sodium Morrhuate gave good results in a few cases—we cannot say more; Sanocrysin was given in a series of thirty-three cases. Of these, sixteen went to work or were well enough to work, six improved considerably in general health, in seven treatment had to be stopped, and four died. Early and advanced cases were treated, gradual dosage used, doses varied from 0.15 to 1 grm., and the reactions were of the same type met with wherever Sanocrysin has been used. The digestive and gastric upset was, however, predominant, and in one case a very severe skin reaction (with constitutional symptoms) occurred even although only a stage of small dosage had been reached. Early and advanced cases were treated, both among miners and non-miners.

Collosol Antimony (1 c.c. twice a week) is being tried and appears to benefit some cases; I have not had long enough experience of it to speak more definitely.

Solarium Treatment.

This has never been the success in South Africa that it has been in European countries and the reasons are obvious: in the summer months direct exposure to the sun, except under most careful conditions, is too risky—the sun is too hot. This form of treatment is not the success in pulmonary cases as it is with bone and joint disease. In South Africa there is only very little trouble of the last-mentioned description among children. Occasionally one does come across a pulmonary tuberculosis patient who co-operates heartily and intelligently with the physician and in some of these cases good results are obtained. Note we are at 26° S. latitude on the Rand—at Cape Town the conditions may be more favourable for this form of treatment.

Collapse Therapy

Artificial pneumo-thorax is used, but I think the percentage of cases that are amenable to this particular therapy is of the same small percentage as obtains in other countries. With a tendency now for there to be more of the tubercular factor in the pulmonary troubles of underground workers, the field for the use of artificial pneumo-thorax will extend from year to year, and I know of one physician who uses this form of treatment in cases of pulmonary tuberculosis among ex-miners.

Effect of Locality and Altitude

At the Sanatorium, our altitude is 5,600 feet, latitude 26° South (Cape Town is at sea level, latitude 34° South).

In sanatoria, the time inevitably comes when some patients ask for a " change ", either to another institution or discharge to go to a different locality. In the majority of cases with silicosis and pulmonary tuberculosis, the coast towns are not favourable. Cape Town in the winter months has a cold, wet and rainy season, somewhat resembling parts of Great Britain—it is in great contrast to the sharp bracing winter of the Transvaal uplands. Durban, also a coastal town, is very hot and humid in summer—the stimulating effect on body metabolism of our perfect Transvaal climate during most of the year must resemble the same conditions as obtain in the situations of the Swiss Sanatoria.

Apart from climatic change, it is a good thing to give periodical leave of absence to patients who show a tendency to become " stale ". They return with improved appetites and settle down more contentedly for further treatment.

Quack Remedies and Patent Medicines

We have had our full share of these; their names are legion; and the faith of human patients in the alluring label remains unshaken until too late. The most recent was a " remedy " widely advertised along the Reef; and our opposition and condemnation of it threatened a libel action; but we stood our ground and the case fizzled out. The " remedy" claimed to cause the lungs to excrete or throw off the particles of silica ! A second patent remedy was an electrical contraption of wires and wood for enveloping the chest. A third consisted of an oil saturated with fine coal dust; this was taken " *per os* ", the coal intended to cause excretion of silica ; the inventor apparently knew nothing of Haldane's and Mavrogordato's work. But the promising cures not materialising, combined with the unpleasant taste of the oil, soon finished off this remedy.

Symptoms

I will now deal briefly with our local experience with some of the symptoms commonly met with in cases of pulmonary tuberculosis.

Haemorrhage

It does not appear that among miners with tuberculosis infection there is any greater percentage of haemoptysis cases than there is among the non-mining tubercular community, and the characteristic features of haemoptysis are the same. It is confirmed that only a very small number of cases of pulmonary haemorrhage are immediately fatal. These are of the sudden overwhelming type when death occurs within a few seconds. The great majority of cases of haemorrhage apart from the above, vary in quantity from mere " colour " up to a pint or two pints of blood. Most of these cases recover from the haemorrhage. To control this haemorrhage, the injection of morphia hypodermically is the only satisfactory, and certainly the quickest method of arrest. Hypodermic injection of haemoplastic serum and collosal calcium do help, but they are not the bedrock of treatment which enables the physician to leave the patient with an easy mind. In respect of the two latter methods of treatment mentioned, in my experience it is wrong, and may be dangerous, to exhibit them too early. The theoretical basis of the arrest of pulmonary haemorrhage is to cause the quick clotting of the blood to close up the source of the bleeding. But there are some cases apparently in which haemoplastic and calcium may induce such clotting that the patient is embarrassed by the collection of blood clots in the bronchi, and his suffocation may be caused by his inability to get rid of such clots quickly. I would cite one case of a heavily built man who was having a moderately severe haemorrhage only, but whom I found quite unconscious and cyanosed. The heroic method I adopted was on these lines. I argued that if left as he was he must surely die—it was imperative to get some air into the lungs; and I therefore hoisted up his legs and stood him on his head. Immediately large clots of blood were ejected from the bronchi; and within a few minutes the patient restored to the prone position was resting comfortably in his bed.

Sweating

Night sweats do not appear to be so frequent among miners affected with tuberculosis as with non-miners. I have not had any success with pharmacopoeial remedies well known to all. I believe rather that as good results as any will be obtained by using the sleeping mat as advocated by Marcus Patterson, and also in some cases by the use of autogenous vaccines.

Loss of Appetite and Loss of Weight

Among miners, this complaint appears to have the same features as among non-miners. As a general rule, where the appetite remains good, not only will the weight take care of itself, but this type of patient always stands a better chance of eventual recovery.

Gastritis and Intestinal Upset

These are commonly met with in all cases of pulmonary tuberculosis.

Tubercular Laryngitis

Over a period exceeding twelve years I have not yet found a case among miners. It may be mere coincidence: if it is not, it is a remarkable feature. In the more advanced cases nearing the fatal termination of their disease, one gets tubercular ulcers in the pharynx, and I have no doubt that in a percentage of these cases some infiltration of the larynx would be found at post-mortem examinations.

Tubercular Testis and Fistula in Ano

Both these combinations appear to occur less among miners than in non-miners.

Alcoholism

This bugbear of all hospitals and institutions that house patients over an extended period is also among our administrative problems. Speaking of alcoholism *per se* with respect to its relation to prognosis in cases of pulmonary tuberculosis, I must say that excessive imbibing of alcohol periodically by a certain type of patient does not appear to have any devastating effect in respect of accelerating the progress of the disease. The prognosis is worse only when alcoholism is associated with unusually bad living conditions with concomitant bad feeding, poverty, and undue exposure to inclement weather conditions.

Infectious Element of the Disease

At the Springkell Sanatorium we have an annual admission rate of more than 100 tuberculosis-infected ex-miners, and this institution has been open for the admission of patients for some eighteen years. I do not know of an instance of any member of the family of a tubercular miner having contracted the disease from living in the same house with such tubercular individual. It is just possible that the standard of living among miners in the Transvaal is higher than it is among the poorer tubercular, badly-housed families in Europe; this observation applying to food, clothing and accommodation; the equable climate and strong sunlight-attack on the bacilli may be the real controlling factors.

Institutional Monotony

We do our best to try and relieve this by granting patients perhaps a little more freedom and leave than has hitherto been considered necessary. In addition, there is a reading room, billiard room, a very good library, and the daily newspapers with the European magazines are easily available. There is a bowling green, and a particularly fine " open air " concert pavilion where entertainments are frequently given. A large wireless installation has been established which receives from the Johannesburg Broadcasting Station; and several patients have their own individual receivers.

Occupations

Whenever and wherever possible, if the patient is fit, he is given occupation if he wants it; and we have had, and have, patients doing the following work: Office clerks, telephone operators (these must be negative tuberculosis sputum cases), motor-drivers, painters, carpenters, bricklayers, gardeners, and handymen. Patients are also employed in poultry keeping, the Sanatorium providing buildings, runs, and fowls; the patient does the work and buys the food—we purchase the eggs. We have tried giving patients outside work to do of the farm-labouring description; but it has consistently failed.

The Factor of Disability

Among miners and ex-miners, there is great variation in respect of disability among individuals classified in the same group, whether that group be Pure Tuberculosis only, Primary Silicosis, Silicosis in the Secondary Stage, or Silicosis complicated with Pulmonary Tuberculosis. With any tubercular factor in lung disease, the activity or dormant condition of the infection generally determines the degree of disability. There is marked difference in the disabling factor of silicosis when this is still in the primary stage. Possibly, however, the most important consideration must be the presence or absence of secondary infections—bronchitis the most common. Lastly, the general health of the individual complicates the situation. " Phthisis " is so much talked about that the individual fails to realise that the cause of his disability may be disease or disorder in some organ of the body other than the lungs.

This variation in disability is commented on here owing to its influence in advising patients with respect to occupations. The types of patients we admit to this institution will never establish a colony like that at Papworth—the local conditions are so entirely different. Those with a knowledge of the efforts made by the Miners' Phthisis Board to establish ex-miners on land settlements will all agree that these ventures have been disappointing. I must here take the opportunity of making some observations with respect to the disposal of the ex-miner patient after he leaves the institution. Finding suitable employment for these patients is with us just as acute now as was the same problem for the partially incapacitated ex-soldier immediately after the Great War. Only the very smallest percentage will ever make even a bare living on the land, and even these must have very little physical incapacitation and some capital. A few million pounds of good money have been lost in this country by unfortunates who had dreams of combining an "open-air" life with occupations such as farming, poultry-keeping, and vegetable gardening. The average tubercular patient is entirely unfitted for this kind of work. I now advise all discharged patients to try and get back to the job for which they were trained and to which they are used, and not to be obsessed unduly with the "open-air" factor. This advice can be taken by non-miners if they so choose, with reservations for such as school teachers (sputum positive tuberculosis) who come in contact with young children. Those who handle foodstuffs (grocers, butchers, bakers, dairymen, and the like) are definitely debarred from returning to their previous occupation. But the ex-miner obviously cannot return to underground work, and only a small number have been trained in some other occupation before they took up mining. A few ex-underground workers, such as timbermen, builders, and mechanics, can get work of this nature on the surface; but for the rest the problem is very difficult. Certain it is that they are better off to continue as employees even at small pay rather than sink such money as they may have in agricultural and farming adventures.

Staffing

In respect of the Sanatorium at Springkell, the nursing staff required does not differ essentially from staffing in similar institutions in other parts of the world.

At the Wedge Farm, however, where patients of the recuperative convalescent type are admitted, the staffing is very small, consisting of a matron and two nurses for an average of roughly forty patients. It is seldom that nursing is required for very bad bed cases. For the benefit of those accustomed to the staffing of hospitals in Europe it might be mentioned that a great deal of the ward work, such as scrubbing floors and sweeping, is done by native boys. The employment of native boys for this work at the two sanatoria under consideration is made easier by the fact that only males are admitted.

Transfers

Wedge Farm Sanatorium is reserved for silicotic cases, and Springkell for tubercular patients. It is unknown for a silicotic patient to develop tuberculosis while resident at Wedge; but patients still classified as being " without tuberculosis " are sometimes admitted to Wedge and on examination by the Medical Officer are found to be suffering from active pulmonary tuberculosis or give a positive tuberculosis sputum; they are, naturally, immediately sent to the proper institution.

The most common aetiological factor in the superimposition of pulmonary tuberculosis are attacks of " bad cold ", influenza, and pneumonia.

Admissions, Springkell

Since this Sanatorium was opened in 1911, 2,482 miners and non-miners have been admitted. Up to 31 March 1929, roughly one-third have died, 1,530 have been discharged, and at that date there were still remaining in the Sanatorium eighty-four patients.

Discharges

These numbered 1,530. The average length of residence of a patient at Springkell is about four months. Were it not for certain economic conditions, and the fact that miners reside here as free patients, I have no doubt that the number of discharges would be higher and the term of residence of shorter duration.

Deaths

Deaths at Springkell average roughly one-third of the admissions. The death rate is an appalling one to quote, but as a criticism of curative treatment it is useless and misleading.

Springkell having been originally built by an industrial body, the factor of being able to select one's cases does not exist. We admit cases in all stages of the disease; and in the very early years, owing to certain local conditions, apparently the great majority of cases admitted were very advanced and in some instances moribund. Within the last ten years I doubt whether there has been a genuine case of death ascribable solely to a heavy deposit of dust in the lungs. In practically all the silicotic cases that remain free from the tubercular complication and that now have a fatal termination, the cause of death is something other than lung trouble. In my experience at the Wedge Farm the great majority are due to cardiac and renal trouble, and these cardiac and renal conditions do not appear to differ in any way from those obtaining among the civilian population who have not worked underground. A certain number of deaths, in so far as the lungs are concerned, are precipitated by influenza, acute bronchitis and pneumonia. Apart from pulmonary tuberculosis (or its complications) as the cause of death, in a certain percentage of cases the cause of death is from some malady not connected with silicosis or pulmonary tuberculosis. On the average at Springkell this figure amounts to

10 per cent. of the total deaths; and at the Miners' Phthisis Board for the years 1922-1927 the number of deaths stated as being " due to causes other than miners' phthisis " among the beneficiaries under the Act was as high as 22 per cent. The age at death remained at an average of forty-five years, but recently is higher. The amount of dust a patient may have and the degree of tubercular infection do influence prognosis, it is true; but I hold that the factor of individual resistance to tubercular disease is very great. Patients have been admitted with definite pulmonary tuberculosis and have survived for thirteen years; others admitted with apparently the same degree of infection do not live thirteen months.

It has previously been mentioned that within the last nine years we have admitted at Springkell non-miners as well as miners; and this enables me to say that the non-miner with pulmonary tuberculosis stands no better chance than the miner with silicosis complicated with tuberculosis; at any rate, in the average age at death of the two classes the non-miner dies at an earlier age, but in some of these cases the illness probably was contracted earlier in life.

Resistance to Disease

Early practitioners on the Reef will recollect the very great number of years that some individuals continued their underground work with apparent immunity from pulmonary tuberculosis, in spite of the fact that they had in their lungs heavy deposits of dust. In recent years there is no question of doubt, but that the silicotic element has been greatly diminished; and yet a large number of miners become fatally ill with pulmonary tuberculosis. Whether in the old days the rapid formation of lung fibrosis did in some way protect the individual from secondary infections it is hard to say; the fact does remain, however, among cases of pulmonary tuberculosis sent to the Sanatorium, that the presence of some silicosis in the lung does not make the vast difference in prognosis that one might expect.

Nationality may be one of the factors. In the very early days the British miners predominated; latterly the South African born miners predominate. In particular, the number of Cornish and North Country miners has diminished to a most remarkable extent.

After some years spent among these pure tuberculosis, and silicosis plus tuberculosis patients, one gets the impression that there are certain individuals who follow definite types in the manifestation of the disease itself. One finds burly heavily built men where the tendency is not for pulmonary tuberculosis to dominate the clinical course, but rather a development of such conditions as bronchitis and asthma; in these cases there is only negligible loss of flesh, and in the end trouble is nearly always cardiac. On the other hand one admits tall, gaunt, lightly built miners where the tubercular disease follows definitely the destructive course that obtains among members of the non-mining community.

TABLE I. — ADMISSIONS AT SPRINGKELL AND WEDGE FARM SANATORIA, FROM 1 JANUARY 1912 TO 31 MARCH 1929

Year ended	Springkell		Wedge Farm: Miners only
	Miners	Non-Miners	
31 December 1912	131	—	—
1913	157	—	—
1914	143	—	—
1915	108	—	—
1916	108	—	—
31 March 1918 (15 months)	141	—	—
1919	142	—	65
1920	99	17	79
1921	150	13	93
1922	148	17	86
1923	145	14	67
1924	136	21	84
1925	135	25	87
1926	108	25	74
1927	112	36	100
1928	118	30	102
1929	124	45	85

(*a*) During the year 1917, it was decided to have the future financial and statistical years not as for a calendar year, but for a period of twelve months beginning on 1 April one year and ending on 31 March of the year following. Financial and statistical figures had, however, already been included for the year 1916 as ending on 31 December. Under the new conditions inaugurated in 1917, the statistical figures therefore were made up for a period of fifteen months from 1 January 1917 to 31 March 1918. From 1 April 1918, all annual figures are calculated for the period 1 April to 31 March accordingly.

(*b*) The Wedge Farm Sanatorium was opened only in June 1918. The number of admissions (65) was therefore for a period of nine months only—June 1918 to 31 March 1919.

(*c*) In so far as the admissions to Springkell are concerned, it will be noted that in the figures as from 1919 onwards there are three columns; 1 and 2 showing admissions of miners and non-miners to Springkell, and column 3 showing the number of admissions to Wedge Farm.

(*d*) At the Wedge Farm it is not always sickness that determines a patient's admission. The economic factor at times bulks very largely. The ex-miner who has left his work in the ante-primary and primary stages of silicosis does not receive an annual pension, but is granted a lump sum. In a great many cases this lump sum soon disappears either through indiscretion or through unwise adventures into investments or occupations where the capital has been lost. These unfortunates often find it difficult to get employment, and just as often are admitted to Wedge Farm to give them an opportunity to rest up for a while until they can get a job.

TABLE II. — ANNUAL ADMISSIONS AT SPRINGKELL

Year	Total	Miners		Non-miners: Tuberculosis
		Silicosis and tuberculosis	Pure tuberculosis	
1920	116	84	15	17
1921	163	123	27	13
1922	165	128	20	17
1923	159	127	18	14
1924	157	107	29	21
1925	160	119	16	25
1926	133	97	11	25
1927	148	100	12	36
1928	148	102	16	30
1929	169	112	10	47

The Medical Bureau was established in 1917. It was only a natural sequence that among a group of specialists who concentrated on the examination of lungs, clinically and radiographically, as the years progressed their estimation of the degrees of silicosis should be modified. Any such modification would naturally mean that once the new standard was accepted a number of miners would become classified as having silicosis where previously a negative result would be given. This may account partly for the variations in the table above. With respect to miners classified as suffering from pulmonary tuberculosis only, there is no indication, so far as the classification is concerned, whether such pulmonary tuberculosis is purely fibrotic and inactive (old tuberculosis fibrosis) or whether the disease is in an active condition.

It will be noticed that the percentage of discharges on annual admissions shows small variation, remaining within recent years more or less constant between 60 and 70 per cent.—this is, respecting the miners admitted.

TABLE III. — DISCHARGES

Year ended	Miners						Non-miners		
	Springkell			Wedge					
	Admissions	Discharges	Percentage of admissions	Admissions	Discharges	Percentage of admissions	Admissions	Discharges	Percentage of admissions
31 December 1911	34	5	14.7	—	—	—	—	—	—
1912	131	67	51.1	—	—	—	—	—	—
1913	157	103	65.6	—	—	—	—	—	—
1914	143	102	71.3	—	—	—	—	—	—
1915	108	83	76.9	—	—	—	—	—	—
1916	108	58	53.7	—	—	—	—	—	—
31 March 1918 (15 months)	141	67	47.5	—	—	—	—	—	—
1919	142	91	64.1	65	45	69.2	—	—	—
1920	99	65	65.6	79	64	81.0	17	3	17.7
1921	150	76	50.7	93	88	94.6	13	3	23.1
1922	148	74	50.0	86	77	89.5	17	10	58.8
1923	145	90	62.1	67	66	98.5	14	8	57.1
1924	136	96	70.6	84	85	101.2	21	14	66.7
1925	135	89	65.8	87	90	103.4	25	14	56.0
1926	108	74	68.5	74	76	102.7	25	14	56.0
1927	112	71	63.4	100	92	92.0	36	27	75.0
1928	118	79	67.0	102	95	93.1	30	36	120.0
1929	122	79	64.7	85	93	109.4	47	32	68.0

For the miners admitted at Wedge Farm, the percentage rate of discharges on admissions is very high, emphasising:

(*a*) The economical factor already mentioned in the notes on the Wedge Farm admissions.

(*b*) The factor of disability. To have such a high percentage rate, it must follow that the general health of the Wedge Farm admissions is good.

Non-miners. — Except for the extraordinary figure for 1918, the discharge percentage rate remains fairly constant from about 60 to 70 per cent.

In the table given above, there has been a tendency since 1916 for the percentage death rate on admissions to become less each year at Springkell. Within recent years it has remained fairly stable at 30 per cent. or a little over. This rate is in sharp contrast with the very low rate for the purely silicotic cases at Wedge Farm.

Among non-miners there appears to be more variation—the figures ranging from 14 to 46 per cent.

TABLE IV. — DEATHS

Year ended	Miners: Springkell Admissions	Miners: Springkell Deaths	Miners: Springkell Percentage of admissions	Miners: Wedge Admissions	Miners: Wedge Deaths	Miners: Wedge Percentage of admissions	Non-miners Admissions	Non-miners Deaths	Non-miners Percentage of admissions
31 December 1911	34	1	2.9	—	—	—	—	—	—
1912	131	46	35.1	—	—	—	—	—	—
1913	157	48	30.6	—	—	—	—	—	—
1914	143	36	25.2	—	—	—	—	—	—
1915	108	41	37.9	—	—	—	—	—	—
1916	108	53	49.1	—	—	—	—	—	—
31 March 1918 (15 months)	141	59	41.9	—	—	—	—	—	—
1919	142	50	35.2	65	2	3.1	—	—	—
1920	99	48	48.5	79	3	3.8	17	5	29.4
1921	150	63	42.0	93	2	2.2	13	6	46.2
1922	148	52	35.2	86	2	2.3	17	5	29.4
1923	145	56	38.7	67	1	1.5	14	2	14.3
1924	136	42	30.9	84	2	2.4	21	7	33.3
1925	135	50	37.0	87	2	2.3	25	7	28.0
1926	108	33	30.6	74	2	2.7	25	11	44.0
1927	112	58	51.8	100	1	1.0	36	4	11.1
1928	118	36	30.5	102	2	1.9	30	5	16.6
1929	124	37	29.8	85	4	4.7	45	7	15.5

TABLE V. — TOTAL DEATHS AND AVERAGE AGE AT DEATH IN SPRINGKELL SANATORIUM

Year ended	Miners and non-miners Total deaths	Miners and non-miners Average age at death	Miners Total deaths	Miners Average age at death	Non-miners Total deaths	Non-miners Average age at death
31 December 1911	1	—	1	—	—	—
1912	46	41.0	46	41.0	—	—
1913	48	41.3	48	41.3	—	—
1914	36	43.4	36	43.4	—	—
1915	41	42.6	41	42.6	—	—
1916	53	42.4	53	42.4	—	—
31 March 1918 (15 months)	59	43.8	59	43.8	—	—
1919	50	45.7	50	45.7	—	—
1920	53	42.90	48	43.4	5	38.2
1921	69	45.4	63	45.28	6	43.16
1922	57	44.23	52	44.79	5	38.4
1923	58	48.46	56	48.79	2	39.5
1924	49	46.30	42	46.50	7	42.28
1925	57	47.10	50	47.06	7	47.42
1926	44	45.34	33	46.24	11	42.63
1927	62	47.68	58	48.34	4	35.50
1928	41	51.8	36	52.0	5	51.8
1929	44	56.2	37	57.7	7	48.1

In table V, the figures apparently point that among miners the tendency is for the age at death to advance. Among non-miners, the average age at death is lower for every year since these two classes of cases have been admitted. The lowest average age at death is thirty-five for non-miners; and for a period covering the same number of years, forty-four for miners.

PERSONAL EXPERIENCES OF MINERS' PHTHISIS ON THE RAND, FROM 1903 TO 1916

BY A. H. WATT, M.B., C.M. (EDIN.), F.R.C.S. (EDIN.), HON. CONSULTING PHYSICIAN TO THE JOHANNESBURG HOSPITAL

In this paper I shall only attempt to give my personal experiences of mining conditions and of the incidence and nature of miners' phthisis between the years 1903 until the formation of the Miners' Phthisis Medical Bureau in 1916.

If I should appear to use the first personal pronoun too frequently I hope I shall be pardoned.

At the latter end of 1902 I was appointed Medical Officer to one of the large mining groups on the Witwatersrand, and I had the advantage of having charge of what, in those days, was a well-equipped small hospital for European employees. In close proximity, there was a Chemical and Metallurgical Laboratory, the staff of which was keen and alive to the importance of the problem of trying to combat the disease by preventive methods in allaying dust and providing pure air underground. The industry owes much to the vision and initiative of the Consolidated Gold Fields of South Africa in providing means to carry out experiments and investigations into underground conditions affecting the health of their employees, and in starting reforms, before any legislation made these compulsory.

After the occupation of Johannesburg, during the Anglo-Boer War, the mines gradually started work. They had been lying idle for over two years, and the miners had either been on service or had been at the Coast or in England.

The mining population in those days was a very different one from what it became later. The managers and officials were mostly of American nationality and a very large proportion of the miners were Cornish or North Countrymen. They practically had all come from overseas and there were very few South African born miners or officials. The miners were skilled men and had spent their lives from boyhood in the practice of their trade. They had lived under conditions where they had been exposed to the infection of tuberculosis from infancy, and were born of parents who had likewise been exposed. Consequently, they had an immunity to tuberculous infection, and the type of miners' phthisis they developed was more of what we classified as pure silicosis, or tuberculo-silicosis, in contrast to the commoner type which developed later—silico-tuberculosis. After the Anglo-Boer War the Deep Level Mines began to be developed. In some, at this time, the shafts had struck the Reef at great depth, and some had not got down to it. Ventilation was bad; the formation of dust was practically unhindered. The practice of blasting the " cut " and the " round " in the same shift was universal. Work was paid for by results, and the earnings of men were large. The attitude was " Let us eat, drink and be merry, for to-morrow we die ".

Very soon the price had to be paid. Many men died or became unable to carry on any work on account of increasing dyspnoea. Cough was not a predominant symptom except in the early morning, on rising. These patients coughed until vomiting was induced without bringing up much expectoration. Ultimately, in very many cases, cardiac failure either sudden and acute, or chronic, supervened, and death resulted without obvious signs of tuberculous infection. Pneumonia, in those days, was a very fatal disease. Sanitation above and below ground was primitive, and there was no water-borne system of sewerage in existence. The water supply was bad, and careful people boiled all the water and milk they consumed. Enteric fever was prevalent.

A Commission was appointed by Lord Milner, in 1903, to enquire into the prevalence of silicosis, and although the medical examinations were not conducted by specialists and X-ray examination was not then employed, about 20 per cent of the miners examined showed signs and symptoms of pulmonary disease.

The late Dr. Donald Macaulay and Dr. L. G. Irvine, the present Chairman of the Miners' Phthisis Medical Bureau, were working at the silicosis problem, and read papers on the subject to the Chemical and Metallurgical Society.

In 1911 another Commission was appointed to report upon the incidence of Miners' Phthisis. This Commission reported, as the result of the examination of 3,136 miners at work, that 32 per cent.

were classed as having miners' phthisis in one or other of its stages. The means of arriving at an accurate diagnosis were not so refined as they are now, and the men were only examined once.

Owing to the generosity of the Board of the Simmer and Jack Hospital, I had been permitted to purchase three X-ray machines, discarding the first ones purchased as improved machines were produced. A standard of X-ray diagnosis had thus been arrived at, but it was not possible to get good plates with the short exposures that obtained then. Films with double screening had not been introduced, and gas tubes were in use.

An attempt was made to correlate the X-ray appearances of films, taken during life and after death, with the signs, symptoms and post-mortem appearances—macroscopic and microscopic. Chemical estimations were also made by the late Dr. Jas. Moir as to the character and amount of inorganic material in the lungs. The men were examined by a number of different medical men, and their standard of normality naturally varied. The majority of the members of the Commission were engaged in practice, and the work had to be carried out in time taken from their practices.

The Commission classified cases of miners' phthisis into four stages:

Class I.	Borderland cases, 5.5 per cent.	
Class II.	Early cases, 21 per cent.	
Class III.	Intermediate or advanced fibrosis	4.5 per cent.
Class IV.	Advanced cases incapable of work	

These figures do not include any miners living on the Rand who had already relinquished work.

The opinion was formed that a miner *might* develop miners' phthisis after two years' work underground, but not sooner.

In 1912, Dr. L. G. Irvine and the author read a paper before the Transvaal Medical Society on miners' phthisis, the causation, signs and symptoms, stages, pathology, diagnosis and treatment of the disease; in which X-ray prints of silicosis were shown.

As a result of the report of the Commission, the first Miners' Phthisis Act was passed and came into operation on 1 August 1912.

Under the Act, miners' phthisis was defined as silicosis of the lungs and silicosis had to be found to be present by definite physical signs before any case could be described as miners' phthisis.

Pure tuberculosis was not miners' phthisis and was not compensatable. In a later Act pure tuberculosis was made a compensatable condition when it occurred in miners. Any underground worker found to be suffering from open tuberculosis was removed by law from underground work, as he was considered a source of infection to his fellow-workers.

An advisory Medical Committee was appointed to examine applicants for benefits under the Act. This Board consisted of three practitioners, each, for the East and West Rand and six practitioners for the Central Area. X-ray examination was recognised as an aid to diagnosis, but was not universally employed. The examiners were not whole-time men. Each applicant had to be examined independently by two members, and on their report his case was dealt with by the Miners' Phthisis Board and compensation paid or not.

I think all will agree that the work of this first Advisory Committee was not entirely satisfactory. The members were engaged in general practice and their standards were unequal.

Previous to starting work underground every miner had to be medically examined. This examination was carried out by the mine doctor. Here again, the personal element entered and standards varied. For example, a man might be rejected by one doctor and go to another on a different mine and be passed, and, once being in possession of a certificate of fitness, would be permitted to work on any mine on the Reef.

The Commission had scheduled the Mines of the Transvaal as either phthisis-producing or non-phthisis mines. All the gold mines of the Witwatersrand were in the former category.

Another result of the Commission's Report was the formation of the Miners' Phthisis Prevention Committee. This Committee (consisting of Government officials, mining officials and workmen, chemists, consulting engineers and medical men) co-ordinated all the work which had been and was being done for the prevention of the disease, and they issued a report in 1916, as the result of which the present Miners' Phthisis Medical Bureau came into being. The work and functions of the Medical Bureau is dealt with by the Chairman of the Bureau.

Such is a short sketch of the history of miners' phthisis before the formation of the Bureau. My personal experience and that of my colleagues are contained in the paper "Silicosis on the Witwatersrand", published as an appendix to the report of the Miners' Phthisis Prevention Committee in 1916.

But much work and research had been done in the meantime.

I can only speak of work done in the Deep Level Mines of the Consolidated Gold Fields Group.

It was recognised from post-mortem examinations that the dust factor was the first problem to be tackled. I well remember going underground in 1903 to watch the effect of dust-laying appliances in drilling with machine drills. When the drill was working, it was impossible to see the face a few feet away, and we all came to the surface covered with white dust. This was the usual experience, not only with machine drillers, but the " hammer boys ", especially those drilling upper holes, came to the surface with their faces and upper parts of the body white with dust.

Mr. McArthur Johnston, soon after, started sampling the air by the sugar tube method. This was a fairly accurate method of estimating the quantity of dust but not the size of the particles. It was, however, an index of the efficiency of the dust-allaying methods with which we were experimenting.

It was recognised from the investigation of the various Commissions that the rock drill miner, especially the machine developer, acquired the disease sooner than the miner who did not work with machines. This was probably due to the inhalation of fine dust produced in drilling. But there were other factors. The blasting of " cut and round " in the same shift, for example. The miner first blasted the cut and then returned to the face, as soon as possible, to charge and blast the round. In doing so, he not only inhaled dust produced by blasting but also the fumes of the explosives used. In the early days, cases of gassing were frequent, but the miner appeared to acquire a degree of immunity to the effects of " gas " provided that the detonation of the explosive was complete; unfortunately, this was not always the case.

Blasting accidents where the miner and his " boys " sustained terrible injuries, often entailing the loss of sight, were common.

Methods used to prevent the formation of dust were experimented upon and developed, and they all entailed the use of water. Whether this is the ideal method of dealing with the problem is now in doubt.

The manager of the Simmer Deep Mine had had much experience in coal mining in Scotland, where much attention had to be paid to ventilation. The Simmer Deep about 1911-1912 was the deepest mine on the Rand. The temperatures were high (average wet bulb, 80° F.).

In July a ventilation exhaust fan had been installed at the Rudd Shaft of the Simmer Deep. The adjacent shafts on either side were thus downcast shafts. The Rudd Shaft was used entirely for ventilation. Before the installation of the fan the amount of air coming out of the shaft was 105,703 cubic feet per minute. Shortly after, 200,000 cubic feet were passed. The purity of the air was tested by its CO_2 content. There was a great improvement as the result of more efficient ventilation.

In 1907, in sampling one of the main air ways of the Jupiter, the adjoining mine to the Simmer Deep, and connected with it, 0.57 per cent. CO_2 was contained in the air, whereas in sampling a " dead end " in the Simmer Deep in 1912, 0.15 per cent. was found and in the upcast air in the shaft it was 0.17 per cent.

In every operation of mining, dust was raised, so that the disease was not confined to the driller, but the lasher and trammer and every man working underground, including shift bosses, samplers and mine captains, were liable to contract miners' phthisis.

Attempts were made to reduce the dust by wetting the downcast shafts, by making the air from the workings pass through screens of vapour formed by ordinary gas burners through which clean water was forced by gravitation, by watering the rock which was being shovelled or moved, by watering down the working places after blasting, and by using jets of water into the holes when drilling and by use of the water blast after blasting. Rock drills with hollow drills to convey water during drilling were introduced later.

What perhaps did more good than any of these was the introduction of blasting in one shift, only, in the twenty-four hours and the prohibition of blasting " cut and round " in the same shift.

Single shift blasting was first introduced on the Simmer and Jack Mine, and considerably later became universal.

About this time, as the result of examinations by the medical examiners, the opinion was formed that a miner could possibly develop silicosis two years after he started underground work in these mines.

In 1907 a strike occurred, and, as a result, many overseas-born miners left the country for good. This was due partly to economic conditions and partly to the high morbidity amongst underground men.

Home-born miners, now, do not come in large numbers to the Witwatersrand, on account of the strictness of the initial examination by the Miners' Phthisis Medical Bureau. A very high standard of general health is required, and if there is any evidence of pulmonary abnormality they are rejected and stranded in this country.

A new type of miner was introduced from the South African veld and farms. He came of a race quite well developed and set up physically but with little acquired immunity to tuberculosis, and the type of the disease, miners' phthisis, began to change and become more of an infective type.

Accurate figures are not available, as the present Miners' Phthisis Medical Bureau had not been started.

On the Simmer and Jack an investigation was made as to the amount of infection which existed underground and on the surface. Visible samples of sputum in the ladderways and workings were collected and examined. Samples were also taken on the surface and from the compound rooms. More samples were found to be tuberculous underground than on the surface, but this might be due to the effect of dryness and sunlight on the surface. The results only proved that there was a good deal of open tuberculosis on the mines.

At the end of 1913 a number of white rats were placed underground at the top of a stope where air containing fumes and dust after blasting passed. These rats were killed after varying times spent underground, and excellent specimens of silicotic lungs were obtained. These specimens formed the basis of a report by Dr. Pratt-Johnson, which is contained in the paper presented to the Miners' Phthisis Prevention Committee in 1916 by the writer and colleagues.

It had been asserted that animals did not develop silicosis underground, but wild rats had only been examined—and they probably had not lived long underground—and some ponies on the Crown Mines.

Perhaps a similar experiment, under working conditions, would help to test Dr. Haldane's thesis that dusting with coal dust would be as efficient as water in preventing silicosis.

The Witwatersrand Mines still produce silicosis, but it takes very much longer to develop.

The type of the disease has changed, and tuberculosis predominates—pure tuberculosis is now compensatable.

Miners' phthisis is a compensatable disease, and finality has not apparently been reached as to how much compensation a sufferer is to receive.

The payment of compensation is a very great burden on the industry and may make the difference as to whether a low-grade mine may run at a profit or not. Therefore, apart from the humanitarian aspect, the prevention of miners' phthisis is a problem of great economic importance.

The man starting underground work to-day is in the A1 Class owing to selection at the initial examination of the Miners' Phthisis

Medical Bureau, and it should be our endeavour to keep him so by improving underground conditions, by providing healthy living conditions on the surface, and by obtaining his co-operation in preventing the disease.

The amount of dust in the underground workings has been very much reduced, but in the deep level mines this reduction has been obtained by saturating the mine air with moisture. Cases of heat stroke are becoming not uncommon, especially amongst natives who have not become accustomed to working in places with a high wet bulb temperature, although attempts to get them "into training" before putting them to work in hot places are invariably made.

I have not discussed the question of miners' phthisis in natives, as it is many years since I have had practical experience in dealing with this part of the problem. The native is more prone to pure tuberculosis and acute diseases of the lung than the European, but does not develop silicosis so rapidly, probably because he has frequent long spells when he goes back to his kraal to live the life of a gentleman attended by as many wives as he can afford, and, lastly, by the anatomical arrangements of his air passages. The South African native is not a mouth-breather.

I have not attempted to give any statistics or figures. These will be available in other papers. The Witwatersrand has led the way in the study of this very ancient disease, because, unfortunately the disease has been more prevalent here than in any part of the world, and the opportunity for research and study has been made possible by the generosity and business acumen of the leaders of the industry.

THE FUNCTIONS OF THE MINERS' PHTHISIS MEDICAL BUREAU AND THE GENERAL SYSTEM OF MEDICAL EXAMINATIONS CONDUCTED UNDER THE MINERS' PHTHISIS ACT

BY L. G. IRVINE, M.A., M.D., C.M., B.SC. (PUB.H.) (EDIN.),

CHAIRMAN, MINERS' PHTHISIS MEDICAL BUREAU

The Miners' Phthisis Medical Bureau was instituted under the Miners' Phthisis Act of 1916, and commenced its work on 1 August of that year. It is a body of whole-time Government medical officials and has been since the above date responsible for conducting or directing all medical examinations under the Miners' Phthisis Acts.

Its first Chairman was Dr. W. Watkins-Pitchford, who already held and continued to hold the post of Director of the South African Institute for Medical Research. Partly owing to this conjunction of offices on the part of the first Chairman, the Bureau has, since its inception, occupied premises in the Institute block of buildings. The arrangement has proved useful in many ways, especially owing to the proximity which it affords the Bureau to well-equipped laboratories. Administratively, however, the Bureau is a totally distinct organisation. It is strictly and solely a Government institution in the Department of Mines. All appointments to it are made by the Minister of Mines and Industries. On Dr. Watkins-Pitchford fell the heavy task of organising the new institution, and he continued to direct its activities for a period of ten years. In September 1926, he was succeeded as Chairman by the present writer, when the personal connection with the Institute terminated.

The examining medical officers composing the Bureau at first numbered six; later, as the amount of work increased, the number rose to ten, and for the past few years it has been eight. The senior examiner, Dr. C. C. Murray, is also Vice-Chairman.

Dr. W. Steuart has since the inception of the Bureau occupied the part-time post of radiologist. The official pathologist (Dr. A. Sutherland Strachan) is Lecturer on Pathology at the University of the Witwatersrand and a member of the pathological staff of the South Africa Institute for Medical Research. The Bureau has thus the advantage of obtaining an independent pathological opinion in arriving at decisions in cases which involve pathological investigation. A secretary and a technical and clerical staff of nineteen complete the establishment.

In respect of all miners of European extraction, termed officially " European miners", the chief duties of the Bureau are as follows:

1. To conduct an " initial examination " of all persons who desire to enter for the first time upon work underground in any of the gold mines of the Witwatersrand area—called " the scheduled mines ".

2. To conduct a " periodical examination " of all working miners, with the object of detecting cases of silicosis, tuberculosis with silicosis, or simple tuberculosis which may arise amongst them.

3. To conduct a " benefits examination " of all claimants for awards under the Act as possible subjects of one or other of these diseases.

4. To investigate and decide all claims preferred by the dependants of deceased miners, on the ground that such miners had been the subjects of silicosis or tuberculosis.

The precise scope of these examinations will be explained more fully later on.

The similar examinations of Eurafrican and Asiatic miners, termed " Non-European miners", are also carried out directly by the Bureau.

In respect of the very large number of " native labourers " employed in the industry, the official initial examination is carried out at the central depot of the Witwatersrand Native Labour Association by the medical staff of that organisation. The periodical examinations are conducted on the mines by the mine medical officers. All of these officials act as medical examiners under the Miners' Phthisis Act. The Bureau exercises a general supervision over all of these examinations by means of periodical visits of inspection to the mines. All native labourers suspected by the mine medical officers of being the subjects of tuberculosis or silicosis are, however, sent forward to the Bureau for final examination and disposal by it. This is the general system.

The Bureau is also charged with the compilation of a statistical account of the incidence of silicosis and tuberculosis as shown by the results of the examinations made during each year. This statement is published in the annual Report of the Chairman of the Bureau.

A general idea of the amount of work performed by the Bureau in each year may be gained from the following table.

TABLE I. — SUMMARY OF THE WORK OF THE BUREAU FOR THE YEAR ENDING 31 JULY 1928

Nature of examination or investigation	Number of examinations	Number of individuals dealt with
Examinations for "initial" certificate (Europeans)	9,251	8,122
Examinations for "periodical" certificate (Europeans)	26,394	14,726
Examinations for "special" certificate (Europeans)	2,507	1,523
"Benefits examinations" (Europeans)	3,900	3,463
Claims in respect of deceased European miners	449	428
Claims for allowances to children of beneficiaries	87	85
Examinations of non-European miners during life	108	104
Examinations in respect of deceased non-European miners	9	9
Examinations of native labourers during life	1,795	1,795
Examinations in respect of deceased native labourers	429	429
Total routine examinations	45,077	30,684
Supplementary Investigations		
Post-mortem examinations:		
Europeans	227	—
Others	438	—
Admissions to Bureau Ward for special observation	558	—
Special visits to sick miners at their homes	39	—
Visits of inspection to scheduled mines	149	—
Total	46,488	—
Daily average	153	—

The Bureau possessed on 31 July 1928 medical and radiographic records of 71,288 European miners, and 21,736 non-European miners and native labourers. During the year a total of 42,524 portrait negatives of European miners were made, for purposes of identification. Natives are identified by fingerprints. The number of radiographs produced during the year was 36,660.

All pathological investigations made on behalf of the Bureau are carried out at the South African Institute for Medical Research. The amount of this work, as shown by the number of specimens examined and reported upon during the year was as follows: lungs (pairs), 665; specimens of urine, 657; specimens of sputum, 23,426; specimens of blood, 962 (Wassermann test, 733; General, 229); specimens of faeces, 87; miscellaneous, 3.

The wealth of pathological material made available through the work of the Bureau is thus apparent. This circumstance has enabled the Bureau to carefully correlate the results of pathological, radiological and clinical examination in a large series of cases, and it is upon the results of such a correlation that its standards of diagnosis are based.

The routine of examination to which each person is subjected *at each examination in any of the four classes mentioned* is as follows: (1) his photograph is taken for purposes of identification, and his signature is also photographed on the same negative; (2) a radiograph of his chest is taken; (3) his weight and height are measured, in trousers and socks, without boots; (4) he is subjected to a clinical examination by a member or members of the Bureau. All persons who are considered by the examining medical officer to be probable or are actual subjects of silicosis or tuberculosis are examined by at least two members of the Bureau.

The examinations are completed each day before 2.30 p.m., when the Bureau meets as a whole to decide upon all cases examined during the day. The examiner or examiners in each case report to the Bureau the result of their examination, the radiograph of the examinee is inspected, and if the case is in any way doubtful it is then discussed by the Bureau. *The final decision is in all cases taken by the Bureau as a whole.* Any possible personal idiosyncrasy on the part of individual examiners is thus eliminated and a uniformity of standards as far as possible secured. But the Bureau maintains a continuous investigation of its material and methods, in order, if possible, to improve the latter and to secure the greatest efficiency possible.

In addition to this routine procedure, free use is made by the Bureau of the Observation Ward in the building occupied by it. Any man in respect of whom special observation is required is admitted to the Observation Ward for a period of three days. His temperature is recorded, the sputa of three consecutive days and the urine examined, a Wassermann test is made, and any other laboratory investigations which may be required are carried out.

During the year, 543 European miners were in this way admitted to the Observation Ward or, in a few cases, to the General Hospital, Johannesburg, for special observation.

Miners of whom examination for the purposes of the Act is required, and who are too ill to be brought to the Bureau, are examined at their homes by a member of that body; thirty-nine such visits were paid during the year.

Further, a " review " examination is readily granted by the Bureau in the interval between the statutory examinations, in the case of miners in respect of whom the Bureau is informed that the health of the individual has deteriorated since the last examination, or in the case of applicants for the initial certificate whose health appears to have improved; 923 such examinations were made during the year.

The system of examinations would thus appear to be as thorough and elastic as is possible in the circumstances *which necessitate dealing with over 30,000 individuals annually.*

Some comments on each class of examination may perhaps be of interest, and it may be well to deal first with the examination of European miners and later with that of non-European miners and native labourers.

Examinations of European Miners

Examination for the Initial Certificate

The " initial certificate " is a certificate of fitness for underground work granted by the Bureau after examination, and the Act requires that any person who desires to enter for the first time upon employment as a " full-time " miner in a scheduled mine must possess such a certificate. The initial certificate certifies that the holder "is free from any disease of the lungs and respiratory organs, and is in other respects physically fit for underground work". *All* certificates issued by the Bureau are in card form, bearing on the back a photograph of the holder and of his signature, and specifying the date on which the certificate ceases to be valid. The initial certificate is valid for six months. At the end of that period the holder, provided that he has in the interval been employed as a " full-time " miner, becomes entitled to appear at a " periodical examination " as a " working miner ".

The object of the initial examination is to debar all persons who have or appear to have more than an average liability to contract silicosis or tuberculosis from entering upon underground work in scheduled mines. The standard of selection adopted must accordingly be a reasonably strict one. The following were the general results during the year 1927-1928:

TABLE II. — RESULTS OF INITIAL EXAMINATIONS (EUROPEANS), 1927-1928

	Total	Born in South Africa	Born overseas
Number of candidates examined	8,122	6,696	1,426
Percentage rejected:			
Temporarily	43.34	—	—
Permanently	18.62	—	—
Number of examinees passed	3,090	2,435	655
Percentage of examinees passed in each class	38.04	36.37	45.93

The high preponderance of South African born candidates is a prominent feature. It will be noted that only 18.6 of the total examinees were permanently rejected, while the "temporary" rejections amounted to over 43 per cent. The latter class comprises those in whom the Bureau finds defects in health or physique which may be remediable. These persons are eligible for re-examination after the lapse of such a period as may, in the opinion of the Bureau, suffice for the removal of these defects, and experience has led that body to give a rather wide latitude in this direction, especially to young and immature would-be recruits. A considerable proportion of such candidates eventually succeed in obtaining an initial certificate.

One very important result of the initial examination has been to introduce into the general body of working miners a gradually increasing number of men of specially selected physique. Those of this selected class who had not worked underground on the Rand prior to 1 August 1916, and who have not had previous service in other mines elsewhere, are termed the "new Rand miners". These men now number over 8,300 and constitute over 54 per cent. of the total body of working miners. The fact that these men have up to the present shown surprisingly low attack-rates for silicosis appears to indicate that the system of selection provided by the inital examination of the Bureau has filled an important preventive function.

The Periodical Examination

By the "periodical examination" is meant the statutory examination of all "working miners" with the object of detecting the presence or absence of compensatable disease amongst them.

The term "working miner" includes, along with all "full-time" miners working beneath the surface, all persons working on or about crusher-stations, or in a sample crushing room or assay office, or in a change-house or on any tailings dump. All of these classes of employee are included under the Act as "working miners" and are subjected to the "periodical examination". The "full-time" miners working underground form the vast majority. The four other classes are included — change-house attendants in order to exclude tuberculous subjects from that employment, the others because their occupation is considered to expose them to some risk of contracting silicosis.

"Working miners" who are in employment must present themselves for examination at intervals of not more than six months. Those who are not employed remain eligible for the periodical examination for an indefinite period, *provided* that they present themselves for examination at intervals of not more than two years from the date of expiry of the last periodical certificate issued to them. If they fail to do so, they are subjected again to an "initial" examination. As a result of this provision the number of working miners examined in each year by the Bureau usually exceeds the *average* number of miners in actual employment underground by about 40 per cent. The provision permits the miner to leave the mines for considerable periods without forfeiting his eligibility to return to underground employment later on.

The "periodical certificate", which is issued by the Bureau after examination to the "working miners", certifies simply that the holder "is not suffering from tuberculosis", and entitles him to continue in or offer himself for employment in any of the occupations specified above. Once it has been granted, the certificate is periodically renewed in the case of all miners who remain eligible and submit themselves for examination, *unless* the holder is found upon examination to be suffering from tuberculosis or tuberculosis with silicosis. In the latter event the miner is debarred from all further underground work in the scheduled mines. Any miner who has accepted an award as the subject of silicosis is likewise debarred from further underground work in these mines and ceases therefore to be eligible for a periodical certificate.

The purpose of the periodical examination is, as has been stated, the detection and notification of all cases of the three " compensatable diseases " — " simple silicosis ", " tuberculosis with silicosis " and " simple tuberculosis"—which exist amongst the "working miners ".

By " *simple silicosis* " is meant silicosis *without* a definitely recognisable or " overt " tuberculosis; by " *tuberculosis with silicosis* " is meant silicosis *with* overt tuberculosis; and by " *simple tuberculosis* " is meant tuberculosis of the respiratory organs, without detectable silicosis.

Any " working miner " who is found to be suffering from one or other of these conditions is notified to that effect. If his condition is one of tuberculosis with silicosis or simple tuberculosis, he is obliged to relinquish underground work immediately. If he is found to have simple silicosis, it is optional for him to apply to the Board for an award of compensation and to leave underground work, or to remain at work and postpone taking an award. Should the miner, however, remain at work for a period of longer than three months after receipt of a notification that he has silicosis, he forfeits during his lifetime all right to an award, other than that to which he would have been entitled at the date of his first notification. Few miners, however, continue to work underground after they have been notified as being silicotic. In 1927-1928 there were at work only 144 unretired silicotic miners, a very considerable majority of whom were mine officials.

The subjoined table illustrates the scope and general results of the periodical examinations conducted during the past three years:

TABLE III. — RESULTS OF PERIODICAL EXAMINATIONS FOR THE THREE YEARS 1926-1927 TO 1928-1929 (EUROPEANS)

	1926-1927	1927-1928	1928-1929
Number of examinations made	24,815	26,542	27,073
Number of individual miners examined	13,654	14,726	15,492
Cases detected:			
Unretired " old " cases of silicosis	127	144	154
" New " Cases:			
Simple Silicosis	364	283	270
Tuberculosis with Silicosis	2 [1]	0	5 [1]
Simple Tuberculosis	42	32	44

[1] These cases occurred in unretired silicotic miners.

It may be added that, during 1927-1928, no fewer than 318 additional examinations were made for special reasons in the interval between the statutory examinations, and that, of the "working miners" examined, 203 were admitted to the Observation Ward for more detailed examination.

Examinations for the "Special" Certificate

The "special" certificate is granted by the Bureau, after examination, to a number of persons whose work takes them underground from time to time, but who are not "full-time" miners. Surface artisans going underground now and then for repair work or for similar occasional duties, mine inspectors, some mine managers and others who do not spend their full time underground fall into this class. These persons also are examined by the Bureau once in six months, particularly since most of them have been at one time full-time miners and had then been exposed to the ordinary risk of contracting silicosis. Such special examinations number about 2,500 per year in respect of some 1,500 persons so employed. A very few cases of silicosis or tuberculosis are detected from time to time amongst these men, and those who are so detected are compensatable under the provisions of the Act.

"Benefits Examinations"

"Benefits examinations" are carried out in claims for awards made by or in respect of living miners. It is to be noted that, in the case of claims for awards made by miners who have been found to have silicosis or tuberculosis or both conditions at a periodical examination, no further examination is required precedent to the first grant of benefits. When, however, such miners make application for *further* awards, they become subject to the "benefits examination" of the Bureau. A small number of retired miners, who have not previously been found at a periodical examination to have silicosis or tuberculosis, and who apply for awards, are also included in the "benefits" return.

The main object of the "benefits examination" is thus the *re*-examination of existing beneficiaries, in order to ascertain whether they have progressed to a further stage of the disease and have therefore become entitled to further awards.

The number of benefits examinations conducted in 1927-1928 was 3,900 in respect of 3,463 persons. The extent to which re-classification takes place is indicated by the fact that, in this one year, out of 2,709 silicotic beneficiaries examined, 502 were certified to have become entitled to further awards, and 291 of these to have become entitled to receive life-pensions.

Claims made in respect of Deceased Miners

During the year the number of claims made by dependants of deceased miners numbered 428. A large number of these claims were made in respect of miners who had died overseas regarding whom the Bureau had had no previous information or opportunity of securing that an adequate examination was made during life, and in such cases particularly a large amount of enquiry and expenditure of time was frequently necessary to enable the Bureau to obtain sufficiently reliable information to enable it to come to a just decision on the presumptive evidence available. The great importance *in the interests of the dependants* of such a simple procedure as a sputum examination in cases of suspected tuberculosis is very frequently entirely overlooked by the medical men who attend such cases during life, and the extremely valuable evidence afforded by a radiograph in cases where the presence of silicosis has not previously been demonstrated, but is merely presumed, is very far from being adequately realised, even in centres where a radiographic examination is readily procurable. The Bureau deals with such cases on their merits, but is sometimes placed in much difficulty owing to the paucity of reliable evidence of the actual condition present at death.

Appeal Examinations

The Miners' Phthisis Act of 1925 established a Medical Board of Appeal with power to revise decisions of the Bureau in respect of examinations involving a possible grant of an award. Two of its three members had previously acted for many years as members of the Bureau. In 1927-1928 the Board of Appeal, according to the returns notified by it to the Bureau, considered 722 cases referred to it, and the Bureau's decision was altered in respect of 44 of these.

EXAMINATIONS OF NON-EUROPEAN MINERS

The number of non-European miners employed underground amounted in 1927-1928 to 426 persons; 104 claims were made by non-European miners or ex-miners, 42 of whom were found to have silicosis, 8 to have tuberculosis with silicosis, and 8 to have simple tuberculosis. By the courtesy of the Witwatersrand Native Labour Association, these examinations and the initial and periodical examinations of non-Europeans are carried out by members of the Bureau at the central depot of the Association.

EXAMINATIONS OF NATIVE MINE LABOURERS

The native labourers undergo, as in the case of European miners, an " initial " and "periodical" examination, and also an additional examination, termed a " final " examination, on the termination of their underground employment. The magnitude of this task becomes apparent from the fact that some 194,000 natives were employed upon the mines during 1927-1928, and that the total complement is replaced to the extent of approximately 90 per cent. during each year. These examinations are not carried out directly by the Bureau, but by the mine medical officers acting as examiners under the Act. The Bureau, however, exercises a general supervision and control over this work, mainly by means of periodical visits of inspection by delegated members of that body to the different mines. Drs. C. C. Murray and G. H. Knapp have carried out this important function for many years. Each mine is visited several times in each year.

The Act prescribes that all medical officers in medical charge of natives on the mines should hold whole-time appointments, except in the case of a few small mines, to which the Minister is empowered to grant exemption from this provision. The mine medical service on 31 July 1928 comprised thirty-six whole-time and four part-time appointments, including in these the medical staff of the Witwatersrand Native Labour Association Central Depot, at which the " initial " examination of all native recruits is conducted.

The general system of procedure in regard to native labourers may be briefly summarised:

1. The *initial examination* is in practice a threefold process. There is a preliminary medical examination in the recruiting areas, a principal and official medical examination at the Native Labour Association's Depot, and a supplementary examination by the mine medical officer.

2. The *periodical examination* under the Regulations of the Act of 1925 consists of two parts:

(i) *Each native employee, whether working on surface or underground, is weighed, obligatorily every three months, actually according to the general practice once in six weeks.* Any native who has lost 5 lbs. in weight between two successive examinations, or 6 lbs. between three successive examinations, is set apart for stethoscopic examination by the mine medical officer. It has been found that approximately 66 per cent. of bacteriologically verified cases of simple tuberculosis amongst mine natives have previously shown a loss of weight of this amount at their periodical examinations. This appears to be the limit of the efficiency of this method of mass examination, which has been adopted in view of the large number of natives concerned and the necessity of not interfering unduly with their daily routine of work and meals.

(ii) *An additional separate stethoscopic examination is made of all natives who have worked upon any one mine for a period of five years or more.* The object of this examination is particularly the detection of possible cases of silicosis or tuberculosis with silicosis in those natives who have worked underground for long periods.

3. The *final examination.* Every native employed underground undergoes, on leaving underground employment, a " final " stethoscopic examination, and can only be discharged if he is found by the medical officer to be free from silicosis and tuberculosis.

These are the examinations prescribed under the Act. In addition, the mine medical officers, on their own initiative, have adopted the system of making a stethoscopic examination of all natives who are admitted to the mine hospital for any cause.

Finally, during the past three years the Chamber of Mines has instituted an annual radiographic examination of all natives who have worked on any one mine for five years or more, the results of which have had the great practical value of demonstrating that no large number of undetected cases of silicosis had existed on the mines.

The system as a whole draws round the mine native labourers a serviceably close net of opportunities for the detection of silicosis and tuberculosis.

The Act prescribes that all native labourers in whom a medical " examiner " finds signs of tuberculosis or silicosis should be sent forward for examination and final disposal by the Bureau. In practice all such cases are transferred to the Central Hospital of the Witwatersrand Native Labour Association. Here a radiograph is taken of their chests, their sputum and urine are examined, and the weight and temperature recorded. They are then clinically examined by a member of the Bureau and the final decision is taken by that body on the evidence.

The following are the results of the examination of such cases by the Bureau during 1927-1928.

Average number of natives employed	193,076
Average number employed underground	147,375
Suspected cases sent forward for examination by the Bureau	1,795

Number of cases of compensatable disease detected amongst these	1,352
viz. simple silicosis	209
tuberculosis with silicosis	409
simple tuberculosis	746

The total number of cases of active tuberculosis detected was 1,155, or 5.89 per 1,000 of the total complement.

The periodical examination of the mine natives thus serves an important preventive function by eliminating from the underground complement cases, which, if they remained, would be potential sources of dissemination of tuberculous infection.

THE FUNCTIONS AND EXPERIENCE OF THE MEDICAL BOARD OF APPEAL APPOINTED UNDER THE MINERS' PHTHISIS ACT

BY MEMBERS OF THE APPEAL BOARD

The Medical Board of Appeal was established under the Miners' Phthisis Consolidating Act of 1925. The Board consists of three members and a Secretary appointed by the Minister of Mines and Industries. The functions of the Medical Board of Appeal are:

(1) The examination of any " miner " who is dissatisfied, on medical grounds, with the certificate of the Medical Bureau on any periodical examination, or on any examination for benefits, provided that he has not accepted any benefits under such an award made as a result of such certificate and provided further that he gives notice of appeal within three months after the receipt by him of the Medical Bureau's certificate of such examination. (The periodical examination is a compulsory six-monthly examination by the Medical Bureau of all working miners; if silicosis or tuberculosis is detected, a certificate by the Bureau must be issued accordingly.)

(2) The reviewing of the case of any deceased " miner " whose dependant is dissatisfied with the Medical Bureau's decision as to the cause of such miner's death.

The word " miner " is defined in the Act as " any person (other than a native labourer) who is or has been employed underground at a scheduled mine in any of the occupations specified in the Act ". It is obvious from the above that the native underground worker has no right of appeal.

Every appellant is X-rayed and independently examined, clinically, by all three members of the Medical Board of Appeal. In the case of post-mortem claims all the pertinent records are considered, and, when available, the lungs are inspected. The lungs of deceased miners, on whom autopsies are performed, are preserved for six months.

A provision of the Act requires the Medical Bureau and the Miners' Phthisis Board to produce, if requested, to the Medical Board of Appeal all records in their possession in respect of any appellant.

The Medical Board of Appeal was established as a result of an insistent demand by miners and beneficiaries who, rightly or wrongly, felt that they were not getting what they considered a "square deal" from the Medical Bureau.

Before the establishment of the Medical Bureau in August 1916, large numbers of miners were compensated in either the primary or secondary stage of silicosis on certificates issued by two or three doctors from a panel appointed by the Government; when these cases came to be reviewed by the Medical Bureau it was found that a large percentage of them were not the subject of silicosis at all and were certified by the Bureau accordingly. This was undoubtedly one of the main factors that led to distrust of and dissatisfaction with the Medical Bureau. Another important factor in this respect is the irresponsible manner in which some medical practitioners will certify, without a thorough scientific investigation, that a particular miner is suffering from silicosis or tuberculosis or both when, in fact, he is free from disease of the lungs and may be suffering from a totally different complaint; a climax is reached when an inexperienced doctor, after post-mortem examination, certifies the presence of silicosis in lungs which show at most a slight excess of pigment. It is to be regretted that, in these cases of difference of opinion between private medical practitioners and the Medical Bureau, the latter should be suspected of incompetence or wilful injustice to the miner.

The constitution of the Medical Board of Appeal was a matter of some difficulty for the Minister of Mines, who had to make the appointments. The Act requires that the Appeal Board shall consist of three medical practitioners with special knowledge of diseases of the lungs and respiratory organs. The Minister realised that the appointment to the Medical Board of Appeal of medical men who were not at least as experienced as members of the Medical Bureau, would be ridiculous and might easily wreck the working of the Act; he therefore decided to divorce two of the senior members from the Bureau for appointment to the Board of Appeal.

This step has caused considerable dissatisfaction among miners, the contention being that these two members would be loth to upset the decisions of a body (the Medical Bureau) to which they formerly belonged. Why this suspicion should arise in the case of medical men promoted to a higher body, and not in the case of the legal profession, is quite incomprehensible.

When it is considered that the Medical Board of Appeal has to review the decisions of an expert and highly organised and competent body such as the Medical Bureau, it is not to be expected that a large percentage of the decisions by that body will be altered on appeal. The members of the Medical Bureau work at high pressure, year in and year out, handling on an average nearly 150 cases per day; it is therefore impossible for them to devote to each individual case the time which the Medical Board of Appeal are able to do; as a direct result of this the Medical Board of Appeal is able, occasionally, to detect signs of very early silicosis or of tuberculosis which may have escaped notice previously; but these cases are really extraordinarily few in number.

It must be remembered that the law allows a period of three months from the date of the Bureau's last certificate within which a miner may give notice of appeal; it therefore often happens that the appellant does not appear before the Medical Board of Appeal until three or four months after his examination by the Bureau; during this time it is quite possible that silicosis or tuberculosis, undetected or perhaps only slightly suspected at the previous examination, may become manifest; this does, in fact, happen in a not inconsiderable number of cases.

In some cases the certificate of the Medical Bureau is altered by the Appeal Board, not because any new facts have been elicited, but because, in considering all the evidence which was previously available to the Bureau, the Medical Board of Appeal comes to a different conclusion. Since, according to the Act, the decision of the Medical Board of Appeal is final, it behoves this body, as it always earnestly endeavours, to neglect no line of investigation that may elucidate doubtful points in any particular case; in cases of genuine doubt, the benefit thereof is given to the appellant, especially in post-mortem claims.

Copies of the certificate of the Medical Board of Appeal are issued to the Miners' Phthisis Board and the Medical Bureau in every case; where the certificate of the Medical Bureau is altered, the reasons for such alteration are notified to that body.

The appellants who appear before the Appeal Board may be divided into two classes:

(1) Miners who are certified by the Bureau to be free from silicosis and tuberculosis.

(2) Miners who have been certified by the Bureau to be in the ante-primary or primary stage of silicosis and those who have been certified to have tuberculosis without silicosis.

Class 1 consists mainly of working miners, but there are included in this class also miners who have ceased work on scheduled mines anything up to twenty or more years ago, and beneficiaries who were compensated by the old administration before August 1916, when the Medical Bureau was established, and who were subsequently certified by the Bureau to be not suffering from silicosis or tuberculosis. In this class, then, the Medical Board of Appeal must decide whether the appellant has silicosis or tuberculosis or both, or whether he is free from these diseases. It may be necessary, here, to draw attention to the fact that the term " miners' phthisis " does not appear in any of the provisions of the Miners' Phthisis Act; silicosis and pulmonary tuberculosis are the only two terms employed to denote disease which is compensatable under the Act.

The question now arises: What is silicosis ? The Act does not define the term " silicosis ", but it is now generally accepted in South Africa that silicosis is a generalised nodular fibrosis of the lungs caused by the inhalation, over a long period, of minute particles of siliceous dust. We have no intention of entering upon a description of the several stages of silicosis either from the pathological or clinical point of view; nor shall we refer to the changes resultant upon infection by the tubercle bacillus. The remarks which follow apply to " simple silicosis ", i.e. silicosis without any clinically obvious tuberculous infection. Before dealing with the clinical diagnosis of a slight degree of simple silicosis, it is necessary to refer very briefly to the naked-eye appearances of a silicotic lung. For the purpose of administering the Act it is the considered opinion of the Medical Board of Appeal and of the Medical Bureau that it is not practicable to recognise any but macroscopic signs in the post-mortem diagnosis of silicosis. The earliest silicotic changes detectable by the naked eye are:

1. Enlarged, pigmented and fibrosed root-glands.
2. Sub-pleural plaque formation.
3. The presence, throughout the lung tissue, of more or less evenly distributed, discrete, small-sized, pigmented fibrotic nodules which project from the cut surface and are palpable.

These changes occur in the order given above; the root glands may be affected, as described, without any involvement of the lung substance. A few scattered sub-pleural plaques may be palpable without any nodules being present in the lung, but we have never seen silicosis of the lung without palpable sub-pleural plaques. It may be asserted, therefore, that, if the pleura presents a normal appearance, section of the lung will not reveal any silicosis.

These small fibrotic nodules are represented in the X-ray picture by small round shadows which are more or less well defined and give the skiagram a typical "mottled" appearance.

According to the Act a person shall be deemed to have silicosis in the ante-primary (first) stage when it is found that the earliest detectable specific physical signs of silicosis are present. It is possible, in the majority of cases, for the expert ear to diagnose stethoscopically the presence of ante-primary stage silicosis; this diagnosis is based on a peculiar harshening and thinning of the breath-sounds with a slightly reduced air entry; this change in the character of the breath-sounds is, however, so subtle in early silicosis and is so often produced by other conditions that it cannot be said to be specific of silicosis.

In the ante-primary stage of silicosis there is no appreciable diminution of the range of chest expansion and there are no constitutional disturbances. It may be stated dogmatically, therefore, that the earliest detectable physical sign which can be said to be definitely specific of silicosis is the fine uniform mottling of the radiograph produced by the resistance of silicotic nodules to the passage of the Röntgen rays; in our experience there is no other condition that can produce this X-ray picture in an apparently healthy subject.

A mere increase or accentuation of linear or branching shadows in the radiograph caused by peribronchial and perivascular fibrosis due to other conditions, e.g. chronic bronchitis, tuberculosis, chronic cardiac disease, etc., must not be confused with the typical radiographic appearances due to silicosis. It is hardly necessary to mention that, for the purpose of the radiographic diagnosis of early silicosis, the X-ray film must be technically perfect.

As regards the inspection of X-ray films, we know of no artificial illumination which can compare with sunlight reflected from a white surface.

With reference to pulmonary tuberculosis, a provision of the Miners' Phthisis Act reads as follows:

A person shall for the purposes of this Act be deemed to be suffering from tuberculosis whenever it is found either:

(*a*) that such person is expectorating the tubercle bacillus, or (*b*) that such person has closed tuberculosis to such a degree as seriously to impair his working capacity, and render prohibition of his working underground advisable in the interests of bis health.

We do not intend discussing the diagnosis of early pulmonary tuberculosis; the extreme difficulty of arriving at a definite diagnosis in early sputum free cases is known well enough to all experienced workers in this sphere.

In order to make a diagnosis of closed tuberculosis in any particular case, we consider it essential that there should be present a combination of signs from the following three groups:

1. Constitutional signs and symptoms, e.g. anorexia, loss of weight, fever, lassitude, languid and hollow- or deep-eyed appearance, night sweats, etc.
2. Physical signs in chest, e.g. localised flattening of chest wall, restricted movement, impaired note on percussion, signs of consolidation, crepitations, etc.
3. Radiographic evidence, i.e. the presence of abnormal shadows of varying degree in the lung field.

In Group 1 nearly all the signs are the result of toxaemia which may be caused by conditions other than tuberculosis.

In Group 2 the signs may be produced by many conditions, e.g. catarrhal infections, unresolved pneumonias, bronchiectasis, pleural effusions, empyema, new-growth, gumma, etc.

In Group 3 shadows may be caused by thickened pleura, unresolved pneumonia, empyema, pleural effusion, new-growth, gumma, etc.

It is obvious, therefore, that a diagnosis of closed tuberculosis ought to be made only after a very careful and painstaking consideration of the whole symptom-complex, and after exclusion, by appropriate investigation, of the many conditions which so frequently produce signs and symptoms simulating those of pulmonary tuberculosis. Haemoptysis, for example, is sometimes a very early and important sign of pulmonary tubercle, but no clinician of experience would dream of making a diagnosis of pulmonary tuberculosis on this sign alone.

It is true that with long experience one is able, or one thinks one is able, to differentiate between the X-ray appearances caused by various lung conditions, but it is also true that with longer experience one becomes convinced, especially if one is also a clinician, that it is foolish to make a diagnosis of a lung condition from radiographic signs only.

We have seen radiographic shadows similar to those produced by tuberculous consolidation disappear like magic after anti-syphilitic treatment in Wassermann ++ cases, and after no treatment at all in cases of unresolved and clinically unsuspected localised pneumonias; we have seen a bilateral primary alveolar carcinoma with abcess formation give X-ray appearances identical with those of silicosis with tuberculous consolidation; a myxosarcoma simulating hydatid cyst and cases of generalised nodular tuberculosis with radiographic features almost indistinguishable from those of silicosis. Whereas in the diagnosis of early silicosis the radiographic is the most, if not the only, reliable sign, in the diagnosis of early pulmonary tuberculosis it must in the majority of cases take the place of corroborative evidence only; in fact, in quite a number of positive sputum cases there are no radiographic abnormalities at all.

A certificate by the Medical Board of Appeal to the effect that a miner is suffering from pulmonary tuberculosis becomes a legal document; on the one hand it means the disbursement of a large sum of money; on the other, if the person so certified is a working miner, he is legally debarred from work in a scheduled mine and will have great difficulty in obtaining employment elsewhere.

The matter is therefore a serious one, and a diagnosis of pulmonary tuberculosis should be made only when definite evidence of the disease is present; a diagnosis of so serious a disease ought never to be made in a haphazard manner, as is unfortunately only too often done, and the diagnosis should never be based on suspicion only. There is a vast difference between suspecting the presence of the disease and making a definite diagnosis; it is this difference which accounts for the large number of miners who are certified by irresponsible medical practitioners to have pulmonary tuberculosis and who are found by the Medical Board of Appeal or the Medical Bureau not to have the disease.

In the second class of appellants it is a question for the Appeal Board to decide whether the stage in which the appellant has been classified by the Medical Bureau is the correct one or not.

In a few cases the Bureau's certificate of ante-primary stage may be altered to primary stage, but the majority of alterations in this class are due to the decision of the Medical Board of Appeal that the silicosis in either the ante-primary or the primary stage already certified by the Bureau is complicated by the presence of pulmonary tuberculosis either open or closed.

For the purposes of the Act a person is deemed to have silicosis in the secondary (pensionable) stage when it is found that he has definite and specific physical signs of silicosis, and that capacity for work is thereby seriously and permanently impaired, or when it is found that he has tuberculosis with silicosis; in the latter case the degree of silicosis is not qualified.

It is a peculiar, yet well-known, fact that if a miner on the Rand suffers from any chronic disease causing loss of weight, lassitude, cough, shortness of breath, etc., he becomes obsessed with the idea that "miners' phthisis" is at the bottom of his trouble. It is quite impossible to convince a miner suffering from serious cardiac disease that his cough and dyspnoea are due to his heart condition, or, in other cases, that his symptoms of ill-health are due to chronic bronchitis, chronic malaria, pyorrhoea, or anaemia, etc. Similarly, it is difficult for dependants of deceased miners who may have had a slight silicosis to realise that there are many causes of death to which silicosis does not predispose or contribute.

STATISTICAL ACCOUNT OF THE INCIDENCE AND PROGRESSION OF SILICOSIS AMONGST THE GOLD MINERS OF THE WITWATERSRAND

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Definitions

In this discussion we shall employ the term "simple silicosis" to connote a condition of silicosis without obvious or overt tuberculosis, the term "tuberculosis with silicosis" to connote a condition of silicosis accompanied by obvious or overt tuberculosis, and the term "simple tuberculosis" to designate a condition of tuberculosis unaccompanied by detectable silicosis.

By the "prevalence" of any one of these conditions for any year is meant the total number of cases of that condition detected in that year amongst the "working miners" examined, and by the "prevalence rate" the ratio per cent. of the number of such cases to the total number of working miners. "Prevalence" thus includes the "new" cases which arise in the year specified *plus* the "old" cases of miners who have contracted the disease in previous years, but who have not retired from work underground.

By the "production" of any one of these conditions one means the number of "new" cases of that condition which are detected in any one year amongst miners who have been previously examined and found to be free from that condition. By the "production rate" is meant the ratio per cent. of the number of new cases of the particular condition specified to the number of such working miners examined.

The terms "ante-primary", "primary", and "secondary" stages of silicosis have the meanings set out in the Act of 1925.

The term "working miner" designates any European eligible for the "periodical" examination of the Bureau and includes, in addition to miners working below ground, a comparatively small additional number of persons working in assay offices, on or about crusher stations, in change houses and on tailings dumps.

The term "scheduled mines" designates the mines of the Witwatersrand area which are scheduled as "phthisis-producing" under the Miners' Phthisis Act.

The first and major portion of this paper deals with the statistics of silicosis amongst European miners, but reference is made in the concluding section to the incidence of silicosis and tuberculosis amongst native mine labourers employed on the scheduled mines.

I. — Evidence regarding the Prevalence of Silicosis during the Period prior to 1 August 1917

Accurate data regarding the production of silicosis were not available prior to the year 1917-1918, i.e. the year following the institution of the Medical Bureau. In 1916-1917 the Bureau carried out a complete examination of all working miners, but the cases detected during that year represent " prevalence ", not " production ". Unfortunately, therefore, no accurate information exists regarding the production of the disease at the time when conditions were at their worst.

There exist, however, certain data regarding the earlier periods from which some idea of the *prevalence* of silicosis during these years may be gained.

The two important landmarks in our local knowledge of the disease, during that time, are the Report of the first " Miners' Phthisis Commission " issued in 1903 and the Report of the " Miners' Phthisis (Medical) Commission " issued in 1912. Some additional but less comprehensive information is also obtainable from the Report of the " Mining Regulations Commission " issued in 1910.

These items of evidence have already been referred to in the " Review of the History of Silicosis on the Witwatersrand ", which forms one of this series of contributions, and it is unnecessary therefore to discuss them in detail. For the sake of completeness, however, a brief reference to this evidence may be made here.

(1) The first official mention of " miners' phthisis " occurs in the *Report of the Government Mining Engineer (Transvaal) for the Six Months ending 31 December 1901*, in which it is stated that of 1,377 rockdrill miners, known to have been employed on the Rand prior to the outbreak of the South African War, 225 had died during the war period or up to the beginning of 1902. This represents an average annual mortality of some 73 per 1,000, but it must be recollected that it refers to a single occupational group and not to the whole body of working miners.

(2) The Report of the Miners' Phthisis Commission of 1902-1903 contains more extensive, but (for reasons for which the Commissioners were not responsible) far from complete information regarding the position at that time. Out of 4,403 miners officially stated to have been working underground in the gold mines of the Witwatersrand 1,210 were examined on behalf of the Commission: it is definitely stated that even on the mines on which this examination was carried out there were a good many abstentions. Of those examined 187, or 15.4 per cent., were certified to be affected by " miners' phthisis " and 88, or a further 7.3 per cent., were suspected cases. The prevalence rate was thus found

to be about 23 per cent., but this figure for the reasons given is probably an understatement. Over 90 per cent. of this first generation of Rand miners were of overseas origin, coming mostly from England, and over 80 per cent. had had previous mining experience elsewhere. The average duration of service amongst the small number of purely Transvaal miners affected was seven years, and in those of this group who had worked only on machine drills it was 5.75 years.

(3) The " Mining Regulations Commission " which reported in 1910 devoted much attention to the question of miners' phthisis.

From evidence submitted in a statement by Drs. Macaulay and Irvine on the " Conditions affecting the Health of Underground Workers on the Mines of the Witwatersrand ", the Commission reached certain conclusions regarding the comparative mortality from the causes specified below of underground workers and of adult non-mining males. Taking the mortality from each of the causes specified amongst all non-mining adult males on the Witwatersrand during the period 1905 to 1907 as unity, the comparative mortality amongst underground employees for the same years is given as:

Phthisis, 6.3,
Other respiratory diseases, 1.7
All other diseases, 0.84.

The comparison is only an approximation, since the size of the two populations compared was only approximately known, no determination of the age distribution of the two populations compared was possible, and deaths from phthisis amongst retired miners occurring outside the Witwatersrand area were not included. The authors of the statement referred to also showed that the age period of highest mortality from phthisis amongst miners (thirty-six to forty years) fell somewhat later than that amongst the general adult male population: this is now recognised as a characteristic feature of " dust phthisis ". They also showed by reference to data presented in a *Report on Miners' Phthisis at Bendigo* by Dr. W. Summons that, although the deaths from phthisis apparently affected a smaller proportional section of mine employees on the Rand, the development of the disease appeared with us to be more rapid. Over 80 per cent. of the phthisis deaths on the Rand lay between the ages of thirty and forty-five, attaining a maximum between thirty-five and forty. At Bendigo the main distribution lay more evenly between forty and sixty-five, reaching a maximum between fifty and fifty-five years.

(4) The next important item of evidence is furnished by the Report of the " Miners' Phthisis (Medical) Commission " which was issued in 1912. There were examined by this Commission 3,146 miners or about 27 per cent. of all the miners employed. The Commission divided cases of the disease into four stages. In the first of these, however, there were no definite physical signs of its presence, and the tentative diagnosis rested on symptoms and history alone. Excluding these doubtful cases, which amounted to 5.5 per cent. of the total number of men examined, the number of those showing definite physical signs of the disease amounted to 26.1 per cent. of the total. The majority of these cases, however, showed no impairment of working capacity. One cannot conclude from these figures that the true prevalence of miners' phthisis was greater than it had been in 1903, neither on the other hand can one find that any marked change had taken place since the former date.

Machine men were, as expected, found to be the heaviest sufferers, but no occupational group, including the supervisory staff was free from risk of attack.

Of those whose mining experience had been gained solely in South Africa, the average age of those slightly but definitely affected was 35 years, with an average underground service of 7.2 years. For those employed only in South Africa, and only on rockdrills, the corresponding figures were 33.6 and 6.5 years. A prevalence rate of 26 per cent. amongst the miners then employed would represent a total number of existing cases of nearly 3,000.

(5) The Miners' Phthisis Act of 1912 introduced a system of compensation for those affected by the disease. From this date, therefore, we have the additional information provided by the number of original awards granted annually by the Miners' Phthisis Board to living miners. These were as follows:

TABLE I. — ORIGINAL AWARDS FOR SILICOSIS OR TUBERCULOSIS WITH SILICOSIS GRANTED BY THE MINERS' PHTHISIS BOARD, 1912-1916

Year	First stage silicosis	Second stage silicosis, including tuberculosis with silicosis	Total
1912-1913	698	1,632	2,330
1913-1914	1,087	993	2,080
1914-1915	912	367	1,279
1915-1916	540	243	783
Total, 1912-1916	3,237	3,235	6,472

Unfortunately only approximate conclusions can be drawn from these figures regarding the probable production of " new " cases of silicosis during these four years.

There certainly existed at the outset of the period a large number of " accumulated " cases, which had first arisen in previous years. The figures also do not represent the outcome of a systematic examination of all working miners, but are awards granted to those who made voluntary application. Finally, owing to the system of medical examination then employed, the medical standard of selection for awards was far from being uniform.

But if we assume, as appears reasonable, that the number of " accumulated " cases amongst working and retired miners was about 3,000, the figures suggest that some 800 to 900 " new " cases were arising yearly. Support is given to this deduction from the fact that after some 6,500 cases had thus during these four years been awarded compensation and debarred from continuing their employment underground, the Medical Bureau in 1916-1917 detected at " periodical " and " benefits " examinations 907 cases of primary and secondary silicosis amongst the miners *who were actually at work during that year.* This deduction is merely an approximation. It suggests, however, that the number of cases of silicosis produced during each of these years was about three times as great as that arising annually during the two years 1927 to 1929.

II. — The Production of Simple Silicosis from 1917 to 1929

We possess in the annual Reports of the Miners' Phthisis Medical Bureau accurate statistics of the production of silicosis since 1917-1918, based on the number of cases detected at the "periodical" examinations of the working miners. The cases shown in these returns do not quite represent all the "new" cases which have arisen amongst the miners who have been at work since August 1917, since a certain number of miners, particularly in the first two years of the period were first detected not at a "periodical" but at a "benefits" examination. Since, however, these did not amount over the whole period to as much as an additional 7 per cent. the data obtained from the periodical examinations give a substantially accurate representation of the position.

Table II, reproduced from the Report of the Medical Bureau for the year ending 31 July 1929, provides the general data for the subsequent discussion. The salient features of this table are shown also in block diagram in fig. 1 (p. 628), which has been prepared by the kindness of Mr. H. Goodwin from the similar diagram published in recent Bureau Reports.

It has been found convenient for the purposes of this discussion to divide the returns into four triennial periods, each of which is found to have certain characteristic statistical features. It will be observed that the number of cases of tuberculosis with silicosis, although very important during the first period, has since then undergone a steady although not altogether uniform decline, and during the fourth triennial period has become insignificant. Having mentioned this fact, we propose to deal in this discussion solely with the production of cases of "simple silicosis".

This has shown, as will be seen from table II, col. 2, rather remarkable variations from year to year, which require explanation. It may be well therefore to have clearly in mind the factors which may influence the figures of production in a population such as we are dealing with.

Factors which Influence the Production of Silicosis

Four such factors exist, the effect of each of which is independent of that of the others.

TABLE II. — NEW CASES OF SILICOSIS, TUBERCULOSIS WITH SILICOSIS, AND SIMPLE TUBERCULOSIS DETECTED AT PERIODICAL EXAMINATIONS, 1917-1918 TO 1928-1929

Year (1 August to 31 July)	Miners examined	Simple silicosis: Number of cases: Primary and secondary	Simple silicosis: Number of cases: Ante-primary	Simple silicosis: Production rate per cent.	Tuberculosis with silicosis: Number of cases	Tuberculosis with silicosis: Production rate per cent.	Simple tuberculosis: Number of cases	Simple tuberculosis: Production rate per cent.
	(1)	(2 a)[1]	(2 b)	(3)	(4)	(5)	(6)	(7)
1917-1918	13,474	153	—	1.179	116	0.861	35	0.259
1918-1919	14,071	349	—	2.539	120	0.852	36	0.256
1919-1920	14,664	398	(556)	2.787	24	0.163	39 (Open 18) (Closed 21)	0.266
Total 1917-1918 to 1919-1920	42,209	*900* (*1,456*)		*2.195* *3.551*	*260*	0.616	*110*	0.260
Annual average	14,070	300 (485)			87		37	
1920-1921	13,641	17	219	1.757	17	0.125	44 (Open 25) (Closed 19)	0.322
1921-1922	13,450	5	254	1.951	24	0.178	22 (Open 14) (Closed 8)	0.164
1922-1923	12,689	2	255	2.049	19	0.150	25 (Open 17) (Closed 8)	0.197
Total 1920-1921 to 1922-1923	39,780	*752*		*1.916*	*60*	*0.151*	*91*	*0.228*
Annual average	13,260	251			20		30	
1923-1924	12,159	1	318	2.652	20	0.165	11 (Open 10) (Closed 1)	0.090
1924-1925	12,587	1	427	3.438	28	0.222	18 (Open 10) (Closed 8)	0.143
1925-1926	12,823	0	490	3.859	7	0.055	61 (Open 30) (Closed 31)	0.476
Total 1923-1924 to 1925-1926	37,569	*1,237*		*3.328*	*55*	*0.146*	*90*	0.239
Annual average	12,523	412			18		30	
1926-1927	13,654	0	364	2.691	2	0.015	42 (Open 22) (Closed 20)	0.308
1927-1928	14,726	0	283	1.941	0	0.000	32 (Open 23) (Closed 9)	0.217
1928-1929	15,492	0	270	1.761	5	0.032	44 (Open 36) (Closed 8)	0.284
Total 1926-1927 to 1928-1929	43,872	*917*		*2.111*	7	0.016	*118*	*0.269*
Annual average	14,624	306			2		39	

[1] Three cases of secondary stage silicosis were detected in 1917-1918, and 2 in 1918-1919. With these exceptions the cases in col. (2 a) are primary stage cases only.

Note — The figures in brackets in col. (2) and (3) represent the numbers and rates of production which would result from allotting the 556 " new " cases of ante-primary silicosis detected in 1919-1920 to the three years 1917-1918, 1918-1919, and 1919-1920.

(1) *The occupational and hygienic factors which produce the disease.* — It is obvious that the worse the underground conditions the greater the number of cases of silicosis which will be produced, and the better the conditions become the fewer the cases which will arise. But changes in occupational conditions take time to produce their effects. The cases of silicosis which actually arise in any year represent on the average the cumulative effect of the occupational conditions obtaining during the previous ten years or so. The average duration of underground service in scheduled mines, worked by those miners who have actually in any year become silicotic, has amounted during the years under discussion to from nine years and five months at the beginning to twelve years and eight months at the end of the period.

One cannot therefore account for the striking variations which are shown in the production of simple silicosis during these twelve years by corresponding sudden changes in the occupational factor. The effect of the latter can only be approximately measured when the influence of other disturbing factors has been excluded.

(2) Obviously also the number of cases produced will depend on the number of working miners examined—these numbers are shown in col. 1 of table II. But what is of more importance from our point of view is the *number of miners working at each year of underground service.*

TABLE III. — INCIDENCE RATES PER CENT. FOR SIMPLE SILICOSIS AMONGST ALL MINERS WORKING IN EACH YEAR OF UNDERGROUND SERVICE IN THE PERIODS SPECIFIED

Years of underground service	Incidence rates for primary silicosis, 1918 to 1920 [1] (A)	Incidence rates for ante-primary silicosis, 1920 to 1923 [2] (B)	Incidence rates for ante-primary silicosis, 1928-1929 (C)
		The 'Standard' rates	
— 1	0.00	0.00	0.00
— 2	0.03	0.03	0.00
— 3	0.08	0.05	0.00
— 4	0.21	0.14	0.06
— 5	*0.74*	*0.34*	*0.22*
— 6	1.78	0.85	0.46
— 7	2.97	1.55	0.77
— 8	4.21	2.70	1.22
— 9	6.00	4.12	1.81
—10	*8.94*	*5.00*	*2.55*
—11	13.00	5.60	3.24
—12	13.91	6.10	3.70
—13	14.28	6.50	4.09
—14	14.46	6.79	4.51
—15	*14.56*	*6.98*	*5.31*
—16	14.60	7.06	6.22
—17	14.58	7.10	6.52
—18	14.48	7.11	6.70
—19	14.33	7.09	6.75
—20	14.13	7.04	6.68

[1] Including 5 cases of secondary silicosis detected in this period.
[2] Including 24 cases of primary silicosis detected in this period.
Note. — The rates shown are "graduated" rates prepared from the observed data, for the periods specified, published in the annual Reports of the Medical Bureau.

Other things being equal, the incidence of silicosis is a function of duration of service, the liability to attack increasing with increase in the number of years worked.

This feature is very clearly apparent in the data shown in table III. If we select the results shown in col. *B* as a standard, chosen because during these years the production of silicosis was fairly uniform, one finds that at the fifth year of service the incidence was 0.34 per cent., at the tenth year 5 per cent. and at the fifteenth year 6.98 per cent. It will be seen that up to the sixth year the incidence is very slight; these " short service " miners, as Dr. Mavrogordato pointed out some years ago, produce very little silicosis. But amongst the " long service " miners with over six years' service, the incidence rises sharply thereafter to the levels shown. It follows, therefore, that provided the incidence rates remain constant over a series of years, the number of cases of silicosis which are produced will directly depend almost wholly upon the number of miners who are working in the later years of service. This is an important consideration, inasmuch as since 1917-1918 the mining population on the Witwatersrand has steadily become a more settled population, and there has been in consequence a progressive increase in the number of miners working in the later years of service.

This feature is clearly shown in table IV.

TABLE IV. — DISTRIBUTION OF WORKING MINERS IN THE UNDER-MENTIONED YEARS IN TERMS OF YEARS OF SERVICE WORKED

Year	Total working miners examined (A)	Total in 1st to 6th years of work (' short service' miners) (B)	Total with over six years of work (' long service' miners) (C)	Number working in 7th to 12th years (D)	Number working in 13th year or over (E)
1917-1918	14,519	10,719	3,802	—	—
1918-1919	14,719	10,345	4,374	3,929	445
1919-1920	15,056	9,868	5,188	4,668	520
1920-1921	13,470	8,146	5,324	4,881	443
1921-1922	13,282	7,146	6,136	5,551	585
1922-1923	12,542	5,914	6,628	5,890	738
1923-1924	12,026	4,469	7,157	6,127	1,030
1924-1925	12,449	4,772	7,677	6,395	1,282
1925-1926	12,698	4,792	7,906	6,321	1,585
1926-1927	13,525	5,667	7,858	5,919	1,939
1927-1928	14,582	6,683	7,899	5,502	2,397
1928-1929	15,333	7,470	7,863	4,943	2,920

It will be seen from these data (col. *C*) that whereas in 1917-1918 the miners with over six years' service numbered only 3,672 or 26 per cent.

of the whole, their number thereafter steadily increased to 7,906 in 1925-1926, since which date it has remained approximately constant. But, even so, this " older " group of miners has itself been steadily becoming " older " in general composition. In the first triennial period the miners with over twelve years' service, who have the highest attack rates, made up (col. *E*) only about one-tenth of the " long service " group. In 1923-1924 they had risen to about one-seventh and in 1928-1929 to well over one-third of all miners having more than six years' service. *Other things being equal*, the effect of this remarkable change must have been to cause a continuous increase in the number of cases of silicosis arising from year to year. It has had such a result, but, owing to the fact that other factors have influenced the position, it has not had the full effect which it otherwise would have had. One such factor has been a steady but not altogether uniform decline in the incidence rates at each year of service, which is well shown in table III.

(3) The third factor which may influence the number of cases of silicosis is a *modification of the standard of selection of diagnosis of cases*, on the part of the medical examiners, i.e. in the present case on the part of the Medical Bureau. If the Bureau improves its technical standard of diagnosis, so that it is enabled to detect silicosis at an earlier stage than formerly, there will naturally be for the time an increase in the number of cases detected. But that increase, so far as it is material, will be temporary only. A liberalisation in the standard of selection of this nature only effects a material increase in the number of cases detected when it is being applied *for the first time*, and when accordingly two grades of the disease are being taken out at once. Once it has been applied to the whole body of working miners, the temporary increase practically disappears. A striking example of the effect of this factor is shown in table II under the year 1919-1920, when the ante-primary stage of the disease was first made compensatable. In that year there were detected under the old standard (the primary stage) 398 cases (col. 2 *a*), and under the new standard (the ante-primary stage) 556 cases (col. 2 *b*) producing the high peak of 954 cases in all for this one year alone (cf. fig. 1).

(4) A fourth factor which may influence the production of silicosis is a possible *alteration in the general physique of the working miners*. This factor has also been operative during the years under review, since the effect of the initial examination of the Bureau has been to introduce into the general body of working miners a specially selected body of men, whom we call the " new Rand miners ", and who in 1928-1929 numbered over 8,300 or 54.5 per cent. of the whole body. But the effect of this intrusion did not make itself felt to any noticeable extent until well after the period 1920 to 1923. Even in 1924-1925 only 716 of these men had passed the six years' line and only an insignificant number had then reached their ninth year of work.

These considerations make it plain that in discussing the actual production of silicosis during these twelve years one has to bear in mind that there have been *four independently variable factors* influencing the position, an alteration *in any one of which* will affect the number of cases of silicosis which are detected from year to year.

Discussion of the Course of Production of Silicosis from 1917-1918 to 1928-1929

Bearing these considerations in mind we may now consider in detail the returns presented in table II and fig. 1.

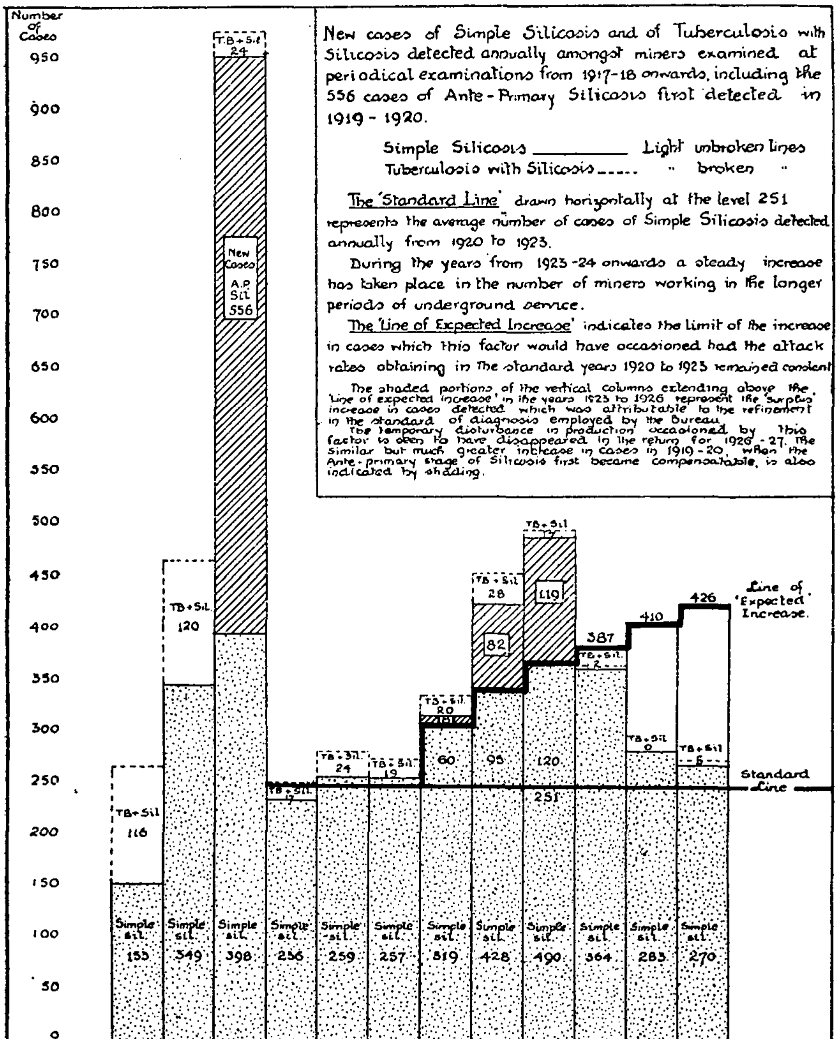
Period 1917 to 1920. — It will be seen that during the first three years there was a staircase rise from 153 cases of primary silicosis (with a very few secondary stage cases) in 1917-1918 to 398 cases in 1919-1920, capped by a peak of 556 cases of " ante-primary " silicosis in the latter year.

(1) The rise in the production of primary silicosis is not difficult to explain. These were war years during which a large number of the " long service " miners were absent on active service and their places were filled by new recruits. With the termination of the war and the return to work of many former miners the number of " long service " miners (table IV, col. *C*) rose from about 3,800 in 1917-1918 to about 5,200 in 1919-1920. This fact explains a large part of the increase although not all of it.

It was also found, however, that the attack-rate for silicosis amongst the " long service " miners was in the two later years practically double (6.79 and 6.84 per cent.) what it had appeared to be in 1917-1918 (3.42 per cent.). The difference is probably to be accounted for by the fact that under the Act of 1916 it was not compulsory for the Bureau when it found a miner to have silicosis to notify him to that effect. As a consequence, many miners who were at work in 1917-1918, instead of appearing at a periodical examination, applied for a benefits examination, and those who were found at such an examination to be silicotic did not figure as they otherwise would have done in the " periodical " returns. The return of cases of silicosis detected at periodical examinations in 1917-1918 was thus artificially lowered. The Act of 1917 by making it compulsory for the Bureau to notify all individuals who were found at a periodical examination to have silicosis removed this source of confusion in later years.

(2) The second feature of these three years is the very large total return of cases of silicosis for 1919-1920. These figures, as we have said, are the result of a change in the standard of diagnosis on the part of the Medical Bureau. Up to 1919-1920 the standard of diagnosis had been what was termed the " primary " stage of silicosis. It was based on the implication of the Act of 1916 that some amount of disability should be present before a case of silicosis was to be regarded as compensatable. This attitude rested on the analogy of compensation for physical " injury ". It was however soon felt that since silicosis is in the majority of cases a progressive disease, the miners affected by it should become compensatable at its " earliest detectable " stage, whether disability was present or not. This change was introduced by the Act of 1919 and the " earliest detectable " stage was labelled the " ante-primary " stage. In 1919-1920 accordingly 556 cases of ante-primary stage silicosis were detected, the majority being accumulated cases, although all may reasonably be presumed to have arisen during the period 1917 to 1920. The returns for 1919-1920 illustrate on a large scale the effect of a change in the Medical Bureau's standard of diagnosis. The 556 cases of " ante-primary " stage silicosis *plus* the 398 cases of primary stage silicosis detected, made a total for the year of 954 cases.

FIG. 1. — PRODUCTION OF SILICOSIS IN ALL FORMS FROM 1917-1918 TO 1928-1929



	1917-1918	1918-1919	1919-1920	1920-1921	1921-1922	1922-1923	1923-1924	1924-1925	1925-1926	1926-1927	1927-1928	1928-1929	Year.
TB + Silicosis	116	120	24	17	24	19	20	28	7	2	0	5	Cases per year
A.P. Silicosis	-	-	[556]	219	254	255	318	427	490	364	283	270	
Pr. Silicosis	150	347	398	17	5	2	1	1	0	0	0	0	
Sec. Silicosis	3	2	0	0	0	0	0	0	0	0	0	0	
Total Silicosis	[1716]			812			1292			924			Three yearly Totals.
Simple Silicosis	[1456]			752			1237			917			
Total Silicosis	[4167]			2067			3473			2127			Production rates per 100,000.
Simple Silicosis	[3551]			1916			3327			2111			

Period 1920 to 1923. — The next three years witnessed a remarkable change. The obvious temporary " skimming " effect of the introduction of a more liberal standard of diagnosis has disappeared and the production falls in a very striking way. Further, although the number of " long service " miners continued to increase from about 5,200 in 1919-1920 to some 6,600 in 1922-1923 (table IV, col. *C*), and one would therefore have expected that the number of cases of silicosis would also have increased, this did not happen *because simultaneously the attack rate for silicosis amongst the " long service " miners fell.* Their attack rate had averaged, in the first three years, 5.8 per cent. — it fell to an average of 3.8 per cent. in 1920 to 1923. It dropped quite suddenly from 6.8 per cent. in 1919-1920 to 3.9 per cent. in 1920-1921. One may regard the first three years as having been the last in which the production substantially reflected the cumulative effect of the conditions which had obtained in the period from 1906 or 1907 onwards to the date of the detection of these cases. The second three years represent the culmination of the first decade of the better conditions, which began about 1911 and 1912. A comparison of the rates of incidence per year of underground service shown for the cases detected in these two respective periods in table III, cols. *A* and *B*, confirms the view that we are here dealing with two different types of case, two different " generations " of miners. It must be remembered in this connection that in few cases, particularly in these earlier years, was a miner's service unbroken.

At all events the one tendency—a fall of 35 per cent. in the average attack rate of the " long service " miners—cancelled the effects of the other, namely, a 35 per cent. increase in their average number, and the production of silicosis remained practically stationary. The standard of diagnosis of the Medical Bureau also remained practically the same for these three years so that no disturbing influence arose from this factor. The production of silicosis during this period was thus moderate and fairly uniform. We have therefore selected these years (1920 to 1923) as " standard years " by reference to which the production of silicosis in the succeeding years could be measured, and with this object we have taken the rates of incidence at each year of service worked which obtained during this period, and which are shown in table III, col. *B*, as " standard rates " of incidence.

Period 1923 to 1926. — The next three years show a different state of affairs. There is again a staircase rise in the production of silicosis to a second peak of 490 cases in 1925-1926 comparable on a smaller scale to the peak of 1919-1920, and due in part to a similar cause. The total increase in these three years over the annual average of 251 cases for the " standard " years 1920 to 1923 was 485 cases in all (table II, col. 2). This increase aroused some alarm and created some misgiving as to the efficacy of the preventive measures employed. But, as Dr. Mavrogordato was the first publicly to point out, it had quite an innocent explanation. The position has been fully analysed in the recent Reports of the Medical Bureau. The falling attack rates (3.9, 3.8 and 3.7 per cent.) of the " long service " miners during this period did not at all suggest that occupational conditions had in recent years altered for the worse.

The explanation of the increase lay in quite another direction. Reference to table IV will show that there had been going on during these years a steady increase in the number of miners at work in the later periods of underground service in which the liability to silicosis is highest. Making the assumption that the attack rates at each year of underground service which had obtained in the period 1920 to 1923 had remained constant, one applied these rates to the *number* of miners working at each corresponding respective year of underground service during each of the three official years 1923 to 1926. The result was to show an " expected " increase during these respective years of 60, 95 and 120 cases or 275 cases in all, constituting 57 per cent. of the total increase of 485 cases. (Cf. table V.)

TABLE V. — COMPARISON OF ACTUAL AND "EXPECTED" INCREASE IN CASES OF SIMPLE SILICOSIS, 1923 TO 1929

Year	Actual	Expected	Actual less expected	
			Plus	Minus
Annual average, 1920-1923 (standard)	251	251	—	—
1923-1924	319	311	8	—
1924-1925	428	346	82	—
1925-1926	490	371	119	—
1926-1927	364	387	—	23
1927-1928	283	410	—	127
1928-1929	270	426	—	156

There still remained, however, a considerable surplus increase of 209 cases, 8, 82 and 119 in the respective years, which could not be explained in this way. The residual increase was attributable to a second factor which became operative during these years, namely, to a further liberalisation in the standard of diagnosis of the " earliest detectable " stage of silicosis, which was attained during this period by the Medical Bureau owing mainly to improvements in radiographic technique, and to the consequent possibility of a more exact correlation of the results of clinical, radiographic and pathological investigation in a large series of individual cases. The operation of this process, which was substantially completed in 1925-1926, was to repeat, although on a smaller scale, the peak of 1919-1920. Since December 1925, the effects of the process described have been accentuated to some extent by the additional cases resulting from the decisions of the Medical Board of Appeal, which commenced its work at that date. These are included in and go to augment the returns shown in table II.

From the result of this investigation it was possible to predict that the temporary increase due to the operation of this process of deeper selection of cases would shortly disappear. This prediction was realised. In 1926-1927 the number of cases of simple silicosis detected dropped from the 490 cases of the previous year to 364.

Period 1926 to 1929. — The next three years show a decided falling tendency in the production of silicosis (table II, col. 2).

The sudden drop of 126 cases in the production for the year 1926-1927 was attributable mainly to the substantial completion of the process of deeper selection of cases by the Medical Bureau, which had been proceeding during the previous years. Some such fall had been predicted. But reference to table V shows that not only had the obvious surplus increase due to this factor totally disappeared, but that the actual number of cases had dropped below the "expected" number by 23. The further fall to 283 cases in 1927-1928 and to 270 cases in 1928-1929, is even more satisfactory *because it has been effected in face of a further increase in the number of miners working in the later years of service* (table IV). In 1925-1926 there were at work 1,585 miners with over twelve years' service—in 1928-1929 their number had risen to 2,920.

If one makes allowance for the influence of this latter factor one may state, with entire confidence, that the true production of silicosis when measured, *as it can only accurately be measured, by the respective incidence rates of the disease amongst miners at work in the corresponding respective years of underground service*, has undergone a decided improvement since the period 1920 to 1923. Reference to table V or fig. 1 will show that had the rates of the "standard" period remained constant, the number of cases of silicosis to be "expected" in 1928-1929 would have been 426 — they were actually instead 270, a decline below the "expected" number of over 36 per cent. The comparative rates of incidence are given for 1928-1929 and 1920 to 1923 in table III. When, further, one compares the former with the rates obtaining for the primary stage of the disease in 1918 to 1920 the improvement is even more decided. In this respect it is well to note that 90 per cent. of the 270 cases of silicosis detected in 1928-1929 had commenced work on the Rand prior to August 1916, prior, that is, to the commencement of the "present-day" period of preventive policy. The figures appear to indicate that there has been, during the past three years, a decided fall in the true incidence rates of the disease similar to that which occurred after 1919-1920. It is mainly in these later years that one would expect the results of the improved preventive policy introduced in 1916-1917 to effect a substantial modification of the production of the disease.

The Present Position and the Future Outlook Regarding the Production of Simple Silicosis

It is important from the point of view of the outlook regarding the probable course of production of silicosis in the near future to analyse a little more fully the reasons for the decline below the "expected" standard during the past three years. The actual amount is indicated in the last vertical column of table V, and in fig. 1.

For this purpose it is desirable to follow the recent practice of the Medical Bureau, and divide the body of working miners into three classes for separate consideration. These classes are:

Class A — "*new Rand miners*", i.e. miners who have worked only in the mines of the Witwatersrand, and only *since* 1 August 1916.

Class B — "*old Rand miners*", i.e. miners who have worked only in the mines of the Witwatersrand, but who commenced work *before* 1 August 1916.

Class C — "*miners, Rand and elsewhere*", i.e. miners who have worked on the mines of the Witwatersrand and also in mines elsewhere.

The particular importance of Class A lies in two facts: (1) that all of these miners have passed the " initial examination " of the Medical Bureau, and (2) that they have been exposed solely to the improved occupational conditions existing since 1916, and have not been affected in any way by mining work elsewhere. This class is naturally a growing one and numbered, in 1928-1929, 8,360 out of the total of 15,333 working miners at that date, or 54.5 per cent. Nevertheless, no miner of Class A had at that date worked for more than thirteen years, and only an insignificant number had reached their thirteenth year of service. In time, but not for a very considerable time, the production of simple silicosis for all miners will depend mainly on the production in this class.

Class B has formed in the past the most numerous group, but it is naturally a decreasing class, and in 1928-1929 it included only 5,672 persons, or 37 per cent. of the total body of working miners. It is still, however, the most important group for the production of silicosis, contributing 197 of the 270 cases of simple silicosis which arose during that year.

Class C is likely always to be a small class, the number of miners included in it in 1928-1929 being 1,301, or 8.5 per cent. of all the working miners. But it contributed during the year more than its proportionate quota of cases.

TABLE VI. — COMPARISON OF ACTUAL AND "EXPECTED" CASES IN THE THREE CLASSES OF WORKING MINERS, DURING THE YEARS 1926 TO 1929

Year	Cases of simple silicosis					
	Class A		Class B		Class C	
	Actual	Expected	Actual	Expected	Actual	Expected
1926-1927	9	48	301	293	54	46
1927-1928	11	67	215	297	57	46
1928-1929	22	84	197	295	51	47
Totals	42	199	713	885	162	139
Actual less expected	—157		—172		+ 23	
Ratio of actual to expected	21 %		81 %		117 %	

A comparison of the " expected " cases, according to the production rates for the standard years 1920 to 1923 (table III, col. *B*) with the actual cases of simple silicosis arising in each of these three classes during the past three years leads to the following interesting results.

It is only necessary to emphasise here the very low production in Class A. This production, however, is as yet dependent upon the rates for the first thirteen years of service only. For that period the incidence rates for each year are for this class very much below the rates for the other two classes, and the curve of incidence does not as yet show any tendency to swing upwards to meet the curves of the other classes in later years. But it is impossible to be too definite with regard to the future. One cannot, of course, anticipate that production rates of the same low order will continue when the " new Rand miners " advance into the later years of underground service. But there is no reason to suppose that even then their incidence rates will reach the relatively higher rates hitherto shown by the two other classes, since the causes producing such low production in the past should have a similar effect at later years of service.

The difference in production rates between the " new " and the " old Rand miners " is due to the facts that the former are specially selected men, and that they have throughout their total period of service been subjected to improved occupational conditions. There are no data which enable one to state how much of the difference can be ascribed to each of these causes. One may reasonably ascribe the decline below the " expected " production which has likewise become evident during the past two years amongst the " old Rand miners " (table VI) to the fact that with each succeeding year a larger proportion of the service of the members of this group also has been passed under improved occupational conditions. The higher production of the " miners, Rand and elsewhere " may reasonably be ascribed to the effect of previous mining work elsewhere.

All of this is re-assuring; nevertheless we must add a word of caution. Although one is justified in concluding that the Rand has turned a big corner in the matter of silicosis, one does not anticipate that the actual number of cases detected will show any significant further decrease in the immediate future. For although the " new Rand miners " with their relatively lower attack-rates are becoming more numerous, nevertheless the older miners who remain — and there are still over 5,000 of them — are every year growing older in years of service, and therefore more liable to contract silicosis. The one factor will probably for some time balance the other, and one does not therefore anticipate much, if any, actual decrease in the number of " new " cases of simple silicosis which will arise for some years to come. That is the position to-day.

One may in conclusion discuss briefly certain other minor factors that may or may not influence production.

The age of the miner would not appear to exert much influence upon production, the data being inconclusive.

It is similarly not possible to say whether miners born in South Africa are subject to higher or lower production rates than those born overseas. The evidence indicates that there is no significant difference.

The particular class of underground occupation engaged in is certainly an important factor in production. No satisfactory statistics have however been accumulated on this subject, partly because such information has not been required for any particular

TABLE VII. — NEW CASES OF SIMPLE SILICOSIS DETECTED AMONGST MINERS WHO HAVE WORKED UNDERGROUND ONLY IN SCHEDULED MINES, DISTINGUISHING BETWEEN MACHINE-DRILLERS AND OTHERS WITH PRODUCTION-RATES PER CENT. — 1 AUGUST 1927 TO 31 JULY 1928

Period Worked	Total miners examined	Machines only		Machines and other work				No machines	
				Over 50 % machines		Up to 50 % machines			
		Number examined and percentage of total	Cases of silicosis and production-rate per cent.	Number examined and percentage of total	Cases of silicosis and production-rate per cent.	Number examined and percentage of total	Cases of silicosis and production-rate per cent.	Number examined and percentage of total	Cases of silicosis and production-rate per cent.
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Up to 6th year	6,255	55 (0.88)	0 (0.000)	465 (7.43)	1 (0.215)	1,085 (17.35)	0 (0.000)	4,650 (74.34)	2 (0.043)
7th to 12th year	5,023	47 (0.93)	6 (12.766)	736 (14.65)	37 (5.027)	2,466 (48.70)	57 (2.330)	1,794 (35.72)	13 (0.725)
13th to 18th year	1,876	19 (1.01)	2 (10.526)	245 (13.06)	27 (11.020)	913 (48.67)	47 (5.148)	699 (37.26)	26 (3.720)

purpose, and partly because miners frequently change from one class of occupation to another. The respective proportions of miners engaged in occupations that are more or less hazardous probably do not differ appreciably from year to year, although in each year they may be made up of different individuals, and the factor of occupation has therefore not influenced statistics dealing with the miners as a whole. There can be no doubt, however, that production is higher among machine-drillers, and amongst those handling broken rock, than amongst those in other occupations, and the factor of occupation would need to be taken into account should the financial system be revised to include differential payment according to occupation. Table VII, showing the production of silicosis for the year 1927-1928 for machine-drillers and others, is of interest (it is taken from the Bureau Report for the year ended 31 July 1928, page 25).

III. — The After-History of Cases of Silicosis and the Progression of the Disease

It has been shown that there has been a considerable decline in the production of silicosis, but unfortunately this has not been accompanied by a corresponding fall in the progression of silicosis, and instead the disease has become of a more infective, and therefore of a more progressive, type. This phenomenon has been discussed in other papers of this series. It may indeed be stated that the importance of the production of a new case of silicosis in the ante-primary stage lies, not in the fact that the miner has silicosis in that stage, but in the likelihood that the disease will progress, first to the primary stage and then to the secondary stage, within a relatively short period.

It thus becomes of importance to measure the rate of progression of the disease. The progression is measured by the " stages " of the disease, and for this purpose the " secondary " stage is treated as including cases of silicosis plus tuberculosis.

Comparison of Progression in Cases originally Certified Respectively as Primary and as Ante-Primary Silicosis

The following table traces the subsequent history (so far as it is known) of *895 cases originally certified as being in the primary* *stage of silicosis* during the three years from 1 August 1917 to 31 July 1920:

TABLE VIII. — SUBSEQUENT HISTORY OF ORIGINAL PRIMARY STAGE CASES CERTIFIED DURING THE THREE YEARS 1917-1920

	Surviving as		Total surviving	Transfers to secondary stage during year	Died during year while	
	primary stage	secondary stage			in primary stage	in secondary stage
New cases	895	—	895	84	30	11
End First year	781	73	854	48	15	23
,, Second year	718	98	816	60	13	26
,, Third year	645	132	777	41	9	38
,, Fourth year	595	135	730	53	10	24
,, Fifth year	532	164	696	62	14	34
,, Sixth year	456	192	648	51	15	31
,, Seventh year	390	212	602	52	14	31
,, Eighth year	324	233	557	24	11	23
,, Ninth year	289	234	523	—	—	—

Note. — The first year represents a period of between one year and two years and averages about eighteen months.

The percentage of these original primary cases surviving in the primary and secondary stages, and the percentage who have died from the outset, at the end of the third, sixth and ninth years respectively are as follows:

Percentage	End of third year	End of sixth year	End of ninth year
Surviving as primary	72.1	51.0	32.3
,, ,, secondary	14.7	21.4	26.2
Died while primary	6.5	10.2	14.6
,, ,, secondary	6.7	17.4	26.9

The following table traces the subsequent history (so far as it is known) of another group of cases, namely, the *728 cases originally certified as being in the ante-primary stage of silicosis during the three years 1920-1923*, and the *1,235 cases similarly certified in the ante-primary stage during the three years 1923-1926*:

TABLE IX. — SUBSEQUENT HISTORY OF ORIGINAL ANTE-PRIMARY CASES CERTIFIED RESPECTIVELY DURING THE PERIODS 1920-1923 AND 1923-1926

	Surviving as			Total surviving	Transfers during year to		Died during year while		
	ante-primary stage	primary stage	secondary stage		primary stage	secondary stage	in ante-primary stage	in primary stage	in secondary stage
Certified during the period 1920-1923									
New cases	728	—	—	728	46	28	18	—	6
End First year	636	46	22	704	63	30	7	3	15
,, Second year	542	100	37	679	86	45	5	2	12
,, Third year	429	161	70	660	81	59	8	6	24
,, Fourth year	320	197	105	622	59	62	5	1	27
,, Fifth year	241	208	140	589	32	47	9	3	20
,, Sixth year	192	198	167	557	—	—	—	—	—
Certified during the period 1923-1926									
New cases	1,235	—	—	1,235	117	56	46	1	7
End First year	1,016	116	49	1,181	195	56	16	3	24
,, Second year	774	283	81	1,138	159	71	11	6	23
,, Third year	593	376	129	1,098	—	—	—	—	—

Note. — The first year represents a period of between one and two years and averages about eighteen months.

The percentages of these original ante-primary cases surviving in the various stages, and the percentages of those who have died from the outset, at the end of the third and sixth years, are as follow:

Percentage	1920-1923 cases		1923-1926 cases: End of third year
	End of third year	End of sixth year	
Surviving as ante-primary	59.0	26.4	48.0
,, ,, primary	22.1	27.2	30.5
,, ,, secondary	9.6	22.9	10.4
Died while ante-primary	4.1	7.1	5.9
,, ,, primary	.7	2.1	.8
,, ,, secondary	4.5	14.3	4.4

These figures lead to certain interesting comparisons. At the end of the sixth year, out of the 895 original primary cases certified during the three years 1917-1920, 27.6 per cent. had died and 21.4 per cent. survived in the secondary stage, while out of the 728 original ante-primary cases certified during the three years 1920-1923, 23.5 per cent. had died and 22.9 per cent. survived in the secondary stage. Bearing in mind that the ante-primary stage is an earlier stage of the disease than the primary stage, the comparison shows that there has been a higher rate of progression among original ante-primary cases, and it exemplifies the change in the form of the disease to a more infective type. A comparison of the percentages "surviving" and "died" at the end of the third year for original, ante-primary cases certified respectively during the three years 1920-1923 and during the three years 1923-1926 shows that the change to a more infective type of disease has continued within recent years.

These conclusions might have been reached by other methods. If the original ante-primary cases be traced until they die in the ante-primary stage or until they progress to a further stage, the average annual rate of progression among those surviving in the ante-primary stage at the beginning of each year is, to the primary stage 17.2 per cent., to the secondary stage 3.0 per cent., total 20.2 per cent. The first year (averaging eighteen months) following the date of certification has been omitted, since for this period there is a halt in the progression of the disease, the total annual rate of progression being only 8.2 per cent. If the primary cases who have been transferred from the ante-primary stage be similarly followed until they die in the primary stage or until they reach the secondary stage, the average annual rate of progression to the secondary stage among those surviving in the primary stage at the beginning of each year is found to be 20.2 per cent. This rate of 20.2 per cent., applicable to the progression to the secondary stage of primary stage cases who have been transferred from the ante-primary stage, may be contrasted with the annual rate of progression to the secondary stage applicable to original primary cases certified during the three years 1917-1920, which was found to be 8.3 per cent.

The reasons for these results have already been discussed. The original ante-primary cases, and particularly those certified in more recent years, are representative of a different body of miners from those originally certified in the primary stage during the three years 1917-1920, they have worked under different conditions during the greater part of their underground employment, and they are subject to a more infective type of silicosis.

It is desirable to emphasise an important change that has taken place in the general body of miners. In the early days the immense majority of the miners were men of overseas birth who had been drawn from older mining communities which had long been industrialised, but in later years, and especially since 1907, there has been a steady increase in the number of South African-born miners, who are drawn mainly from the rural districts, and who now constitute over 70 per cent. of the working miners. When a pastoral or agricultural population turns to industry, a rise in the tuberculosis rate of that population is to be expected, and this rise will be accentuated if the industry selected should be a phthisis-producing industry. This, as Drs. Mavrogordato and Irvine have recently put it, is largely the position in South Africa to-day. Although the increasing proportion of South African-born miners has apparently not led to an increase in the production of new cases of silicosis, there can be little doubt that it has been an important influence in the change in the nature of the disease to a more infective and progressive type.

The annual rate of mortality amongst ante-primary cases while they remained in the ante-primary stage, but excluding the first year, averaged 1.7 per cent. During the first year, when the rate of progression was low, the annual rate of mortality was 2.3 per cent. *The annual rate of mortality among primary cases transferred from the ante-primary stage*, while they remained in the primary stage, was 1.9 per cent. The corresponding *annual rate of mortality among the cases originally certified primary* during the period 1917-1920, while they remained in the primary stage, was 2.3 per cent. These figures do not call for any remark except that a low rate of progression would appear to be accompanied by a rather higher rate of mortality.

Mortality of Miners in the Secondary Stage of Silicosis

It is more important to consider *the mortality of miners in the secondary stage*, where the "secondary" stage has again been taken to include cases of silicosis plus tuberculosis. Miners in the secondary stage have since 1 August 1919 received monthly allowances, and a mortality experience was taken out in respect of all such miners, whenever certified, who were in receipt of allowances during the nine years from 1 August 1919 to 31 July 1928; the experience covered 3,438 cases.

This investigation showed the following features:

(*a*) The most important factor influencing mortality was the period that had elapsed since miners were certified in the secondary stage.

(*b*) The ages of the miners were not a material factor, except at very old ages, but the number of such miners was too small to influence the general results.

(*c*) The mortality among miners with silicosis plus tuberculosis was much heavier than among miners with silicosis in the secondary stage without tuberculosis.

(*d*) The mortality among miners certified in the later years under review was lower, after taking into account the period elapsed since certification, than among miners certified in the earlier years.

These features, with the exception of that mentioned under (*b*), have now to be considered.

(*a*) *The rates of mortality according to the period elapsed since certification*, calculated in respect of cases certified after 31 July 1919, were as follow:

Year after certification	Annual rate of mortality per cent	
1st	18.7	
2nd	21.3	
3rd	19.1	
4th	20.1	
5th	18.2	
6th	14.5	
7th	16.2	
8th	5.5	9.0
9th	14.7	

(*b*) It will be observed that the mortality is very heavy for some years following certification, but the survivors after a number of years are subject to lower rates. This feature of the lower mortality among the relatively few survivors after some years is seen more clearly by considering the cases who were in the secondary stage prior to 1 August 1919, and who are dealt with in (*c*) below.

(*c*) The mortality was calculated separately for cases of silicosis plus tuberculosis, and for cases of silicosis in the secondary stage without tuberculosis, in respect of miners who were granted allowances as from 1 August 1919 and who were in the secondary stage prior to that date; the results are as follow:

Year from 1 August 1919	Annual rate of mortality per cent.	
	Silicosis plus tuberculosis	Silicosis in secondary stage without tuberculosis
1st	21.9	9.8
2nd	20.3	10.6
3rd	15.3	9.0
4th	12.1	9.8
5th	14.8	7.9
6th	12.7	9.2
7th	13.1	7.8
8th	10.1	9.3
9th	7.9	6.5

This table gives results which were to be expected, but the table is also of interest in showing the lower rates of mortality among survivors who had been in the secondary stage for some years.

(*d*) The feature of decreasing mortality according to the year of certification is shown in the following table, which gives, in respect of cases certified in the secondary stage after 31 July 1919, the percentage of the actual deaths that occurred to the deaths that would have been "expected" on the basis of the mortality for all years combined.

Year certified secondary	Percentage of actual to expected deaths
1919-1920	110
1920-1921	137
1921-1922	99
1922-1923	95
1923-1924	119
1924-1925	89
1925-1926	88
1926-1927	75
1927-1928	88
All years	100

This feature of decreasing mortality is thought to be temporary. It will be observed that the mortality of the last four years has remained fairly constant, and having regard to the more progressive type of disease shown in recent years, it would appear that the mortality of future secondary cases should tend to be higher.

Average Expectation of Progression in Cases Originally Certified as Ante-Primary Stage Silicosis

A general summary of the results relating to the progression and mortality of ante-primary cases certified from 1920-1921 onwards may be given in an interesting way. The average period spent by a miner in the ante-primary stage, from the date of certification until he dies in that stage or until he progresses to a further stage, is 4.59 years. For a miner transferred to the primary stage from the ante-primary stage, the average period spent in the primary stage, from the time he is certified primary until he dies in that stage or until he progresses to the secondary stage, is 3.85 years. The average period spent by such a miner in the secondary stage, from the time he is certified secondary until he dies, is 7.26 years.

The average future lifetime of a miner certified in the ante-primary stage cannot, of course, be obtained by adding together these three separate periods of years, because to do so would leave out of account the fact that those dying while in the ante-primary or primary stage could have no lifetime in a further stage or stages, and also the further fact that those progressing direct from the ante-primary stage to the secondary stage could have no lifetime in the primary stage. The figure has been correctly calculated, and the average future lifetime, or expectation of life, of a miner certified to be in the ante-primary stage is 13.66 years.

Mean Duration of Underground Work and Average Working Lifetime of a Miner

The *mean duration of underground service* in all the new cases of silicosis which have arisen amongst those miners who have worked only in scheduled mines is shown below for each year since 1918-1919 (the data are extracted from the Reports of the Medical Bureau):

Year certified	Mean duration of underground service	
1918-1919	9	2
1919-1920	9	6
1920-1921	9	1
1921-1922	9	7
1922-1923	9	5
1923-1924	10	3
1924-1925	10	3
1925-1926	10	10
1926-1927	11	9
1927-1928	12	1
1928-1929	12	8

The increase in the mean duration of underground service is due not only to an improvement in underground conditions, but to two other factors. The first of these factors is the progressive intrusion into the body of working miners of a specially selected group with relatively low attack-rates for the disease, namely, the " new Rand miners ". The second influence is to be found in the fact that the mining community has become more and more a settled community with a continually increasing proportion of miners with relatively long periods of underground service. Even allowing for these two factors, however, the increase in the mean duration of underground service is undoubtedly a satisfactory feature.

Although the mean duration of underground service among miners contracting silicosis is of interest and has to be recorded, it has to be pointed out that this mean duration does not represent the average working lifetime of a miner, since it leaves out of account the fact that many miners still working with relatively long periods of underground service have not yet contracted silicosis, and also the further fact that a number of miners have left underground employment without contracting silicosis. It is necessary, therefore, in considering the true average working lifetime of a miner, to take these further factors into account.

The question of *the average working lifetime* is a difficult one to answer. In the first place, the rate of production of silicosis has been changing, and it is necessary to adopt a reasonable basis for production; it was assumed that the rates of production of simple silicosis during the year 1928-1929 would apply throughout the miner's working lifetime. Secondly, a miner may give up underground employment owing to the contraction of simple tuberculosis or of silicosis plus tuberculosis, the average rates found to be applicable within the last few years were here adopted. Thirdly, underground employment may be terminated owing to death, which might occur through a mine accident or for some other reason, or employment may be terminated through a breakdown in health owing to a mine accident or otherwise. Fourthly, it was presumed that miners would not voluntarily give up underground work. On this basis (and the assumptions appear to be reasonable) a miner might expect to have a working lifetime of nearly eighteen years. We are of the opinion that this average working lifetime of nearly eighteen years represents fairly the average conditions existing at the present time.

It should be added that a miner commencing work now could anticipate an average working lifetime considerably exceeding eighteen years. It is impossible to state with any degree of definiteness what his future working lifetime is likely to be, since the rates of production of " new Rand miners " are available for only the first thirteen years of their underground service, and it is impossible to say what the rates will be in later years, but there can be no doubt that it will be considerably in excess of eighteen years.

IV. — The Prevalence of Silicosis and Tuberculosis amongst Native Labourers on the Gold Mines of the Witwatersrand

A brief reference may be made in conclusion to the general statistics which are available regarding the prevalence of silicosis and tuberculosis amongst native mine labourers.

Table X shows the general data regarding the prevalence of simple silicosis, tuberculosis with silicosis, and simple tuberculosis amongst native mine labourers employed on the mines of the Witwatersrand since 1916-1917. The general system of detection of these conditions amongst mine natives has been described in other papers in this series.

A comparison of the returns here presented with those for European miners in table II shows several very striking differences.

Although in the first two years 1917-1918 and 1918-1919 a very considerable number of cases of silicosis complicated with active tuberculosis was detected amongst the European working

TABLE X. — PREVALENCE OF SIMPLE SILICOSIS, TUBERCULOSIS WITH SILICOSIS, AND SIMPLE TUBERCULOSIS AMONGST NATIVE LABOURERS IN THE GOLD MINES OF THE WITWATERSRAND, 1916-1917 TO 1927-1928

	1916-1917	1917-1918	1918-1919	1919-1920	1920-1921	1921-1922	1922-1923	1923-1924	1924-1925	1925-1926	1926-1927	1927-1928
Average number all mine natives	191,202	180,415	171,959	178,571	168,547	160,600	179,182	178,006	179,881	177,368	184,937	193,976
A. — Cases simple silicosis detected	91	31	47	126	134	45	75	119	85	201	238	209
Prevalence rate per cent.	0.047	0.017	0.027	0.070	0.079	0.027	0.041	0.066	0.047	0.113	0.129	0.108
B. — Cases tuberculosis with silicosis detected	252	232	378	394	276	203	327	312	359	434	409	397
Prevalence rate per cent.	0.131	0.128	0.219	0.220	0.163	0.126	0.182	0.175	0.200	0.245	0.221	0.204
C. — Cases simple tuberculosis detected	1,103	946	789	794	810	580	663	585	456	561	787	746
Prevalence rate per cent.	0.576	0.524	0.458	0.444	0.480	0.361	0.370	0.328	0.253	0.316	0.425	0.385
Combined prevalence rates per cent.:												
Silicosis in all forms (A + B)	0.178	0.145	0.246	0.290	0.242	0.153	0.223	0.241	0.247	0.358	0.350	0.312
Tuberculosis in all forms (B + C)	0.707	0.652	0.677	0.664	0.643	0.487	0.552	0.503	0.453	0.561	0.646	0.589
All compensatable diseases (A + B + C)	0.754	0.669	0.704	0.734	0.722	0.514	0.593	0.569	0.500	0.674	0.775	0.697

Note. — The returns for 1924-1925 onwards do not as in previous years include cases detected amongst the small number of Eurafrican miners.

miners, the number of cases of that condition has markedly declined since that date, and during the past three years has practically reached vanishing point. The number of cases of " open " or active simple tuberculosis arising amongst European miners has never for the last three triennial periods averaged more than 0.18 per cent. The overwhelming majority of cases of compensatable disease amongst European miners since 1919-1920, have been when first detected cases of simple or uncomplicated silicosis.

The reverse is true of the native mine labourers, amongst whom the great majority of cases of compensatable disease are cases of active simple tuberculosis, or, in those with longer service, of active tuberculosis preceded or accompanied by an element of silicosis.

The incidence of simple silicosis amongst the mine natives is relatively small. The low figures for the prevalence of this condition recorded for the first nine years may present an underestimate of the true position, since at that time no systematic investigation of the prevalence of silicosis amongst mine natives was made. But in 1926 a systematic annual radiographic examination of all natives with more than five years' service on any one mine was instituted by the Chamber of Mines. The result, as the figures from 1925-1926 onwards indicate, has been to secure the detection of a considerably larger number of cases of simple silicosis, but the prevalence rate for this condition still remains low as compared with that amongst European miners. It is not that the native labourer is less susceptible to silicosis than the European miner, given an equal intensity and an equal duration of exposure to dust. This was shown by Dr. Watkins-Pitchford in the Bureau Report for 1923-1924. The difference is to be explained by the fact that the service of the mine native is in general much shorter and less continuous than that of the European miner.

On the other hand, the higher susceptibility of the African native to tuberculosis is a matter of common knowledge, and that disease frequently assumes in the native the acute " infantile " type, particularly amongst new or recent recruits. Even so, when judged by European or American standards, the incidence of tuberculosis amongst mine natives, even when taken to include cases of active tuberculosis with silicosis, is not alarming. But the actual number of cases is considerable. It amounted in 1927-1928 to over 1,100 cases, each a potential source of dissemination of infection.

It will be noted in the returns presented in table X that the prevalence of simple tuberculosis fell steadily from 0.58 per cent. in 1916-1917 to 0.25 per cent. in 1924-1925. During that period, the general working conditions on the mines and the medical system of detection of cases remained substantially unaltered.

The Miners' Phthisis Act of 1925, however, provided that the medical service for mine natives should thereafter be a whole-time service, and introduced further provisions to improve the methods of detection employed. It will be noted that the number of cases of all three of the conditions specified in the table underwent thereafter a simultaneous increase. It is reasonable to assume that much of this increase has been due to the improved system of detection employed from 1924-1925 onwards. Sufficient time has not however elapsed to determine whether the increase which has been observed since that date will prove to be temporary only, or will be found to be permanent.

REVIEW OF THE DEVELOPMENT OF SILICOSIS LEGISLATION IN SOUTH AFRICA, WITH PARTICULAR REFERENCE TO COMPENSATION

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It had long been known that miners engaged in metalliferous mining in hard rock were prone to suffer, to a greater extent than did the general population, from chronic disease of the lungs or respiratory organs. This excessive incidence of lung disease is not a feature peculiar to the mines in the Transvaal and has been the subject of serious attention and of official investigation in almost every important mining area, especially since the introduction, many years ago, of rockdrills into mining practice.

In the Transvaal the excessively high mortality from miners' phthisis which had occurred, especially amongst rockdrill miners, during and just after the Anglo-Boer War arrested the attention of the Government and the mining community; and in 1902 a Commission was appointed to enquire into the extent to which the disease prevailed, to ascertain its causes and to recommend preventive and curative measures. Since then the subject of miners' phthisis has continuously occupied serious attention; the nature, prevalence, causation and prevention of the disease; the benefits to be granted to persons suffering from the disease and their dependants, and other matters incidental thereto, have been investigated and reported upon by numerous Parliamentary Select Committees and Commissions (judicial, medical and otherwise) and many important papers bearing upon the disease have been contributed to scientific societies, all of which have done much to elucidate the many problems connected with the subject.

The earlier investigations and enquiries showed that preventive measures had become an urgent necessity, and since then steps have been taken, from time to time, by the Government in South Africa and the mining industry to secure the better regulation of mining work, to introduce methods to prevent the generation and dissemination of dust in the mines, to improve the ventilation of the mines and to protect the health and safety of persons working in the mines; and an enormous advance has been made in this connection.

Four Commissions, in addition to the Commission of 1902 mentioned above, have been appointed to investigate the subject of Miners' Phthisis and other matters incidental thereto, namely:

(i) The Miners' Phthisis Medical Commission appointed under the Miners' Phthisis Allowances Act, No. 34 of 1911, to enquire into the prevalence of miners' phthisis and pulmonary tuberculosis on mines within the Union of South Africa. This Commission, which consisted of seven medical practitioners, reported on 2 February 1912.

(ii) Commission to enquire into the working of the Miners' Phthisis Acts. This Commission reported on 7 December 1918.

(iii) Commission, with a Judge as Chairman, to enquire into the working of the Miners' Phthisis Act, No. 40 of 1919. This Commission reported on 16 April 1921.

(iv) Commission to enquire into the working and administration of the Miners' Phthisis Acts, Consolidation Act, No. 35 of 1925, which is at present in force. This Commission is at present carrying out its investigations.

Ten Select Committees on Miners' Phthisis have been appointed by Parliament and these Committees reported on 23 May 1912; June 1914; 20 April 1916; 12 June 1917; 22 April 1918; 30 May 1919; 20 July 1920; 9 April 1924; 14 July 1925, and 25 March 1929.

Nine Acts, dealing with *Compensation for persons found to be suffering from miners' phthisis (silicosis) and their dependants and other matters incidental thereto*, have been passed by the Parliament of the Union of South Africa; namely:

(*a*) Miners' Phthisis Allowances Act, No. 34 of 1911.
(*b*) Miners' Phthisis Act, No. 19 of 1912.
(*c*) Miners' Phthisis Act, Amendment Act, No. 29 of 1914.
(*d*) Miners' Phthisis Act, No. 44 of 1916.
(*e*) Miners' Phthisis Act, Amendment Act, No. 44 of 1917.
(*f*) Miners' Phthisis Acts, Further Amendment Act, No. 24 of 1918.
Called the " prior Law "
(*g*) Miners' Phthisis Act, No. 40 of 1919 (called the " principal Act ").
(*h*) Miners' Phthisis Act, Amendment Act, No. 35 of 1924 (called the " previous Act ").
(*j*) Miners' Phthisis Acts, Consolidation Act, No. 35 of 1925 (the " present Act ").

(*Note.* — Only the Acts of 1912, 1914, 1916, 1917 and 1918 are included in the term " prior Law ".)

The Miners' Phthisis Allowances Act, No. 34 of 1911 (which is not included in the prior Law), came into force on 12 May 1911, and was superseded by the Miners' Phthisis Act, No. 19 of 1912, which came into force on 1 August 1912, and was amended by the Miners' Phthisis Act, Amendment Act, No. 29 of 1914, which came into force on 1 August 1914. The Miners' Phthisis Act, No. 44 of 1916, came into force on 1 August 1916, repeals the Miners' Phthisis Acts of 1912 and 1914 (with the exception of certain sections thereof), was amended by the Miners' Phthisis Act, Amendment Act, No. 44 of 1917, which came into force on 1 August 1917, and was further amended by the Miners' Phthisis Acts, Further Amendment Act, No. 24 of 1918, which came into force on 22 May 1918. The Miners' Phthisis Act, No. 40 of 1919 (the principal Act), came into force on 1 August 1919, repeals the Miners' Phthisis Act of 1911, the unrepealed sections of the Miners' Phthisis Acts of 1912 and 1914 and the Miners' Phthisis Acts of 1916, 1917, and 1918 and was amended by the Miners' Phthisis Act, Amendment Act, No. 35 of 1924 (the previous Act), which came into force on 1 August 1925. The Miners' Phthisis Acts, Consolidation Act, No. 35 of 1925, the present Act, came into operation on 1 August 1925, and repeals the Miners' Phthisis Act, No. 40 of 1919 (the principal Act), and the Miners' Phthisis Act, Amendment Act, No. 35 of 1924 (the previous Act). It consolidates and amends the laws relating to miners' phthisis and is at present in force.

The making of awards and payments of compensation to miners' phthisis sufferers and their dependants is placed under a Board styled the "Miners' Phthisis Board", consisting of a Chairman and not less than three or six other members who are appointed by the Government. This Board has power to collect, by means of levies on the mines enumerated in the scheduled list published under the Miners' Phthisis Act, the necessary funds for the payment of compensation and for carrying out the other functions of the Board.

Since 1 August 1916 all medical matters and the certification of claims for compensation were placed under a body of medical practitioners styled the "Miners' Phthisis Medical Bureau", consisting of a Chairman and a number of medical practitioners appointed by the Government.

On 1 August 1925 a special Medical Appeal Board, consisting of a Chairman and two medical practitioners having special knowledge of diseases of the lungs and respiratory organs, was appointed by the Government. The function of the Appeal Board is to deal with appeals by persons who are dissatisfied with the decisions of the Medical Bureau.

Summary of Compensation Provided under the Miners' Phthisis Acts

The following is a summary of the main provisions under which benefits were granted in terms of the above-mentioned Miners' Phthisis Acts and the various regulations published under those enactments. Unless an express statement to the contrary is made, the Board was not precluded from granting benefits to miners and dependants who were not resident in the Union of South Africa.

Miners' Phthisis Allowances Act, No. 34 of 1911

Allowances under this Act could be granted, in the absolute discretion of the Board, to persons (and their dependants) who were or had been employed in the scheduled mines (certain gold mines in the Transvaal) and were wholly or partially incapacitated by miners' phthisis (silicosis) from pursuing their avocations or were suspended on account of such disease by any rule or regulation in that connection.

To all intents and purposes, the benefits under the Act were *ex-gratia* grants pending the introduction of miners' phthisis legislation of a more comprehensive nature and any payments made thereunder were to be deducted from the benefit to be granted under any subsequent Miners' Phthisis Act. In cases where further benefits were so granted, the awards have been treated as original awards under such subsequent Act, the beneficiary being deemed to be a non-beneficiary for the purposes of granting further benefits thereunder.

The funds under the control of that Board were limited and in a number of cases benefits were refused, the applicant being advised to re-apply at a later date. No benefits were provided for the dependants of a deceased miner unless the miner had been granted benefits under the Act. The provisions of the Act and the Regulations thereunder precluded the Board from granting benefits to miners not resident in the Union of South Africa.

Applicant miners were medically examined by the Miners' Phthisis Medical Commission established under the Act to investigate and report upon the extent to which miners' phthisis was prevalent amongst persons employed upon the scheduled mines and awards were made on the certificates of that body.

The amount of the benefit in each case was limited to £250, but, except in a few cases in which single sums of £100 to £250 were granted or in which the applicant and his wife and children were repatriated and granted small monthly payments for a few months, the award made was usually £15 to £20 payable immediately, to enable the applicant to discharge his debts, and £8 15s. per mensem for a few months; in many cases the monthly payments were prolonged until the next Miners' Phthisis Act (No. 19 of 1912) came into operation on 1 August 1912.

Miners' Phthisis Act, No. 19 of 1912

Under this Act a miner in the earlier (primary) stage of miners' phthisis (silicosis) became entitled to £8 per mensem for a period *not exceeding twelve months* and in the later (secondary) stage *not exceeding* £400 (lump sums being in each case payable at the discretion of the Board for debts, repatriation, farming, business, etc.). A miner granted £96 and thereafter found to be in the later stage, became entitled to an amount not exceeding £304 (£400 less £96).

The miner had, however, first to satisfy the Board that he had been employed underground on the scheduled mines during the four years immediately preceding the date of this claim, and if he had been so employed for a period or periods amounting to less than two years during such four years he had also to satisfy the Board that he had contracted miners' phthisis on the scheduled mines.

Applicant miners were medically examined by two (or in special cases three) medical advisers to the Board, the Mines Medical Inspector and a number of medical practitioners being appointed by regulation as medical advisers. Applicant miners resident outside the Union of South Africa were examined and reported upon by medical practitioners registered as such in the country where the applicant resided, and the medical advisers granted certificates after considering such reports. Awards were made in accordance with the decisions of the medical advisers.

Dependants (wholly or partially dependent) of a deceased beneficiary miner became entitled to an amount of £400 (less the amount paid to the miner), payable in instalments, provided the Board was satisfied that the miner died of miners' phthisis, and dependants of a deceased non-beneficiary miner became entitled to £400 (payable in instalments) provided the Board was satisfied that the miner had died of miners' phthisis and was qualified to receive an award under the Act, viz. if the miner had died prior to the commencement of the Act (1 August 1912), the period of *four* years mentioned above, during which the Board had to be satisfied that the deceased had been a miner on scheduled mines, was the four years immediately preceding the commencement of the Act (1 August 1912), but if he died after the commencement of the Act the said period was the four years immediately preceding the date of the application by the dependants.

The Board could, in its discretion, contribute (in addition to any benefits which could be granted to dependants) an amount not exceeding £20 towards the reasonable expenses of medical attendance and burial of a miner who died from miners' phthisis, while a beneficiary under the Act or while his claim to any benefit thereunder was being investigated.

A miner was defined by the Act as a person of European descent who, before or after the commencement of the Act, performed or had performed as his regular occupation any class of work underground (i.e. below the surface) on a scheduled mine (excluding managers and managing directors).

A native (i.e. any member of the aboriginal races or tribes of Africa) who had been employed underground as a native labourer on the scheduled mines became entitled to an amount *not exceeding*

£20 (to be assessed by the Director of Native Labour) if found by the medical advisers to have had miners' phthisis in the earlier (primary stage), and to an amount not exceeding £50 (to be assessed as aforesaid) in the later (secondary) stage. In the event of the death of such a native who had not been granted benefits, his dependants became entitled to an amount of £10 if the Director was satisfied that he had died from miners' phthisis and had a wife, child, parent or other person dependent upon him.

Deductions amounting to 2½ per cent. could be made by the companies (which owned or worked the scheduled mines) from the earnings of the miners employed by them, and the companies were required to contribute to the funds of the Board 5 per cent. of such earnings during the two years ended 31 July 1914, and thereafter 7½ per cent. Persons who were employed underground on the scheduled mines and who were neither Europeans nor natives (i.e. coloured persons, Indians, Asiatics, etc.) could elect that, for so long as they were so employed, the aforesaid deductions should be made from their earnings by the mining companies. Such a person, so electing, became entitled during the two years ended 31 July 1914 to benefits, within the discretion of the Board, not exceeding half those which could be granted to a miner, and after 31 July 1914, to the benefits which could be granted to the miner, according to the circumstances applicable to each case. Failing such election, such a person became entitled to the benefits prescribed by the Act for a native.

The Act of 1912 was amended by the next Miners' Phthisis Act (No. 29 of 1914), which came into force on 1 August 1914.

Miners' Phthisis Act, Amendment Act, No. 29 of 1914

Under this Act the term " underground work " was extended to include work " *on* or about the rock crushers in a crusher station " and provision was made for a final decision by the Government Mining Engineer as to whether any person was a " miner ". The said official gave a general ruling that any person who spends, in any month, more than half his working time underground or on or about the rock crushers in a crusher station was to be deemed to be a miner under the Act during that month.

The benefit to be granted to miners in the earlier stage of miners' phthisis was increased by the Act to an amount not exceeding £200. A miner who had been granted benefits (£96) under the 1912 Act, or his dependants, could be granted, at the discretion of the Board, an amount not exceeding £100, provided the claimant was permanently resident in the Union of South Africa, was in need of assistance and made application before 1 August 1915.

Dependants of a deceased miner who had died from any cause became entitled to the balance of the award granted to the miner before or after the commencement of the Act, provided the dependants applied within nine months from the date of his death. Dependants of a beneficiary miner also became entitled to benefits as provided by the 1912 Act for such cases, if pre-existent miners' phthisis was the chief contributing factor in the causation of his death, but, save as regards the dependants mentioned above, the dependants of a deceased beneficiary or non-beneficiary miner were required to make application within two years of the date of death of the miner, failing which the benefit could not be granted.

Special provision was made for *ex-gratia* grants (not exceeding £10,000 in all) to dependants of deceased non-beneficiary miners who died of miners' phthisis prior to the commencement of the 1911 Act (12 May 1911), provided the dependants were permanently resident in the Union of South Africa, were in need of assistance and made application before 1 August 1915.

The Acts of 1912 and 1914 were repealed by the next Miners' Phthisis Act (No. 44 of 1916), which came into force on 1 August 1916.

Miners' Phthisis Act, No. 44 of 1916

Under this Act, the benefits provided were:

An amount not exceeding £300 (in instalments) to a non-beneficiary miner found, between 1 August 1916 and 1 August 1918, to have primary silicosis; the unpaid balance to be granted in instalments to his dependants, wholly or partially dependent, in the event of his death. An amount of £400 (payable £10 per month if married and £8 per month if unmarried) to a non-beneficiary miner found, between 1 August 1916 and 1 August 1918, to have secondary silicosis (the unpaid balance of £400 to be granted in instalments to his dependants, in the event of his death), but if the £400 had been paid *to the miner*, payments *to him* could be continued until £750 had been paid, provided he was a permanent resident in the Union of South Africa on and after 1 August 1916, and was in need of financial assistance. An amount not exceeding £375 (in instalments) to a miner found, after 1 August 1918 to have silicosis (in either the primary or secondary stage); the unpaid balance to be granted, in instalments, to his dependants, in the event of his death. An amount of £300 (in instalments) to a miner found to have tuberculosis without silicosis, provided he was thereby prevented, prior to 1 August 1917, from working underground on scheduled mines and had been so employed after 1 May 1916; the unpaid balance to be granted in instalments to his dependants, in the event of his death. An amount not exceeding £750 (payable £12 per month if married and £10 per month if unmarried) to a miner found to have tuberculosis with silicosis provided he was thereby prevented, prior to 1 August 1917, from working underground on scheduled mines and had been so employed after 1 May 1916; the unpaid balance to be granted in instalments to his dependants, in the event of his death, if they were permanent residents in the Union of South Africa on and after 1 August 1916.

The silicotic miner had, however, first to satisfy the Board that he had been employed as a miner on scheduled mines after 1 August 1908, and, if he had been so employed for a period or periods amounting to less than two years since that date, that he had contracted silicosis on scheduled mines.

Dependants of a deceased miner whose claim was under investigation when he died became entitled to the benefit (in instalments) which he was then entitled to. Dependants of a non-beneficiary miner (who had not lodged a claim with the Board, who had been proved by post-mortem examination to have died from silicosis or any other cause if silicosis was present as a contributing or predisposing factor and who had qualified to receive a benefit under the Act) became entitled to £300 (in instalments) if the miner died between 1 August 1916 and 1 August 1918, and £375 (in instalments) if the miner died after 1 August 1918.

A miner who had been granted benefits under the earlier Acts for primary silicosis (£96, £196 or £200) became entitled, at the discretion of the Board, to a further amount not exceeding £100, provided he was a permanent resident in the Union of South Africa on and after 1 August 1916, was in need of financial assistance owing to his suffering from silicosis and made application prior to 1 August 1917 (if such a miner was found to have secondary silicosis he became entitled to the benefit—not exceeding £400—provided for such cases under the earlier Acts less the amount paid to him for primary silicosis); in the event of his death the balance to be granted, in instalments, to his dependants. A miner who had been paid the *full* amount of £400 under the earlier Acts for secondary silicosis became entitled to a further £350 (payable £10 per month if married and £8 if unmarried), provided he was a permanent resident in the

Union of South Africa on and after 1 August 1916, and was in need of financial assistance; in the event of his death the balance to be granted in instalments to his dependants.

A miner who had been granted benefits for the primary stage and thereafter was found to be in the secondary stage became entitled to the secondary stage benefits, less the amount previously granted.

A miner who had silicosis but was not eligible for and had not received a benefit under this or the earlier Acts could be awarded an *ex-gratia* grant, and dependants of such a miner who had died from silicosis or from a disease of which silicosis was a contributing or predisposing factor could also be awarded an *ex-gratia* grant, provided that, in both cases, the claimant was in need of financial assistance, was a permanent resident in the Union of South Africa on and after 1 August 1916 and applied before 1 August 1917; the amount available for these grants being £20,000.

Applicant miners and native labourers were medically examined by the Miners' Phthisis Medical Bureau which had been established under the Act for this purpose, and benefits could only be granted, under this Act, in accordance with the certificates of that body.

The definitions of "miner" and of "underground work" in this Act were the same as the definitions under the Act of 1912 as amended by the Act of 1914.

Provisions were made in this Act empowering the Board:

(i) to acquire land to be devoted to small agricultural holdings and to establish on such holdings beneficiary miners and other suitable persons,

(ii) to assist financially, by means of loans or otherwise, in establishing or carrying on industrial undertakings which undertook to employ or were employing, at the Board's request, beneficiaries or dependants of beneficiaries,

(iii) to open and conduct a bureau, or co-operate with other labour bureaux and other institutions, for obtaining employment for beneficiaries or dependants of beneficiaries, and

(iv) to assist financially in defraying the expenses of transport of beneficiaries to places where employment for them had been obtained.

The provisions of Act No. 19 of 1912 regarding the following were re-enacted:

(i) contributions by the Board towards the funeral and medical expenses of deceased miners,

(ii) benefits for miners' phthisis (silicosis) to natives and their dependants, and

(iii) election by persons, other than miners or natives, to have deductions made by the mining companies from their earnings and the benefits to be granted to such persons.

A native labourer who had been employed underground on the scheduled mines and who was discharged from such employment after 1 August 1916 and prior to 1 August 1917, on the ground that he had tuberculosis, became entitled to the benefits provided in the Act for a native labourer for primary silicosis, if the tuberculosis was not complicated by silicosis, or to the benefits provided for secondary silicosis, if the tuberculosis was complicated by silicosis.

The Act of 1916 was amended by the next Miners' Phthisis Act (No. 44 of 1917), which came into force on 1 August 1917.

Miners' Phthisis Act, Amendment Act, No. 44 of 1917

Under this Act the amounts to be granted to miners and dependants were fixed at £300, £375, or £750 (as the case may be) instead of " an amount *not exceeding* such sum "; the amount for secondary silicosis was increased from £400 to £750 (i.e. miner —non-beneficiary under the Miners' Phthisis Acts of 1912 and 1914—need not necessarily be " resident " to qualify for the additional £350, and the unpaid balance of the £750 could be granted to his dependants, in the event of his death). The date " 1 August 1917 " in the Act of 1916 was extended to " 1 August 1918 ". Dependants of a deceased miner who had been granted £750 for tuberculosis with silicosis need not necessarily be " resident " to qualify for the unpaid balance of the amount awarded to the miner. Benefits for tuberculosis with or without silicosis to be granted only if such tuberculosis was found at the *periodical* examination of a miner (compulsory medical examinations, by the Miners' Phthisis Medical Bureau, of working miners, at intervals of six months). Further benefits (subject to " residence " and otherwise, as in the Act of 1916) to a miner who had been granted an award under the Acts of 1912-1914 for primary silicosis, namely, £300 (less previous benefits of £96, £196, £200 or £296, as the case may be) if found to have primary silicosis, tuberculosis without silicosis or to be unfit for underground work by reason of silicosis though not primary or secondary, and £750 (less previous benefits), if found to have secondary silicosis. Further benefits (subject to " residence " and otherwise, as in the Act of 1916), to a miner who had been granted an award under the Acts of 1912-1914 for secondary silicosis (not necessarily the full amount of £400), namely, £500 (less the previous benefit) if found to have primary silicosis or to be unfit for underground work by silicosis, though not in either the primary or secondary stage, and £750 (less the previous benefit), if found to have secondary silicosis or tuberculosis with or without silicosis. *Ex-gratia* grants, provided for miners and dependants by the Act of 1916, could also be awarded (on the same terms and conditions as to " residence " and otherwise, as in the Act of 1916) to dependants of beneficiaries who died prior to 1 August 1916.

Provisions were made in this Act empowering the Board:

(i) to assist, by means of loans, beneficiaries who are already established in business or in farming operations, and
(ii) to contribute amounts not exceeding half the cost of establishing and maintaining a sanatorium for purely silicotic patients.

The Acts of 1916-1917 were amended by the next Miners' Phthisis Act (No. 24 of 1918), which came into force on 22 May 1918.

Miners' Phthisis Acts, Further Amendment Act, No. 24 of 1918

Under this Act the date " 1 August 1918 " in the Act of 1916 (before and after amendment by the Act of 1917) was extended to " 1 August 1919 ". The *ex-gratia* grants, previously mentioned, could also be awarded (on the same terms and conditions as before); to *dependants of deceased beneficiaries who had not received further awards under the Acts of 1916 or 1917* (instead of *dependants of beneficiaries who had died before 1 August 1916*) and a further amount of £40,000 was available for the *ex-gratia* grants provided by the Acts of 1916 and 1917 and this Act.

The Acts of 1916, 1917 and 1918 were repealed by the next Miners' Phthisis Act (No. 40 of 1919) which came into force on 1 August 1919.

Miners' Phthisis Act, No. 40 of 1919 (the Principal Act)

Under this Act a miner (non-beneficiary under the prior Law) became entitled to a one-sum benefit, for the ante-primary or primary stage of silicosis or tuberculosis without silicosis (calculated on his *month's earnings*) as is provided in the present Act (No. 35 of 1925) (*vide* paragraph (*j*) hereof) and such a miner became entitled to an award of a monthly allowance (pension) for secondary silicosis or tuberculosis with silicosis (calculated on his *month's earnings*) as is provided in the present Act (No. 35 of 1925) (*vide* paragraph (*j*) hereof) *except* that the tuberculosis whether with or without silicosis was to be found at a *periodical examination* (compulsory medical examinations, by the Miners' Phthisis Medical Bureau, of working miners), that the silicotic miner had first to satisfy the Board that he had been employed underground on scheduled mines for at least two years since 1 August 1908, or that he had contracted silicosis on such a mine and that additional allowances could not be granted to a miner for more than three of his children, for his invalid children who were over sixteen years of age when the miner became entitled to the allowance or for his stepchildren (unless they had been " adopted " before the grant of any benefit to him).

The conditions, attached to awards of monthly allowances (pensions) to miners and dependants under the Act of 1919, were similar to the conditions attached to such awards under the present Act (*vide* paragraph (*j*) hereof).

A miner who had been granted a one-sum benefit for ante-primary silicosis could become entitled to a further one-sum benefit for primary silicosis or tuberculosis without silicosis and a miner who had been granted a one-sum benefit could become entitled to a further award of a monthly allowance for secondary silicosis, but in both cases only if he had applied for benefits within the prescribed period of three months from the date on which he had been first notified after 1 August 1919, that he had silicosis (in unsuccessful appeals the period was one month from the date he was notified of the result of the appeal).

Dependants of a deceased beneficiary miner (non-beneficiary under the prior Law) became entitled to the balance of the award made to the miner, but if the miner was in receipt of a monthly allowance or had died from secondary silicosis or any other cause if secondary silicosis was present as a contributing or predisposing factor, the dependants became entitled to an award of a monthly allowance. Dependants of a deceased non-beneficiary miner became entitled to such benefit (for ante-primary or primary silicosis) as the miner would have been entitled to, had he not died, but, if secondary silicosis was the cause of his death or was present as a contributing or predisposing factor in the causation of his death, the dependants became entitled to an award of a monthly allowance. Dependants of a deceased beneficiary miner to or in respect to whom benefits had been granted under the prior Law became entitled to awards of monthly allowances, if the miner died prior to 1 August 1919, but, if the miner died after that date, only if silicosis was present as a contributing or predisposing factor in the causation of his death; these dependants had to apply before 1 August 1920, and had to be resident in Africa (south of the Equator) on and after 31 July 1916, or the date of the miner's death (whichever was the *later*). Dependants of a non-beneficiary miner who had died between 31 July 1916 and 1 August 1919, and had qualified to receive benefits under the prior Law, became entitled to an award of a monthly allowance on the terms and conditions precedent to the grant of such an award to the dependants of a prior Law beneficiary miner who had died after 1 August 1919.

Dependants (other than the widow and a child under sixteen) could not be granted an award of a monthly allowance *unless* they were *wholly* dependent upon the deceased miner; the widow of a miner could not be granted an award of a monthly allowance if she had re-married; and an allowance could not be granted for more than three children of a deceased miner.

A miner who had been granted benefits under the prior Law on the grounds of silicosis and had secondary silicosis or tuberculosis with silicosis became entitled to an award of a monthly allowance, provided he was resident in the Union of South Africa on and after 31 July 1916. A miner who had been refused the additional award under the Acts of 1916, 1917 and 1918, owing to his not having been resident in the Union of South Africa, as required by that enactment, became entitled to that additional award if he returned to South Africa before 1 June 1919 and was in necessitous circumstances.

Awards to miners, native labourers and dependants could only be granted on certificates of the Miners' Phthisis Medical Bureau which had been established under the Act of 1916.

The Board could, in its discretion, contribute in addition to any benefit which could be granted to dependants an amount not exceeding £25 towards the reasonable expenses of burial and of medical attendance during the last illness of a deceased miner who had been a beneficiary under this Act or the prior Law or who, in the opinion of the Bureau, died from silicosis or from any other cause if silicosis was present as a contributing or predisposing factor.

A miner was defined as any person (other than a native labourer and therefore included a non-European, such as a coloured person, Indian, Asiatic, etc.) who was employed underground on the scheduled mines in any of the forty-five occupations specified in the Act, or any other occupation which necessitated the incumbent spending 100 or more working hours per month underground.

" Underground work " comprised work beneath the surface of a mine, upon or about rock crushers in a crusher station and in a sample crushing room or assay office. Underground work on a gazetted mine was deemed, for the purposes of granting benefits, to be underground work on a scheduled mine.

The provisions of Act No. 44 of 1916 and Act No. 44 of 1917 regarding the following were re-enacted:

(i) land settlement,
(ii) loans to industrial undertakings,
(iii) employment bureaux,
(iv) transport expenses of beneficiaries,
(v) loans to beneficiaries, and
(vi) contributions for silicotic sanatorium.

Provisions were made in this Act empowering the Board,

(i) to provide for the training in trades and industries of beneficiaries, and
(ii) to establish co-operative workshops for beneficiaries.

The provisions of the Act of 1912 regarding deductions from the earnings of miners for the purposes of the Board's funds, which provisions had remained in force under the Acts of 1916, 1917 and 1918 were *not* re-enacted in this Act of 1919 (or any subsequent Act).

An inspector of mines (employed underground in connection with the scheduled mines) who retired from the public service before attaining the age of retirement prescribed under the pension statute applicable to him, and whose retirement was due to the fact that he had contracted silicosis, became entitled either:

(i) to one year's salary which he had been in receipt of at the date of his retirement, in addition to the pension payable to him under such pension statute, or
(ii) to have five years added to his period of pensionable employment for the purpose of calculating his pension on such retirement.

In the event of such an inspector having died, from silicosis or from any other cause if silicosis was present as a contributing or predisposing factor, before attaining the age of retirement, as mentioned above, or within five years after retirement in the aforesaid circumstances, his dependants became entitled to an amount representing one year's salary which he was in receipt of at the date of his death, in addition to any other benefits allowed to them by the pension statute in the event of his death while in the public service.

A native labourer who had been employed underground on scheduled mines after 31 July 1912, and who had not been granted benefits under this Act or the prior Law became entitled to benefits—

(i) for silicosis in the ante-primary stage: twelve times his *month's earnings* (as defined in the present Act (vide paragraph (*j*) hereof),

(ii) for silicosis in the primary stage or tuberculosis without silicosis: eighteen times his *month's earnings*, and

(iii) for secondary silicosis or tuberculosis with silicosis: twenty-four times his *month's earnings.*

In cases of tuberculosis with or without silicosis, he must however have been so found at a " final " examination (compulsory medical examination, by the Miners' Phthisis Medical Bureau, of a native labourer when leaving his employment permanently or otherwise, after having been employed underground on a scheduled mine for a period exceeding one month).

In the event of the death of a native labourer who had not been granted benefits under this Act or the prior Law and who had died from silicosis or from any other cause if silicosis was present as a contributory or predisposing factor, his dependants became entitled to such benefits as the native labourer would have been entitled to had he not died.

The Act of 1919 was amended by the next Miners' Phthisis Act (No. 35 of 1924) which came into force on 1 August 1924.

Miners' Phthisis Act, Amendment Act, No. 35 of 1924
(the Previous Act)

Under this Act the miner or his dependants became entitled to the additional benefits as if the miner had applied within the prescribed period, provided he had ceased underground work on scheduled mines within three months after the first notification that he had silicosis.

A prior Law beneficiary miner or his dependants became entitled to benefits, as if such prior Law benefit had not been made, provided the miner had *lawfully* worked underground on scheduled mines after the grant of such prior Law benefits.

Awards made from the Consolidated Revenue Fund (*Special Grants*) to dependants of a prior Law beneficiary miner who had died too late to enable them to apply before 1 August 1920 were deemed to be awards lawfully made under the Act.

The date before which the dependants of a prior Law beneficiary miner (who died after 1 August 1919) had to apply for an award of a monthly allowance was extended to twelve months from the date of the miner's death, and, if the miner was in receipt of or entitled to an award of a monthly allowance, silicosis need not, necessarily, have been a contributing or predisposing factor in the causation of his death.

Widows in receipt of monthly allowances became entitled to a one-sum payment (twenty-four times such allowance) on remarriage.

A South African widow who had left South Africa with her husband (a prior Law beneficiary miner), and was therefore not entitled to an award of a monthly allowance, became entitled to such an award, as if she had been resident in South Africa at the date of his death, provided she had returned to South Africa within two years of the said date.

Additional allowances could be granted to and in respect to children (under sixteen years of age) in excess of three in number.

The Acts of 1919 and 1924 were repealed by the present Act (No. 35 of 1925) which came into force on 1 August 1925.

Miners' Phthisis Acts, Consolidation Act, No. 35 of 1925 (the Present Act)

Under this Act benefits are granted by the Board to miners and dependants of deceased miners: (1) who had contracted silicosis during or in consequence of underground employment on scheduled mines or a mine at any time on the list of scheduled mines or on gazetted mines, or (2) who were found to have tuberculosis without silicosis within twelve months of their having ceased such underground work and had been employed on such underground work for a period or periods amounting to at least two years.

Dependants are such members of a deceased person's family as were dependent upon him for maintenance and had not contracted a marriage since the date of his death, namely, his widow and children under sixteen years of age (including illegitimate children born before the date of the Bureau's certificate that he had secondary silicosis or tuberculosis with silicosis), failing whom, his other relatives by consanguinity or affinity in a certain order of preference.

Awards to miners, native labourers and dependants can be granted only on certificates from the Miners' Phthisis Medical

Bureau (established under the Act for medical purposes) that such miners or native labourers have silicosis or tuberculosis or both those diseases and awards to dependants of a deceased miner or native labourer can be granted only on certificates from the said Bureau either that the deceased had silicosis or tuberculosis or both or that he had died from silicosis or from any other cause with which silicosis was present as a contributing or predisposing factor.

A miner or the dependants (of a deceased miner), dissatisfied with the decision of the said Bureau, may appeal in the prescribed manner from that decision to the Medical Board of Appeal, and certain special cases of miners who went on active service and who had been refused benefits under the Miners' Phthisis Acts and also under the War Special Pensions Act, No. 42 of 1919, can be dealt with by the Joint Medical Board. Under such circumstances the certificate of the Medical Board of Appeal or the Joint Medical Board (as the case may be) is deemed to be the certificate of the Bureau for the purposes of the Act.

Awards are calculated on the *month's earnings* of the miner or native labourer being one-sixth part of the amount earned by him for the 156 days he worked, as such, last prior to the date he was first certified by the said Bureau to have developed silicosis or tuberculosis to a degree entitling him to benefits under the Act. A return of earnings for the number of days mentioned is usually obtained from the mining company or companies concerned but, if the amount of the earnings cannot be so ascertained, the *month's earnings* of the miner or native labourer is to be determined by the Board or the Director of Native Labour (as the case may be). The *month's earnings* of a miner to or in respect to whom benefits have been granted under the prior Law is deemed to be £30. In cases where original awards are made after 1 August 1925, fractions of £1 in the month's earnings of a miner are reckoned as £1 if the fraction is 10s. or more and are disregarded if less than 10s.

A miner who has been granted benefits under the prior Law and who has *lawfully* worked underground on scheduled mines after the grant of such benefits is deemed to be a miner who has *not* been granted benefits under the prior Law.

One-Sum Awards

A non-beneficiary miner who has silicosis in the ante-primary or primary stage or tuberculosis without silicosis is entitled to an award payable in one sum. The award to a miner who has silicosis in the ante-primary stage is calculated as follows:

Twelve times that part of his month's earnings which does not exceed £29 3s. 4d.
Six times that part which exceeds £29 3s. 4d., but does not exceed £37 10s.
Three times that part which exceeds £37 10s.

The amount of the award for silicosis in the primary stage is that payable for the ante-primary stage with an addition of 50 per cent. and the amount of the award for tuberculosis without silicosis is the same as that for the primary stage of silicosis. A miner who has been granted a one-sum award for ante-primary silicosis becomes entitled to a further one-sum award, 50 per cent. of such previous award, for primary silicosis or tuberculosis without silicosis, provided he had applied for benefits or ceased underground work on scheduled mines within three months of the date he was first notified after 1 August 1919 that he had silicosis.

One-sum awards could not be granted under the Acts in force prior to the commencement of the principal Act (1 August 1919), and the averages of the one-sum awards made, since that date, are:

£401 for ante-primary silicosis, without tuberculosis,
£581 for primary silicosis without tuberculosis, and
£534 for tuberculosis without silicosis; the maxima being £803, £1,216 and £805 respectively.

Awards Payable in Monthly Instalments

A miner who had been refused the additional benefits under the Acts of 1916, 1917 and 1918, owing to his not having been resident in South Africa as required by that enactment, becomes entitled to that additional award if he returned to South Africa before 1 July 1924.

A miner who has been granted benefits under the prior Law and who has silicosis in the ante-primary or primary stage or tuberculosis without silicosis is entitled to an award, *in such instalments as the Board may decide*, calculated, as mentioned above, on *his month's earnings* (viz. £30), but the amount of the prior Law benefit must be deducted from the amount so arrived at. (An amount of £355 represents the award, for ante-primary silicosis, calculated on *month's earnings* of £30, and an amount of £532 10s. represents such an award for primary silicosis or tuberculosis without silicosis.) A miner who has been granted benefits under the prior Law and who has silicosis in the secondary stage or tuberculosis with silicosis is entitled to an award, *in such instalments as the Board may decide*, of £750 less the amount of such prior Law benefits, unless such miner is entitled to an award of a monthly allowance, as mentioned below.

The dependants of a deceased miner are entitled to the award, *in such instalments as the Board may decide* for the ante-primary, primary or secondary stage of silicosis, or tuberculosis with or without silicosis if the miner was, at the time of his death, entitled to such an award, unless the dependants are entitled to an award of a monthly allowance, as mentioned below.

Awards of Monthly Allowances (Pensions)

A non-beneficiary miner who has silicosis in the secondary stage or tuberculosis with silicosis is entitled to an award of a monthly allowance.

A miner who has been granted a one-sum award becomes entitled to a further award of a monthly allowance for secondary silicosis or tuberculosis with silicosis, provided he had applied for benefits or ceased underground work on scheduled mines within three months of the date he was first notified after 1 August 1929 that he had silicosis.

A miner who has been granted benefits under the prior Law and who has silicosis in the secondary stage or tuberculosis with silicosis is entitled to an award of a monthly allowance, provided he was resident in South Africa on and after 31 July 1916 or the date on which he was first granted any benefits (whichever is the *later*).

The dependants of a miner who died after 1 August 1919, and to or in respect to whom benefits had not been granted under the prior Law, are entitled to an award of a monthly allowance: (1) if the deceased miner was in receipt of or entitled to such an award, or (2) if the Bureau certifies before or after his death that he had silicosis in the secondary stage or tuberculosis with silicosis or certifies that he died from silicosis or from any other cause with which silicosis was present as a contributing or predisposing factor.

Under the principal Act, an award of a monthly allowance could not be granted to the dependants of a deceased non-beneficiary miner who had died from silicosis or from a cause with which silicosis was present as a contributing or predisposing factor *unless* the deceased miner had silicosis in the secondary stage at the time of his death. In the other cases in which silicosis (though not in the secondary stage) was a factor in causation of death of the miner, the dependants became entitled to the award, payable *in such instalments as the Board may decide*, which the miner, had he not died, would have been entitled to for silicosis in the ante-primary or primary stage (as the case may be). The present Act provides that in such a case the award, if granted to the widow and children (under sixteen years of age) of a deceased miner, can be converted into an award of a monthly allowance on certain conditions.

The dependants of a deceased miner to or in respect to whom benefits had been granted under the prior Law are entitled to an award of a monthly allowance: (1) if the deceased miner was in receipt of or entitled to such an award, or (2) if the dependants were resident in South Africa on and after 1 July 1916 or the date of the miner's death (whichever is the *later*), and the Bureau certifies that the miner died from silicosis or from any other cause with which silicosis was present as a contributing or predisposing factor.

The dependants of certain deceased non-beneficiary miners were refused *ex-gratia* grants under section 11 (*b*) of the Miners' Phthisis Act, No. 44 of 1916, on the grounds that they were not in necessitous circumstances, as required by that section. Provision is made in the present Act for awards of monthly allowances to be granted to the dependants in such cases, as if such prior Law awards had been made.

A South African widow and the children (under sixteen years of age) of a deceased miner who had left the Union of South Africa with the miner and are, on that account, not entitled to an award of a monthly allowance become entitled to such an award, as if they were resident in the Union of South Africa at the time of his death provided they have returned to the Union of South Africa within two years of such date and have not since the date of such return left the Union of South Africa for any purpose whatever.

Calculation of Monthly Allowances

A monthly allowance granted to a miner is calculated as follows:

For the miner. — One-half of that part of his month's earnings which does not exceed £20; one-quarter of that part which exceeds £20, but does not exceed £28 6s. 8d., and *one-twentieth* of that part which exceeds £28 6s. 8d.

For his wife. — If dependent upon him and if he was married to her before 1 August 1919 or the date of the Bureau's certificate entitling him to an award of a monthly allowance (whichever date is the *later*): *one-fifth* of the total amount payable for the miner.

For each of his dependent children (legitimate and certain adopted and stepchildren) not exceeding three in number, until such child attains the age of sixteen years: *one-tenth* of the total amount payable for the miner.

For each such child in excess of three. — One-twentieth of such amount.

(i) The amount payable for a wife or child ceases upon the death of such wife or child or on the marriage of such child.

(ii) An allowance is not payable to a miner for a wife or child of a marriage contracted by the miner after 1 August 1919 or the date of the Bureau's certificate entitling him to an award of a monthly allowance (whichever date is the *later*).

(iii) An allowance is not payable to a miner for more than three children for any period prior to 1 August 1924.

(iv) An allowance is not payable to a miner for his illegitimate children.

(v) Subject to paragraph (ii) above, an allowance is payable to a miner for a child born after the date of the Bureau's certificate entitling him to an award of a monthly allowance.

(vi) An allowance is payable to a miner for an adopted child if adopted before the date of the *first* certificate of the Bureau entitling him to an award under the Act and if the child has been solely or mainly dependent upon him since the date of adoption.

(vii) An allowance is payable to a miner for his dependent stepchildren if they are the legitimate children of his wife to whom he was married before 1 August 1919, or the date of the Bureau's certificate entitling him to an award of a monthly allowance (whichever date is the *later*).

(viii) An allowance is payable to a miner for his child over the age of sixteen years, if such child is, in the opinion of the Bureau, unable to earn a living by reason of ill health or physical or mental incapacity, and such an allowance can be continued for so long as, in the opinion of the Board, it might reasonably have been expected that the miner would have continued to contribute to the support of the child. (Such a child is deemed, for the purposes of the Act, to be a child under sixteen years of age.)

(ix) An allowance granted to a miner is payable from 1 August 1919 or from the date of the Bureau's certificate entitling him to such an award or from the date the miner finally ceased underground work on scheduled mines (whichever date is the *latest*), but if the miner was, for any reason, not entitled to such an award under the principal Act or the previous Act the allowance is not payable from a date prior to 1 August 1925.

A monthly allowance granted to the dependants of a deceased miner is calculated as above, except that:

(1) *Widows and children (under sixteen years of age)* are entitled to double the allowance prescribed for the miner for his wife and children (under sixteen years of age).

(2) *Dependants wholly dependent*, if the miner left no widow or child under sixteen years of age, are entitled to the allowance which would have been payable to the widow.

(3) *Dependants partly dependent* if the miner left no dependants as mentioned in (1) and (2) above, are entitled to an allowance equal to the average monthly support accorded by the miner but not exceeding the allowance which would have been payable to the widow.

(4) Children of a deceased miner include also:

(*a*) His unmarried illegitimate children if born before 1 August 1919, or the date of the Bureau's certificate that he had silicosis in the secondary stage or tuberculosis with silicosis (whichever date is the *later*).

(*b*) His unmarried legitimate children of a marriage contracted after the date of the Bureau's certificate entitling him to an award of a monthly allowance.

(5) The allowance prescribed for the children mentioned in (4) above (or any other dependant under sixteen years of age) is the same as that prescribed for the legitimate children of the deceased miner.

(6) An allowance granted to the dependants of a deceased miner is payable from the date of death of the miner, but if the miner died before 1 August 1925, and the dependants were not entitled, for any reason, to such an award under the principal Act or the previous Act, the allowance is payable from 1 August 1925.

A monthly allowance granted to a miner or dependant ceases in the event of the death of such miner or dependant and the allowance is reduced, accordingly, in the event of the death of any of the dependants included in the award. An allowance granted to a widow or dependant (other than a child under sixteen years of age) ceases in the event of marriage, subject to the payment of twenty-four times the allowance payable for one month. An allowance granted to a dependant (other than a widow or child under sixteen years of age) is to be continued for so long as, in the opinion of the Board, the deceased miner could reasonably have been expected to continue to contribute to the support of the dependant.

The allowance granted to a beneficiary will cease and determine when an amount of £750 has been paid, should the beneficiary have been resident outside the Union of South Africa when the award was made or should the beneficiary leave the Union of South Africa permanently or without the written permission of the Board granted for temporary purposes. In the case of a miner the amount of £750 is calculated from the date of the award of a monthly allowance; in the case of a dependant from the date of the award to the dependant, if the dependant was resident in the Union of South Africa at the date of the miner's death but, if the dependant was not so resident, from the date of the award of a monthly allowance to the miner or the dependant (whichever is the *earlier*).

A beneficiary, in receipt of a monthly allowance, who desires to leave South Africa for *other than* temporary purposes (i.e. permanently) can be granted a passage by the Board to his or her destination together with an amount for incidental expenses on the journey.

Awards of monthly allowances could not be made under the Acts in force prior to the commencement of the principal Act (1 August 1919) and the average amounts of the monthly allowance awards made since that date are:

Miner: £17 19s. 7d. per mensem (for himself, his wife and two or three children).

Widow of deceased miner: £4 18s. 4d. per mensem.

Children (not exceeding three and under sixteen years of age) of a deceased miner: £2 9s. 3d. per mensem each.

Children (in excess of three and under sixteen years of age): £1 4s. 10d. per mensem each.

Other dependants: £4 1s. 10d. per mensem.

The amount of the *maximum* monthly allowance granted to a miner (for *himself*) is £19 7s. 8d.; the miner, being single, could not be granted additional allowances for dependants; the award was calculated on his *month's earnings* of £74 and he had previously been granted a one-sum award of £1,216 for primary silicosis, being the amount of the maximum one-sum award under the Act. The amount of the *maximum* monthly allowances granted to a miner (for himself and his dependants) is £28 1s. 3d., the miner having been granted a monthly allowance for himself, his wife and eight children. The amount of the *maximum* monthly allowance granted to a widow (for herself) is £7 14s. 2d. and in the same case a monthly allowance of £3 17s. 1d. was granted to a child, the widow receiving £11 11s. 3d. per mensem for herself and the child. The amount of the *maximum* monthly allowance granted to the dependants of a deceased miner is £20 17s. 2d., allowances having been granted to the widow and nine children. The largest number of children in respect to whom additional allowances were granted to a miner is eleven, the miner having been granted a monthly allowance of £23 11s. 6d. for himself, his wife and those eleven children. The largest number of children of a deceased miner to whom a monthly allowance was granted is nine (three cases), in one case the widow and those nine children were granted a monthly allowance of £20 17s. 2d., as mentioned above, and in the other two cases £20 13s. 6d. and £19 17s. 2d.

Payments to the miners will, in many cases, continue for several years and, on their demise, awards of monthly allowances will be made to their dependants (mainly widows and children). Payments in respect to children will, in almost all cases, continue until each child attains the age of sixteen years and it can be reasonably anticipated that payments to the widows will continue, *on an average*, for about twenty years and to the other dependants for about ten years.

In numerous cases the beneficiaries (miners and dependants of deceased miners) have been in receipt of monthly allowances since the commencement of the principal Act (1 August 1919).

The Board may contribute (in addition to any benefit which can be granted to dependants) an amount not exceeding £25 towards the reasonable expenses of the burial of and medical attendance during and incidental to the last illness of a deceased miner who was a beneficiary under this Act, the previous Act, the principal Act or the prior Law or who, in the opinion of the Miners' Phthisis Medical Bureau, died from silicosis or any other cause if silicosis was present as a contributing or predisposing factor.

A miner is defined as in the principal Act, and six occupations are added to the forty-five occupations specified in that Act. These fifty-one occupations and any other occupation necessitating the incumbent spending 100 or more hours per month underground renders him a " miner " during the month in which he is so employed and provision is made that eleven occupations on the *surface* of a mine (to which other such occupations can be added by Government Notice) renders the incumbent a " miner " during each day he is employed *underground* (if less than 100 hours per month). Two such occupations have been added to the list by Government Notice.

" Underground work ", as defined in the principal Act, is extended to include also work in a change-house or on any tailings dump.

Provisions are made empowering the Board:

(i) to provide for the training in trades and industries of beneficiary miners, their wives and children and beneficiary widows and children,

(ii) to conduct a bureau or to co-operate with other bureaux for the purposes of obtaining employment for such persons as are mentioned in (i) above,

(iii) to assist financially, by means of loans or otherwise, in establishing or carrying on any undertaking in which beneficiary dependants or dependants of beneficiary miners are employed or will, at the Board's request, be employed,

(iv) to assist financially in defraying the reasonable expenses incidental to the transport of beneficiary miners, their wives and children (under sixteen years of age) to places within the Union of South Africa where employment for such miners has been obtained,

(v) to contribute an amount not exceeding half the cost of establishing and maintaining one or more sanatoria for purely silicotic patients,

(vi) to establish or assist in establishing co-operative workshops for such persons as are mentioned in (i) above, and

(vii) to condone the delay (due to certain circumstances arising out of the 1914-1918 war) in cases where the making of an application or the return to South Africa within a prescribed period is a condition precedent to the grant of benefits under the Miners' Phthisis Acts.

The provisions of the principal Act and the prior Law regarding land settlement and loans to beneficiaries established in business or farming operations are *not* re-enacted in the present Act.

If an inspector (including an assistant inspector, deputy inspector, or sub-inspector) of mines or an inspector of mining leases employed in connection with the scheduled or gazetted mines contracts silicosis or tuberculosis or both, he and his dependants are entitled to benefits under the Act, as if he were a miner, in addition to the pension or other benefit payable under any pensions statute applicable to him.

The provisions of the principal Act regarding benefits, for silicosis of tuberculosis or both, to native labourers and their dependants are re-enacted in the present Act.

Summary of Provisions to Meet Claims for Compensation

The provision of compensation for claims by sufferers and their dependants, and the expenses of carrying out the various functions of the Board, are provided out of a fund termed the Miners' Phthisis Compensation Fund, which is under the control of the Board.

For the purposes of this fund the Board has power to make quarterly levies upon employers who own or work the scheduled mines (i.e. those mines wherein the mineral dust is, in the opinion of the Minister of Mines, of such a nature as to cause silicosis) to provide the amount which the Board considers necessary for the purposes of the Compensation Fund for the quarter.

(1) Under the prior Law:

Compensation Fund. — Quarterly levies by Board of amount actually required for payment of benefits. The amount levied to be assessed in proportion to the average number of miners employed per month by each employer during the period of three years immediately preceding the quarterly levy. The Government Mining Engineer to furnish the statement of average number of miners.

Insurance Fund. — Every employer to make a contribution on or before the tenth day of each month in respect of every person employed underground as a miner, or on or about rock crushers in a crusher station of a mine during the previous month. Such contribution, from 1 August 1912 to 31 July 1914, to be 5 per cent. of the earnings of each person so employed, the employer being empowered during this period, to recover from such employees onebalf (50 per cent.) of the amount contributed to the Fund. From 1 August 1914 to 31 July 1919, the contribution by employers was 7½ per cent. of such earnings, and in turn they were entitled to recover one-third (33⅓ per cent.) of the contributions to the Fund, from the earnings of the particular employees.

(2) Under the Principal Act of 1919 the quarterly levy on each employer was assessed as follows:

(*a*) 45 per cent. on the earnings of underground miners.

(*b*) 35 per cent. based on the silicosis rate of the mine.

(*c*) 20 per cent. based on the amount which the employer is assessed for normal income tax during the last accounting period under the Income Tax Act.

(3) Under the present Act of 1925 the amount levied quarterly from each employer is assessed as follows:

(*a*) 30 per cent. based on the earnings of underground miners.

(*b*) 50 per cent. based on the silicosis rate of the mine.

(*c*) 20 per cent. based on the amount which the employer is assessed for normal income tax during the penultimate accounting period under the Income Tax Act.

From the commencement of the principal Act (i.e. 1 August 1919) to 31 July 1925, an amount of £200,000 per quarter was levied by the Board from the scheduled mines, except during the nine months ended 30 April 1922 when £150,000 was levied per quarter.

Under the present Act the levies have been maintained at £200,000 per quarter, except during the first two months after the Act came into force, when the sum of £200,000 was levied for these two months.

Under the Act of 1924 a special fund termed the " Outstanding Liabilities Fund " was incorporated under the Compensation Fund, and in terms of that Act the Government Actuary was required to determine annually the total outstanding liabilities of the Compensation Fund and to apportion such liabilities between the various employers. The outstanding liability of each employer to the Compensation Fund becomes immediately payable to the Board when the mine of the employer is closed down or ceases operations. This provision was also incorporated in the present Act, and by arrangements between the Board and the various employers steps have been taken by the latter, where they are in a financial position to do so, to set aside amounts annually against their outstanding liabilities, based on the probable life of each mine. The annual determination of the outstanding liabilities of the Compensation Fund, as determined by the Government Actuary at 31 July 1929, amounted to a present value of £8,296,365, against which the amount standing to the credit of the Compensation Fund and the Outstanding Liabilities Fund at that date amounted to £1,896,365, leaving a net outstanding liability of £6,400,000.

STATISTICS

The following are brief particulars of the expenditure and awards under the Miners' Phthisis Acts:

(1) Miners' phthisis compensation: annual expenditure in connection with miners (excluding natives) and dependants:

From 1.5.1911 to 31.7.1912	. . . . . .	£50,601
„ 1.8.1912 to 31.7.1913	. . . . . .	£355,644
„ 1.8.1913 to 31.7.1914	. . . . . .	£487,677
„ 1.8.1914 to 31.7.1915	. . . . . .	£545,178
„ 1.8.1915 to 31.7.1916	. . . . . .	£391,860
„ 1.8.1916 to 31.7.1917	. . . . . .	£378,389
„ 1.8.1917 to 31.7.1918	. . . . . .	£603,292
„ 1.8.1918 to 31.7.1919	. . . . . .	£411,427
„ 1.8.1919 to 31.3.1920	. . . . . .	£885,901
„ 1.4.1920 to 31.3.1921	. . . . . .	£798,040
„ 1.4.1921 to 31.3.1922	. . . . . .	£544,584
„ 1.4.1922 to 31.3.1923	. . . . . .	£535,186
„ 1.4.1923 to 31.3.1924	. . . . . .	£498,494
„ 1.4.1924 to 31.3.1925	. . . . . .	£711,437
„ 1.4.1925 to 31.3.1926	. . . . . .	£951,152
„ 1.4.1926 to 31.3.1927	. . . . . .	£965,864
„ 1.4.1927 to 31.3.1928	. . . . . .	£852,503
„ 1.4.1928 to 31.3.1929	. . . . . .	£829,500
Total to 31.3.1929 is	. . . . .	£10,796,729
Total to 30.9.1929 is	. . . . .	£11,208,015

(2) The nine Acts can be divided into four groups because the basis of compensation and benefits under each group differ, and therefore the Acts under each group should be read together.

AVERAGE ANNUAL EXPENDITURE UNDER THE FOUR GROUPS

Group (A) Acts of 1911, 1912 and 1914.	1.5.1911 to 31.7.1916	£372,354 per annum.
Group (B) Acts of 1916, 1917 and 1918	1.8.1916 to 31.7.1919	£469,811 per annum.
Group (C) Acts of 1919 and 1924.	1.8.1919 to 31.7.1925	£693,526 per annum.
Group (D) The Consolidation Act of 1925.	1.8.1925 to 31.7.1929	£911,747 per annum.

(3) Miners' phthisis compensation expenditure in connection with native labourers and their dependants. — The total amount paid under the various Acts up to 31 July 1929 is £702,036.

Monthly expenditure. — The average monthly expenditure on compensation in respect of miners' phthisis sufferers (excluding natives) and their dependants during the last five years amounted to approximately £72,000.

The cost of administration in connection with the Miners' Phthisis Board, the Miners' Phthisis Medical Bureau and the Miners' Phthisis Medical Board of Appeal, which is borne by the Government, during the past year amounted to approximately £53,000.

The number of miners (excluding natives) and the number of widows of miners who have been awarded compensation under the various Miners' Phthisis Acts up to 31 October 1929, amount to:

(*a*) Miners.	13,866
(*b*) Widows	5,093

THE ACTUARIAL VALUATION OF THE OUTSTANDING LIABILITIES UNDER THE SOUTH AFRICAN MINERS' PHTHISIS ACT

BY D. SPENCE FRASER, F.F.A., A.I.A.,

ACTUARY TO THE MINERS' PHTHISIS BOARD

The outstanding liabilities, and their gradual redemption by the mines, form an important part of the general system that has been adopted in the Union for financing the benefits granted in respect of miners' phthisis. This financial system is not necessarily the most suitable for adoption in other countries, and it is well to preface this paper with a brief review of the financial systems that may be adopted.

The *assessment method* will first be described. Each year's income would be just sufficient to meet the payments falling due during the year and no fund would be accumulated. This is the method adopted, for example, by the Dominions for financing old-age pensions to the general population, each year's payments being met by the Government out of its revenue for the year, and no moneys being kept in hand in respect of future payments under existing pensions or of the accruing liability in respect of those approaching the age when pensions become payable. While it is possible to defend the method in the case of a Government dealing with the general population, the method is not a sound one for financing miners' phthisis benefits.

Payments of benefits are likely to be lower in the early years and to increase later. This would certainly be so if, as is likely, the benefits take the form of pensions or payments by instalments, and the difficulty would be accentuated if there should be more than one stage of the disease so that the miner might progress from the first stage to the second stage (and possibly to a third stage) and receive further benefits. Under a sound financial method the payments should, as far as possible, be equalised from year to year.

If the time should arrive when the mining or other industry would cease to exist, there would be a large outstanding liability, no fund would be available to meet it, and future payments of benefits would have to be made by the Government out of its own revenue. These payments might be a heavy burden on the country, especially as the Government would also lose the taxation it would doubtless have imposed on the industry. This difficulty would arise before the industry had actually ceased to exist, because for some years previously the miners' phthisis benefits would probably form too heavy a burden for the declining industry and the Government would be compelled to come to its assistance.

The *insurance method* will now be considered. Under the contracts issued by a life assurance company, premiums are paid in advance and the company accumulates a fund which, together with future premiums, is sufficient to meet its liability for all future claims. On a claim arising, the money is available to meet it; if the claim should take the form of a pension, the capitalised value of the pension would be available.

The insurance method is undoubtedly the best that can be used for financing miners' phthisis benefits provided circumstances permit of its adoption. Contributions would be paid in advance during the working lifetime of the miners, and when miners are certified to have miners' phthisis, the money would be available to pay immediate benefits and also to meet future benefits payable to the miners on reaching a further stage or stages of the disease, and to their dependants on their death.

It may not be out of place to issue a warning to those contemplating an insurance scheme. It is impossible to estimate accurately in advance the various contingencies that it is necessary to take into account in the calculation of the contributions and in the periodical valuations, and it is therefore essential that there should be a quick and easy means of adjusting the contributions according to the actual experience. It will be necessary to amend the basis of calculations frequently, and any consequent change required in the contributions should receive immediate effect.

A disadvantage of the insurance method is that it necessitates the accumulation of a large fund. This fund would be in the nature of a trust fund, since it would all be required, together with future contributions, to meet future payments of benefits. Unfortunately, legislators do not always appreciate the object of such a fund, and they might be tempted to use the fund as an easy means of increasing the benefits without any further apparent cost to the country. It is therefore desirable that the insurance fund should be called by such a name, and protected by such legislative provisions, that it cannot be used for any other purpose than that for which it has been accumulated.

The insurance method cannot always be adopted, since usually benefits would be granted only after the mining or other industry had been in existence for some years, by which time a substantial liability would have accumulated.

Modified assessment and insurance methods. — Various modifications of the assessment and insurance methods might be adopted. The assessment method may be modified by making each year's income exceed each year's payments, so that a fund, whether adequate or not, would be accumulated against future liabilities.

The insurance method could be modified in many ways, and usually the modification would depend upon the circumstances of the particular industry and country. The natural modification would be to provide that benefits for miners' phthisis to be created in the future would be met by insurance contributions and by an accumulated insurance fund, while benefits for miners' phthisis created in the past would be met by assessment contributions. The contributions for past phthisis might be made rather larger than assessment contributions in order gradually to overtake the existing liability and ultimately to attain a pure insurance method.

Methods Adopted in the Union

The financial method which has been adopted in the Union during the last few years is of such a special nature that in order to understand why it was adopted it is desirable to review the methods previously employed.

The first Compensation Act was passed in 1911, and was only intended to deal with the position temporarily while a comprehensive measure was being discussed.

In 1912 an Act was passed which laid down a financial basis on a modified insurance method. The benefits were financed by means of two funds, the Miners' Phthisis Compensation Fund and the Miners' Phthisis Insurance Fund. The Compensation Fund was responsible for the payment of benefits " to persons entitled thereto who make application for such payment within the period of two years immediately succeeding the commencement of this Act " or to whom allowances were granted under the 1911 Act. The Fund consisted of: (*a*) quarterly levies on the mines, (*b*) interest on any investments, (*c*) a contribution of £100,000 from the Government for the purpose of assisting the poorer mines and (*d*) the balance of the fund under the 1911 Act. The Insurance Fund was responsible for the payment of other benefits, that is, in respect of persons entitled thereto making application after the expiration of two years from the commencement of the Act. The Fund was financed by contributions from the mines and from miners, which were at the rate of 5 per cent. of wages (2½ per cent. from mines and 2½ per cent. from miners) during the first two years of the Act and at the rate of 7½ per cent. of wages (5 per cent. from mines and 2½ per cent. from miners) thereafter. The Fund also received the interest earned on its investments, together with any fines imposed for the contravention of Mining Regulations dealing with the prevention of miners' phthisis.

Amending Acts were passed in 1914, 1916, 1917 and 1918, which all gave additional benefits, but while the Government contributed in part to some of these additional benefits, the general financial system was not affected. The benefits payable under these Acts were in the form of lump sums payable by monthly instalments.

In 1919 a further Act was passed which provided for amounts payable in one sum for the first two stages of the disease, and for monthly allowances or pensions payable to miners in the third stage or to the dependants of such miners. At the same time a new financial system was introduced.

The amount of the Insurance Fund, about £675,000, was transferred to the Compensation Fund, which Fund alone is responsible for the payment of benefits. Quarterly levies are imposed on the mines for " such an amount as may in the opinion of the Board be required during that period of three months for the purposes of the Compensation Fund ". This quarterly levy has been at the rate of £200,000 (except for three quarters when it was £150,000), since the commencement of the Act. The Act also required mines to pay certain amounts on closing down, but these amounts were found to be less than the proper share of the outstanding liability that should be paid by such mines and this provision was amended in 1924. In 1924, and again in 1925, further Acts were passed granting further benefits and modifying the payments by mines upon closing down.

When a mine closes down, it is required to pay its correct proportion of outstanding liability. The first calculation of outstanding liability as defined by the 1924 and 1925 Acts was made as at 31 July 1922, and after taking into account the amount of the Compensation Fund, it amounted to £4,650,000. The 1924 and 1925 Acts added greatly to the outstanding liability, which by 31 July 1929 had increased to £6,400,000. The proportion of the outstanding liability due from a mine upon closing down is paid into a separate Outstanding Liabilities Fund, but from this Fund a certain amount is transferred each year to the Compensation Fund for current purposes.

Outstanding Liability

The explanation of the calculation of the outstanding liability will be facilitated by taking, as an example, the typical case of a miner whose monthly earnings were £35 3s. 4d. and who has a wife and one child under age sixteen. On being certified in the ante-primary stage of silicosis (which is the first stage of the disease) and leaving underground employment, he would receive £386. Should he progress to the primary stage, he would receive a further £193. If he had been first certified in the primary stage the award would have been £579. Should he further progress to the secondary stage of silicosis, he would receive a monthly allowance or pension; the annual amount would be £149 2s. in respect of himself, £29 16s. 5d. in respect of his wife, and £14 18s. 2d. in respect of his child, giving a total of £193 16s. 7d. A miner suffering from tuberculosis is regarded for the purpose of benefits as if he were in the primary stage of silicosis, and one suffering from silicosis plus tuberculosis as if he were in the secondary stage of silicosis, and the primary and secondary stages will be taken to include such cases. If a miner in the secondary stage should die, his dependants would receive a pension which in our typical case would be £89 9s. 2d. If a miner in the ante-primary stage or primary stage should die, and if the Medical Bureau should certify that he died from silicosis or from any other cause with which silicosis was present as a contributing or predisposing factor, his dependants would receive the same pension as if the miner had been in the secondary stage, that is, in our typical case, £89 9s. 2d. The miners are practically all Europeans, but include a few coloured persons.

Natives are also entitled to certain benefits which are paid direct by the mines to the Director of Native Labour on the natives' behalf, except that if a native should have worked on a mine that has closed down and he should afterwards be entitled to benefit, the amount would be paid from the Compensation Fund. There are other miscellaneous benefits such as the payment of funeral expenses.

The Compensation Fund is also responsible for payments to the Board's Trades and Industries Fund, contributions to the Sanatorium and the like, as well as gratuities to retiring officers of the Board or to the dependants of deceased officers; but under the law such payments are not taken into account in calculating the outstanding liability.

A description of the items taken into account in ascertaining the outstanding liability each year is contained in the following ten paragraphs, and it should be explained that no statistics are given since they are dealt with in a separate paper reviewing the statistics of miners' phthisis. The rate of interest used in discounting estimated future payments is taken throughout at 4½ per cent. per annum.

(1) *Existing monthly allowances or pensions to dependants.* — The pensions to widows and children of deceased miners are easily valued, the widows' pensions ceasing on death or remarriage (though on remarriage she receives two years' pension) and the children's pensions ceasing on death or attainment of age sixteen. Other dependants may be included where the miners left no widows. The mortality of widows is taken according to a standard table, and their rates of remarriage are based upon their own experience.

(2) *Existing pensions to miners.* — In valuing the pensions to miners, it is necessary to take into account the chance of their wives dying during their lifetime, of children dying or attaining age sixteen, and of further children being born, since these contingencies would affect the amount payable. The mortality of miners is taken according to a special mortality table, based upon the experience of miners in the secondary stage; in this experience the age is neglected and the mortality depends upon the time elapsed since miners were certified.

Under this head there is also included the value of reversionary pensions to dependants on the future death of miners at present in receipt of pensions. The contingencies stated above and in item (1) have to be taken into account, including, it will be observed, the chance of a present wife remarrying after the miner's death.

(3) *Future awards to miners in the primary stage and to their dependants.* — Miners in the primary stage must either: (*a*) die while still in the primary stage, or (*b*) progress to the secondary stage, and the rates of mortality and of progression have been calculated from the accumulated past experience.

If the miner dies while in the primary stage, there has to be taken into account the chance of silicosis being a contributing or predisposing factor, together with the value of the pension that would then be payable to his dependants.

In the case of miners progressing to the secondary stage, the value of the benefit at the time of being certified in the secondary stage can be calculated on the lines laid down in item (2), and would include the value of the reversionary pension to dependants on the subsequent death of the miner.

(4) *Future awards to miners in the ante-primary stage and to their dependants.* — In the case of miners at present in the ante-primary stage the calculations are rather more complicated, because the miner may: (*a*) die while still in the ante-primary stage, (*b*) progress to the primary stage, (*c*) progress to the primary and secondary stages during the same year, or (*d*) progress direct to the secondary stage. The rates for these contingencies have been calculated from the accumulated data.

For miners dying in the ante-primary stage the present value of the pensions to dependants (provided silicosis was a contributing or predisposing factor in death) is calculated on the same lines as the similar liability in the previous item.

Miners progressing to the primary stage will receive a lump sum, and in addition there has to be included the liability for death while in the primary stage or progression to the secondary stage as in the previous item.

For miners progressing to the primary and secondary stage in the same year, the liability at the time of progression is represented by the lump sum on becoming primary and by the pension to the miner on becoming secondary and to his dependants on his subsequent death as in item (2).

For miners progressing direct to the secondary stage, no lump sum is payable, and the liability at the time of progression is calculated as in item (2).

(5) *Future awards to prior Law miners and to their dependants.* — Prior Law miners are those miners who received benefits under the Acts (excluding the 1911 Act) prior to the 1919 Act.

Where prior Law miners are at present in receipt of monthly allowances, the value of the reversionary pensions to their dependants are already included under item (2).

Certain benefits may still be payable to prior Law miners, and if they receive pensions their dependants will also receive reversionary pensions. Certain dependants of prior Law miners (who are not entitled themselves to further benefits) are also entitled to pensions on the death of the miners if silicosis was a contributing or predisposing factor towards death.

It is difficult to obtain an accurate estimate under this item. The number of prior Law miners can be estimated and a further estimate made of the number of miners or their dependants likely to benefit in the future, from which the liability can be calculated. Alternative calculations are made by a process of extrapolation from the awards granted in recent years. The method of calculation is not satisfactory, but fortunately the class is a decreasing one.

(6) *Future awards to miners certified by the Bureau who have not yet received awards and to their dependants.* — Certain miners who have been certified by the Bureau as having silicosis or tuberculosis are still working at the date of valuation. Those with tuberculosis must give up underground work, and those with silicosis must give up work within three months or else forfeit certain benefits. Excluding miners with silicosis who have not given up underground work within three months, the liability for those in the ante-primary stage is the lump-sum award plus

an amount calculated as in item (4); for those in the primary stage the lump-sum award plus an amount calculated as in item (3); and for those in the secondary stage an amount calculated as in item (2). For those who did not give up work within three months, only the reduced benefits would be taken into account.

(7) *Balances of lump-sum awards and similar items.* — Certain benefits are payable by instalments to prior Law miners, and some balances are still outstanding. Benefits under the later law may, in certain circumstances, be payable by instalments at the discretion of the Board. In certain cases where miners have gone overseas the total amount payable is limited to £750. In all these cases the liability is taken as the balance still outstanding.

(8) *Future awards to working miners not yet certified.* — The rate of production of silicosis or tuberculosis increases with the period the miners have worked underground, and the outstanding liability at any time must be debited, in respect of the past service of working miners, with a portion of the cost of future awards to miners who are still working and who are free from silicosis or tuberculosis. It is to be noted that in a pure insurance scheme a considerable liability would be included under this head.

An alternative way of regarding this item would be to assume that all the mines closed down at the date of valuation, in which case there can be no doubt that many of the miners working at the date of valuation would be found subsequently to be suffering from silicosis.

It is difficult to obtain an accurate estimate. There are two methods of approach indicated above, that is: (*a*) to estimate the present value of future awards to the present working miners, and to debit part of that present value to the service of such miners prior to the date of valuation, and (*b*) to assume all the mines closed down, and to estimate the present value of future awards to such miners on the basis of specially reduced rates of production. Neither of these methods is satisfactory, but between the two it is possible to decide upon an amount.

(9) *Miscellaneous items.* — Under this item are included a few miscellaneous items such as funeral expenses and the liability for the benefits to native labourers after a mine has closed down.

(10) *The amount of the Compensation and Outstanding Liabilities Funds.* — The amounts of the liability under the first nine items are added together, and the amount of the Compensation and Outstanding Liabilities Funds is deducted therefrom, the balance forming the outstanding liability at the date of valuation.

The outstanding liability represents the amount that it is estimated would be required, in addition to the amount standing at the credit of the Compensation and Outstanding Liabilities Funds, if all the Mines closed down as at the date of valuation.

The outstanding liability is apportioned among the mines concerned, and on any such mine closing down during the year following the date of valuation, it is required to pay its portion of the outstanding liability. The amount is paid into the Outstanding Liabilities Fund, from which every year there is transferred to the Compensation Fund for current purposes the total interest earned on the Fund together with 5 per cent. of the amount of the mean Fund, this annual transfer being intended to give, in a rough and ready way, the amount required each year to finance the awards in respect of phthisis created by the mines that have closed down and have paid their portions of outstanding liability. It should be added that from a purely financial point of view there is no object in having two separate Funds, but from a wider practical point of view it is desirable that there should be a separate Outstanding Liabilities Fund, in order to emphasise that the moneys are trust moneys paid into the Fund for the special purpose of financing the awards for which the portions of outstanding liability have been paid.

There is another matter of interest in connection with the outstanding liability. The amounts to be paid by mines closing down in the future are high, and it is desirable that the Board should have security for their due payment. It has been arranged that the mines (with the exception of a few poor mines) will set aside sums annually which, accumulated with interest over their probable future lifetime, should amount to the estimated amounts payable when they close down. The question of the formation of a Trust Fund to deal with the accumulation of these annual sums is at present under consideration. It should be noted that if a mine should close down and be unable to meet the whole of its outstanding liability, the shortage would, at the next valuation and apportionment, be automatically allocated as an addition to the outstanding liabilities of the remaining mines.

Quarterly Levies

In order to have a proper appreciation of the nature of the outstanding liability, it is desirable to explain the relation between the quarterly levies and the outstanding liability.

It is first necessary to state the annual charges that must be met from the levies or other sources if the outstanding liability, after taking closed mines into account, is to remain constant from year to year. These annual charges are as follow:

(*a*) The outstanding liability calculated at any 31 July will, if correctly estimated, provide for all payments of benefit in respect of phthisis created up to that date, and the current levies must therefore pay for the cost of any present and future awards in respect of phthisis created during the ensuing year. Though not strictly accurate, this amount may be taken as the cost of the awards to miners under new cases of phthisis certified during the year, and of future awards to such miners and their dependants.

(*b*) The next charge consists of the annual interest on the outstanding liability, this interest being calculated at the valuation rate of 4½ per cent. If all the mines actually closed down at the date of valuation, the total outstanding liability would be received in cash or securities, and interest would be earned thereon. With the possible exception of the portion of the outstanding liability paid in respect of any mines closing down during the year, no interest is earned on the outstanding liability, and this interest has consequently to be met out of current levies.

(*c*) The last charge consists of a number of miscellaneous items which are not taken into account in calculating the outstanding liability. Such items comprise the appropriation to the Trades and Industries Fund, gratuities to officers, and other items of a similar nature.

Let the position be considered in 1925 when the 1925 Act granting further benefits had become law, and when the outstanding liability had become part of the financial system. The levies were to be for such amounts as would be required for the purposes of the Compensation Fund; these purposes were naturally interpreted to mean the current payments, but instead it should be taken as the annual charges, which are at present, and have been for some time, in excess of current payments. It was also the intention of the financial system that the " annual transfer " from the Outstanding Liabilities Fund to the Compensation Fund should likewise be used for these purposes. The quarterly levies should therefore be for such amounts that the annual amount payable in levies, together with the " annual transfer ", should be sufficient to meet the annual charges. Let it be considered how this system would work in different circumstances.

If the mines remained at the same working capacity from year to year, and no new mines were opened, then as the mines closed down the levies and the outstanding liability would both be affected. The " annual transfer " would increase, while the number of new cases of silicosis, with fewer miners, would gradually decrease, and the result would be that the total levies would decrease to such an extent that the levies on each remaining mine should remain approximately constant; if the rate of production should decrease, the levies on each mine should similarly decrease. The outstanding liability would be gradually reduced because of the payments by mines closing down (after allowing for the " annual transfers ") and the reduction would approximately be of such an extent that the portion of outstanding liability applicable to each remaining mine should remain constant. When the last mine closed down, the total amount standing to the credit of the Outstanding Liabilities Fund and of the Compensation Fund should be sufficient to meet all future liabilities.

If the mines should expand and new mines should open, the position would be more favourable, because the outstanding liability, representing the accumulated liability of past years, would be spread over more mines and over larger mines, and it would become a smaller burden relative to the increased operations of the mines. The outstanding liability would, in theory, remain for a longer time than if no new mines were opened or if other mines had not expanded, because it would be payable in part by mines with longer lifetimes, but in practice the outstanding liability would finally become unimportant and could be met by a margin in levies.

The actual position has been unfavourable in one aspect, and favourable in another. The levies plus " annual transfers " have not been sufficient to meet the annual charges, and although a number of mines have closed down and paid substantial sums for outstanding liability, the total outstanding liability has increased instead of decreased. The favourable feature has been that the remaining mines have expanded to a sufficient extent to maintain the output of gold, so that the mines have, as a whole, further resources to meet the increased burden. Special circumstances existed to increase the annual charges within recent years, and it is hoped that, with the reduction in new cases of silicosis, the position will soon be reached when without any increase in levies the annual charges will be met by " annual transfers " and by levies. It should also not be overlooked that substantial sums have already been set aside on trust by the mines towards meeting their outstanding liabilities.

The financial system thus adopted in the Union, while dictated by the fact that a very heavy liability was thrown on the industry by means of the 1919 and later Acts without adequate funds to meet it, may be regarded as working satisfactorily. As stated earlier, however, it is not necessarily the system that should be adopted in other countries.

THE WORK OF THE MINERS' PHTHISIS BOARD AND OF THE MINING INDUSTRY IN PROVIDING EMPLOYMENT FOR SILICOSIS SUFFERERS AND THEIR DEPENDANTS

BY C. J. WILLIAMS, DEPUTY CHAIRMAN, MINERS' PHTHISIS BOARD; C. S. RAATH, MEMBER, MINERS' PHTHISIS BOARD; AND B. G. O. ORPEN, PRESIDENT, ASSOCIATION OF MINE MANAGERS

The following notes are in respect of European miners and their dependants.

Employment of Silicosis Sufferers

The employment of silicotics has engaged the attention of the mining industry since the passing of the first Miners' Phthisis Act of 1911 and its subsequent Amendments of 1912, 1914, 1916, 1917, 1918, 1919, 1924 and 1925.

In October 1916 a Silicotic Employment Office was opened under the ægis of the Association of Mine Managers in order to assist phthisis beneficiaries to find employment. The running expenses of this office were provided by the Transvaal Chamber of Mines.

The following classes of work were reserved for silicotics, as far as possible, on the mines; they were also reserved for employees who had been permanently injured by accident:

Banksmen.
Motor attendants.
Motor trolly drivers.
Meter house attendants.
General surface work (unskilled).
Preparation and cartage of mining timber.
Caretakers, single quarters.
Recreation hall and swimming bath attendants.
On sorting stations when separated from crushers.
Ore loading and transport work.
Jumpermen or drill sorters on surface.
Surface sandfilling.
Reduction works assistants (unskilled).

Secretarial, time office, etc.
Firemen.
Stationary engine-drivers.
Surface pump stations.
Compound guards and watchmen.

As a result of enquiries which have from time to time been made, the maximum number of jobs on the mines which might be filled by silicotics provided that suitable men were available and the jobs became vacant, is estimated to be in the neighbourhood of 1,000.

The work of the Silicotic Employment Office was carried on until the passing of the 1925 Act. It was thereafter agreed by all parties concerned that the matter of finding employment for beneficiary silicotic miners should be taken over by the Miners' Phthisis Board.

In June 1926 the appointment of an official under the control of that Board took place.

This official was designated the Employment Officer and the position, since its inception, has been filled very ably by Mr. W. J. Carbis, himself a silicotic, who has now taken over all the work originally carried out by the Silicotic Employment Office.

The Secretarial Department of the Association of Mine Managers, however, still keeps in touch with the matter and continues to compile statistics in connection therewith.

Records to date show that:

The total number of applications registered from October 1916 to 31 August 1929 was	5,223
The total number of individuals for whom employment has been found during this period was	3,875
The total number of jobs found for these men during this period has been	6,119
There are still on the books	344

Employment was found for these men on gold, platinum, coal, base metal and asbestos mines, on railways, farm settlements, and various industrial undertakings in the Union of South Africa.

The miners who first became beneficiaries under the original Act were principally, what is termed in this country, " oversea men ", drawn from the mining districts of Great Britain, chiefly from the counties of Cornwall, Cumberland, Northumberland and Durham. A large percentage of these men returned to their native homes on becoming silicotic. In fact, it has been authoritatively stated that, up to date, 75 per cent. of the miners who have contracted miners' phthisis are overseas men.

Then followed the 1914 Act, passed shortly before the outbreak of the Great War. It is remarkable that a large number of men who had been certified to be in the early stages of silicosis, joined various field units in which they served. Many of these men served to the conclusion of hostilities. A number of silicotics, who remained on the Witwatersrand, were able to obtain employment rendered vacant by the more fit men who had joined the Army.

During an official business visit to Great Britain in 1926, Mr. C. J. Williams observed that many men, who were in the first stages of silicosis, and who had returned to England, were engaged in various occupations there, principally mining, and appeared to be as competent to do the work as those men who had not been declared silicotic.

In this connection, it might be of interest to quote from a Memorandum prepared by the Chairman of the Miners' Phthisis Medical Bureau (Dr. Watkins-Pitchford) in 1919, in response to certain enquiries made by the Silicotic Employment Office:

The ante-primary stage of silicosis is not associated with any apparent impairment of capacity for work. Workers who are certified to be in this stage are usually men in good health and able to perform a full day's work. A complete abandoning of hard-rock mining and the following of some wholesome occupation should secure that the prospect of life and health of such men is little if at all depreciated.

The primary stage of silicosis is associated with some impairment of the capacity for work although the impairment is not of a serious and permanent nature. In the great majority of instances the reduced capacity for work is not admitted by the man himself; he is, usually, to all appearances, in vigorous health.

Silicosis is not a communicable disease: it can be contracted only by the long-continued inhaling of dust containing minute particles of free silica. The association of silicotic with non-silicotic workers is entirely free from risk to the latter.

A more recent statement made by the present Chairman of the Medical Bureau, Dr. L. G. Irvine, in an address delivered to the Association of Mine Managers on 20 July 1928 is also of interest:

Dust *per se*, of course, can and does produce a fibrosis of the lungs which affects particularly their expansibility. But an uncomplicated dust fibrosis, at all events as dust conditions are to-day, will not very seriously incapacitate a man, nor will it directly kill him.

The following information regarding the incidence of miners' phthisis is derived from the returns of the Miners' Phthisis Medical Bureau:

EUROPEAN MINERS: NEW CASES OF SIMPLE SILICOSIS, TUBERCULOSIS WITH SILICOSIS, AND SIMPLE TUBERCULOSIS, DETECTED AT PERIODICAL EXAMINATIONS, 1917-1918 TO 1927-1928

Year	Simple silicosis: Primary and secondary	Simple silicosis: Ante-primary		Tuberculosis with silicosis	Total silicosis		Simple tuberculosis
1917-18	153			116	269		35
1918-19	349		1,456	120	469	1,716	36
1919-20	398+	(556)		24	422 + (556)		39
1920-21	17	219		17	253		44
1921-22	5	254	752	24	283	812	22
1922-23	2	255		19	276		25
1923-24	1	318		20	339		11
1924-25	1	427	1,237	28	456	1,292	18
1925-26	—	490		7	497		61
1926-27	—	364		2	366	649	42
1927-28	—	283		0	283		32
Total						4,469	365

There are at present living in South Africa, south of the Equator, approximately:

	Men
Suffering from silicosis in ante-primary stage	2,500
In the primary stage	2,350
In the secondary stage (tuberculosis plus silicosis) . . .	2,200
Simple tuberculosis	360
Total	7,410

With regard to the number of silicotics employed in various parts of the Union of South Africa, Mr. Williams has made the following estimate:

On surface work, scheduled mines . .	800
On mines other than scheduled	450
By municipalities on the Witwatersrand	250
By private industries and persons . . .	350
By railways and public works	200
On relief works	250
On alluvial diggings	350
Engaged in farming operations	350
Established in business	100
Total	3,100

INTERNATIONAL LABOUR OFFICE

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SILICOSIS

(SUPPLEMENT)

Resolutions adopted by the
International Conference held at Johannesburg
13-27 August 1930

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RESOLUTIONS
ADOPTED BY THE SILICOSIS CONFERENCE

I. Report upon the Medical Aspects of Silicosis, including Ætiology, Pathology and Diagnostics

Reporters: Drs. L. U. GARDNER, E. L. MIDDLETON and A. J. ORENSTEIN [1]

1. The Conference confined its discussion almost entirely to silicosis, as the other pneumonoconioses are, with the possible exception of asbestosis, in the present state of available information, of less importance, and furthermore have not been subjected to sufficiently detailed study.

2. Silicosis is a pathological condition of the lungs due to inhalation of silicon dioxide. It can be produced experimentally in animals.

3. To produce the pathological condition, silica must reach the lungs:

(*a*) in a chemically uncombined condition, although the dust inhaled may be either a natural mixture of silicon dioxide with other dusts, such as occurs in granite, or an artificial mixture, such as scouring powder;

(*b*) in fine particles of the order of less than ten microns. There is no evidence as to the lowest limit of size in which the particles may be capable of producing the disease;

(*c*) in sufficient amount, and over a certain period of time; these two factors are reciprocal variants. The minimum of these two respective factors has not yet been determined.

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[1] Dr. W. STEUART was unable to participate in the preparation of this report. He submitted a memorandum which is reproduced later as an Appendix. The report, including the memorandum, was adopted by the Conference at its Eleventh Sitting, 25 August 1930.

4. Silica dust plays the dominant role in the production of silicosis, admixture of other dusts tending to modify the picture in the direction of that of other pneumonoconioses, in some relation to the proportion of free silica inhaled.

5. There is experimental evidence that the solubility of silica in the tissues is an essential factor in the causation of silicosis.

6. Infection of the lung with B. tuberculosis or other pathogenic organisms, whether it occurs before, simultaneously with, or subsequent to the development of silicosis, alters the disease and influences it unfavourably, tuberculous infection being particularly unfavourable.

7. The establishment of a silicotic process in a lung renders the subsequent inhalation of other dusts, in themselves relatively innocuous, capable of producing serious pneumonoconiosis.

8. It was suggested that intermittency of employment retards the onset of silicosis, but the evidence adduced in support of this, though suggestive, is not conclusive, when the total period of exposure is not affected.

9. It was agreed that the microscopic pathological changes which may be produced by the prolonged inhalation of silica dust are:

(*a*) The development of a condition designated in South Africa as a dry bronchiolitis, characterised by an accumulation of dust-filled phagocytes in or in relation to the terminal bronchioles, with possibly some desquamation of their epithelium.

(*b*) The accumulation of dust-containing phagocytes about and in the intra-pulmonary lymphoid tissue, and their transportation through the lymphatics into the tracheo-bronchial lymph nodes.

(The conditions described above under (*a*) and (*b*) do not constitute the disease silicosis.)

(*c*) The gradual development of fibrous tissue within such accumulations of phagocytes and the formation of characteristic nodules of hyaline fibrous tissue.

(*d*) Degenerative changes in these foci.

(*e*) The hyaline nodules increase in size by extension at their periphery.

Coalescence of adjacent nodules takes place and brings about involvement of further areas of the lung.

(The conditions described under (*c*), (*d*) and (*e*) constitute the disease silicosis.)

10. Macroscopically the changes observed in silicosis are:

(*a*) *In the early stage.* A variable number of palpable pearly-white nodules up to 2 or 3 mm. in diameter on the pleural surface of the lung. On section, the cut surface of the lung is studded with pigmented foci, widely scattered, a moderate proportion of which are only just palpable. The tracheo-bronchial lymph nodes are slightly enlarged and deeply pigmented, and may exhibit foci of fibrous induration.

(*b*) *Later stages.* The fibrotic nodules are increased in number, size and density, and coalescence of these may be found. The portion of the lung between the fibrotic nodules may be emphysematous. The tracheo-bronchial lymph nodes may be smaller in size than those seen in the early stage and are fibrosed.

11. The presence of tuberculous infection usually modifies the pathological appearance. Special attention was drawn to the three following types:

(*a*) In which the picture of silicosis above described may be little, if at all, modified, but in which only a biological test can demonstrate the presence of B. tuberculosis.

(*b*) In which the coexistence of silicosis and typical tuberculosis lesions is easily recognisable.

(*c*) In which the presence of tuberculosis is easily recognisable, but the existence of silicosis is more difficult to determine.

12. There is evidence that with B. tuberculosis, *in vitro* the period before growth becomes apparent is shortened in the presence of silica, and that *in vivo* an environment favourable to the continued growth of the bacillus is produced in the presence of silica, but the virulence apparently remains unaltered.

13. In *massive* silicosis cardiac hypertrophy and subsequent dilatation may occur. In silicosis with infective processes, cardiac changes may also occur.

14. No evidence was adduced in regard to involvement of kydney or liver.

15. For the diagnosis of silicosis as a disease it is necessary to take into consideration:

(*a*) the employment history;

(*b*) the symptoms and physical signs;

(*c*) the radiological findings.

16. The disease can conveniently be divided into three stages, designated " first ", " second ", and " third " stages.

17. In the differential diagnosis of silicosis from other pneumonoconioses a history must be established of exposure to inhalation of silica dust in a quantity reasonably commensurate with the clinical and radiological findings.

18. In the " first stage " symptoms referable to the respiratory system may be either slight or even absent. Capacity for work may be slightly impaired. There may be a departure from the normal in percussion and in auscultatory signs, and the radiograph must show an increased density of linear shadows, and the presence of discrete shadows, indicative of nodulation.

19. In the " second stage ", there is an increase of the physical signs observable in the " first stage ", and the radiograph shows an increase in the number and size of the discrete shadows indicative of nodulation with a tendency to their confluence. There must be some degree of definite impairment of working capacity.

third 20. In the "~~first~~ stage " all the above conditions are grossly accentuated and indications of areas of massive fibrosis are usual. There is serious or total incapacitation.

21. Pulmonary tuberculosis may be present in any of the above described " stages " of silicosis, altering the symptoms, physical signs and radiographic appearances, and the degree of working capacity. Its presence must therefore influence the " stage " classification of the individual, which classification must in these circumstances be based more on the degree of loss of working capacity than on physical signs and radiographic appearances.

22. Radiographs may frequently be met with which show a slight, moderated, or well marked increase beyond the normal in radiating linear shadows. These may or may not be due to fibrosis.

23. The inhalation of asbestos dust produces a definite pneumonoconiosis, which may occur also in association with tuberculosis, and deaths have been recorded.

This pneumonoconiosis is associated with the presence in the lungs of " asbestosis bodies ", but the mere presence of these bodies in the lungs or sputum does not constitute evidence of the disease.

For the diagnosis of this pneumonoconiosis the same criteria as described for silicosis should be applied, *mutatis mutandis.*

There is not at present sufficient evidence to show definitely to what extent tuberculosis and this type of pneumonoconiosis react upon one another.

26. There are other dusts, such as those from marble, coal, carborundum, etc., which may contain small quantities of silica and which produce demonstrable lung changes, radiographically resembling in some cases the appearances observed in early silicosis.

There is not a sufficient body of evidence available to enable a definite statement to be made of pathological changes in man. In animal experiments, the inhalation of carborundum dust over a period of four years has produced fibrosis only in the tracheobronchial lymph nodes; the lungs were entirely free of fibrotic changes. This, and collateral observations on inhaled granite and asbestos dusts suggest the hypothesis that to produce pulmonary fibrosis a sufficient concentration of a relatively insoluble dust must be brought by the activity of phagocytic cells into intimate contact with connective tissues. With the dusts last mentioned the migration of phagocytes, for at least a prolonged period, is ineffective in establishing such contact in the lung. Only in the tracheobronchial nodes are these conditions realised during a period of four years.

25. The Reporters beg to recommend that appropriate action be taken:

(*a*) To establish an international classification of silicosis on the lines indicated in paragraphs 16 to 21 inclusive.

(*b*) To enquire into the possibility of establishing an internationally comparable technique of radiography, and terminology of radiographic findings.

(*c*) To institute further studies in the correlation of radiographic appearances, morbid anatomy and symptomatology of silicosis and silicosis with tuberculosis.

(*d*) It is desirable that further scientific research into the ætiology, pathology and diagnosis of silicosis and other dust diseases should be undertaken on an international basis, at an early date.

APPENDIX

Memorandum on Radiography of Silicosis

By Dr. W. Steuart

With a view to obtaining uniformity in films of the thorax in cases of silicosis a description of the technique used at the Miners' Phthisis Bureau is given in detail.

The transformer receives three phase current and the secondary current is rectified by means of six valve tubes. Its output is much in excess of the capacity of present X-ray tubes.

The X-ray tube used is a metallic DN type. The distance from focus to film is 48 inches.

The length of exposure and penetration vary with the antero posterior thickness of the examinee according to the following table:

Depth of thorax in inches	Time in seconds	Kilovolts
7	0.1	61
7½	0.11	61
8	0.12	61
8½	0.15	62
9	0.175	62
9½	0.2	63
10	0.22	63
10½	0.23	64
11	0.24	64
11½	0.25	65
12	0.26	65
12½	0.26	66
Filament current 4.3 amperes	Current through tube 200 M.A.	

The man lies in the prone position on the casette with the tube above him.

Kodak films and Agfa intensifying screens are employed. If other makes of screens and films are preferred allowance should be made in exposure and penetration as films and screens differ considerably as regards speed.

Casettes are such that uniform contact between films and screens is secured.

The developing solution is made up according to Kodak's formula, but to every 5 gallons 4 lb. of sodium carbonate and 4 lb. of sodium sulphide are added.

The temperature of the developer is 65° F. and the time of development is five minutes.

Terms used in indicating the diagnosis on X-ray report form:

1. *Normal thorax.* — This is taken as that of a healthy youth of about eighteen.

The heart occupies a left medial position and is approximately triangular in shape, its shadow accounts for about one third of the area of the thoracic shadow. Its size and shape vary.

The right hilus is seen as a faint rather small shadow but the left is hidden by the heart.

The diaphragm is dome shaped on each side, the right being higher than the left. Its level is variable.

The pulmonary tissues throw no shadows so that between the ribs the skiagram should be uniformly clear.

Radiating from each hilus faint shadows can be made out due to the roots of the bronchial tree of bronchi vessels and supporting tissues.

The costal cartilages are transradient.

2. *Rather more fibrosis than usual.* — This is really the normal thorax and is seen in healthy adults, but through the continuous inhalation of dust, smoke, etc., the hilus and bronchial tree shadows become accentuated, otherwise the picture is that of a normal thorax.

3. *More fibrosis than usual.* — This is an extension of the previous condition. The hilus shadows are denser and the bronchial tree shadows are more numerous and found throughout the thorax. It is seen in old people, in cases of chronic bronchitis, asthma, and in old healed infections. Though not an absolute bar to underground work it is a factor that goes far in deciding the rejection of an applicant for mining work.

Then come a series of classifications of conditions that arise from gold mining, viz.:

4. *Commencing generalised fibrosis.*

5. *Moderate generalised fibrosis.*

6. *Well marked fibrosis.*

7. *Very well marked fibrosis.*

8. *Gross fibrosis.* The commencing generalised fibrosis shows itself on the Witwatersrand after five or more years depending on the particular work done and the idiosyncrasy of the miner. It is a further accentuation of " more fibrosis than usual " and here and there small pin head shadows can be made out, the first indication of the typical " mottling " of silicosis.

Thereafter the mottling is common to all the others, the chief indication of the amount of fibrosis being the size of the nodules.

The nodule or unit of mottling varies from about one twentieth of an inch (1.25 mm.) in diameter in moderate generalised fibrosis to about a quarter of an inch (7 mm.) in gross fibrosis. These figures are of course merely approximate and not absolute.

9. *Fibrosis partly or mainly silicotic in type.* — This is deduced when the nodules are clearly cut in outline and uniform in distribution throughout the lung.

10. *Fibrosis partly or mainly infective in type.* — A slow infective process has the effect of increasing the size of the nodules in certain areas so that there is no uniform distribution as in pure silicosis. The outline of the nodules becomes fluffy instead of sharply defined. The usual infection is tuberculous, but syphilis and other chronic infective process may cause the same appearances.

11. *Appearances suggestive of tuberculosis,* $\frac{\textit{right}}{\textit{left}}$ *lung.* — A sudden increase in the density of the hilus shadows, increased apical density or patchy shadows in other lung areas lead to the initialing of this item in the report.

12. *Apparently definite tuberculosis,* $\frac{\textit{right}}{\textit{left}}$ *lung.* — Tuberculosis is often so well established in periodical cases that there is practically no doubt as to the meaning of the shadows shown. The appearance can best be described by imagining some French chalk being thrown on the film and then rubbed round with the fingers. In the shadows produced dark areas of varying size may possibly be seen due to cavities.

The word " apparently " is retained because occasionally syphilis causes much the same kind of shadow.

13. *Peribronchial thickening; hilus thickening.* — From the experience obtained since the commencement of examining individuals who wished to take up mining, it has been found that the accentuation of the shadows cast by the larger branches of the bronchial tree (called by the Bureau " Peribronchial thickening ") and of the hilus shadows is a definite indication of tuberculous susceptibility and examinees are frequently rejected on this account.

14. *Pleural thickening* $\frac{right}{left}$ *side.*

15. *Pleural effusion* $\frac{right}{left}$ *side.*

Both of these conditions are readily noted by a radiographical examination and are considered important on account of their possible association with tuberculosis.

16. *Consolidation* $\frac{right}{left}$ *side.* — This diagnosis is given in the case of any dense shadow that does not alter its size and shape in different positions of the subject. The causes of consolidation are so numerous that unless there is some special indication in size, shape or position no diagnosis is attempted except possibly a query.

17. *Heart, asthenic or vertical in type.* — Although the heart shadows vary to a considerable extent within normal bounds, individuals having a tubular shaped heart or one casting a very small shadow, are regarded as " suspect " by the members of the Bureau for the same reasons noted in 13, 14 and 15.

18. *Heart enlarged.* — In most cases of cardiac disease and pericarditis the heart shadow usurps more than its normal share of the thoracic space, and attention is always drawn to this variation, as cardiac disability is often ascribed by outside medical practitioners as being due to silicosis.

19. *Aorta enlarged and aortic aneurysm.* — These items have frequently to be initialed and are often associated with patchy shadows suggestive of tuberculosis which however disappear after a course of appropriate treatment for specific disease.

20. Other changes, viz.:

(1) *Aerophagy.* — Occasionally at the left base it will be found that the phrenic shadow is pushed up into the thorax and that below it a negative shadow is shown. This is due to the subject

swallowing air which distends the stomach and may cause discomfort.

(2) *Aneurysm of heart.* — The condition is very rare, only one case in 80,000 persons having been noted at the Bureau.

(3) *Atelectasis.* — Due to obstruction of a bronchus, gives a fan-shaped shadow radiating from direction of lung root which is as dense as a consolidation shadow.

(4) *Azygos lobe.* — In about one case in twenty thousand there is an abnormal azygos vein which leads to a shadow in the upper lobe of the right lung.

(5) *Bronchiectasis.* — This is indicated in skiagrams by No. 13, " peribronchial thickening ". A definite diagnosis however can only be given after a lipiodol injection.

(6) *Bronchitis.* — Chronic bronchitis gives the picture described in No. 3, " more fibrosis than usual ".

(7) *Calcification.* — Calcium is deposited in old inflammatory foci and in costal cartilage. It is often deposited in silicotic nodules and in lymphatic glands at the root of the lung. Its presence is indicated by an increased density of the shadow.

(8) *Carcinoma.* — Carcinoma may occur as a primary or secondary condition.

In the former case it leads to a consolidated area which increases in size. In the latter several shadows are seen which are circular and become larger and larger in diameter until the patient succumbs.

(9) *Emphysema.* — The lung tissue becomes more transradient so that other shadows are accentuated owing to the increased contrast.

(10) *Empyema.* — The shadow is very dense and may occupy any part of the lung field.

(11) *Hodgkins disease.* — The thoracic involvement causes a dense mediastinal shadow.

(12) *Hydatid cyst.* — This is indicated by a dense oval shadow with a uniform contour.

(13) *Liver and subphrenic abscess* normally occur on the right side. The diaphragm is pushed up into the thorax.

(14) *Miliary tuberculosis.* — The appearance is practically the same as a *moderate generalised fibrosis mainly silicotic in type.*

(15) *Pneumonia.* — The shadow is dense and varies in size according to the severity of the disease.

(16) *Pneumothorax.* — The collapsed lung can be seen in the root area. It is surrounded by a uniform negative shadow stretching to the periphery.

II. Report of the Sub-Committee on Preventive Measures [1]

Reporters: Dr. LORIGA, Dr. BADHAM and Mr. ROBERTS

1. The Conference dealt with the matter of prevention at its sessions held on Friday afternoon and Saturday morning, 15 and 16 August 1930.

The first six papers and the papers presented by the visiting members, were taken as read, and discussed on broad lines, members having remarks to make calling freely upon their experience in regard to one or other of the various aspects of the question.

The feeling of the Conference was that the present opportunity should be used for an interchange of ideas with a view to mutual inspiration which would be of value in future research, rather than that it should be used for the purpose of arriving at conclusions and the making of recommendations.

2. It was generally agreed that so far as the present heading is concerned, the disease which it is sought to prevent is that which arises from the inhalation of free silica (SiO_2) as distinct from silica in chemical combination with other substances.

3. From the information supplied by various members, the disease becomes noticeable after differing periods of exposure to siliceous dust, depending, apparently, upon:

(*a*) The amount of dust inhaled;

(*b*) the percentage of free silica contained therein;

(*c*) the size-frequency (or fineness) of the particles inhaled;

(*d*) the nature and sort of such other substances (including vapours and gases) as may be inhaled simultaneously, or otherwise;

[1] Adopted by the Conference at its Twelfth Sitting, 26 August 1930.

(*e*) the powers of resistance of the individual concerned;

(*f*) the presence or absence of a complication by an infective process.

In regard to (*a*), it was agreed that by the use of water and other preventive measures the dust contents of air can fairly readily be reduced to ordinarily invisible amounts. In Australian experience this represents something in the neighbourhood of 4 or 5 milligrams per cubic metre, or say 400 or 500 particles per cubic centimetre when the particles are from 1 to 10 microns with a size-frequency ratio of 3. It was, however, evident from the discussion that it is impossible, under existing conditions, properly to correlate dust determinations made in different countries, in different industries and for different purposes, as well as for different immediate objects.

With regard to (*b*), it appeared from the information placed before the Conference that silicosis can be contracted through inhaling for a sufficient period dust containing percentages of silica varying from say 95 per cent. down to from 30 to 35 per cent. and even lower.

In regard to (*c*), it was pointed out that with existing preventive measures carried out in certain mining areas there are now relatively few large particles in the air; and it appeared from the discussion that the greatest amount of harm is done by particles of less than say 3 microns in size. Some of the evidence seemed to suggest that particles of an ultra-microscopic size are factors in the causation of the disease, but evidence in this direction was not conclusive.

In regard to (*d*), the experience on the subject of certain members went to show that while exposure to various other dusts *simultaneously* with silica might affect the development of silicosis, the suggestion that other dusts might be used as an antidote against silica should be treated with great caution and reserve. Further research in this direction is urgently called for. It was pointed out that experimental evidence and practical experience under working conditions had shown that prior or subsequent inhalation of other dusts in no way delayed the development of silicosis.

In the course of the discussion under this heading some reference was made to the alleged immunity from silicosis in some districts where quartz in company with non-siliceous rock is mined, but it was pointed out that further investigation had shown in the one case that the allegation was unfounded in that the existence of silicosis had been obscured by the migratory nature of the working population; while in other cases it appeared that by reason, possibly, of the absence of laws relating to compensation, the medical evidence is not so complete as it might otherwise be, and there is sufficient room for doubt as to the exact position of the workers vis-à-vis silicosis. In all cases where there are laws relating to the compensation of silicotics it is but natural that the examination of the workers will be more thorough.

In regard to (*e*), it was generally agreed that this is an important feature, and there was a certain consensus of opinion that alternative employment and periods free from exposure to siliceous dust tended to increase the resistance and thereby delay the development of silicosis.

4. The discussion on methods for the prevention of dust and the inhalation thereof fell, on broad lines, under the following headings:

(*a*) the use of water;
(*b*) exhaust draught applied at or near the point of origin of the dust;
(*c*) dust traps and masks;
(*d*) ventilation;
(*e*) other methods.

There was something said in favour of each of the methods referred to. It was agreed that no one method is applicable in all circumstances, but that in most cases, and especially in mining, there should be a combination of methods.

With regard to water, it was pointed out that, as far as the Witwatersrand was concerned, it is used in three different ways, namely:

(1) to prevent the formation of dust during the drilling of holes, in blasting, and the handling of broken rock;
(2) for the wetting of all surfaces with a view to securing a "fly paper" effect in retaining dust which might settle on those surfaces;
(3) for spraying into the air in order to allay dust which had been formed.

In regard to (1) it was generally agreed that the application of water at the site of percussion or fracture tends to minimise the formation of dust, but attention was drawn to the fact that in several operations, e.g. rock drilling, stone cutting, grinding, etc., sparks accompanied by dust escape even when the surfaces concerned are actually under a film of water.

In regard to (2), the view was expressed that since there is no particular reason why dust particles of the order of less than 3 microns should settle on the roof and sides of working places, and that they would settle on the floor only after many hours, the value of these wetted surfaces as dust catchers is probably small.

With regard to (3), it was pointed out that the dust particles with which the Conference was concerned are of the same order in size as micro-organisms, and that no one nowadays would expect to catch micro-organisms by means of a spray. In this connection it was mentioned as a matter of interest that Lord Lister, in his famous address delivered at Berlin, had stated that he felt ashamed of ever having suggested such a possibility in surgery.

The consensus of opinion was that as sprays are of little value for removing fine dust from the air and that since, further, a humid atmosphere and the presence of droplets had been shown experimentally to increase the risk of various infections their use should be restricted.

This view, however, does not necessarily apply to water blasts used on the Witwatersrand when firing in development ends, since while such blasts might not catch much of the finer dust (except by the subsequent condensation of water vaporised by the heat generated in blasting) they put into solution some of the noxious gases and wet the broken rock so as to prevent the escape of the dust when that rock comes to be handled.

In regard to (*b*), it was mentioned that exhaust draught was of great value in those processes of manufacture where there is an objection to the use of water. In some cases water cannot be used for fear of spoiling the material, and in other cases the workmen at times turn it off because it makes them wet. In all such cases, exhaust hoods should, if applicable, be used. It is necessary, however, that these hoods should be placed in close proximity to the work, and that regard should be had to the direction and speed of rotating objects. As an example of what could be done in manufacturing processes by the use of exhaust draught, cases were mentioned of a decrease in the incidence of silicosis which had followed the abandonment of wet grinding in favour of dry grinding with suitably applied exhaust draught. It was also pointed out that before exhaust draught was used for the dry grinding of metals this process was much more dangerous than wet grinding, but that since the introduction of efficient exhaust draught with dry grinding the position had been reversed.

(1) *Dust traps.* — As an example of the application of this method to the drilling of holes in mines, mention was made of an apparatus (such as is referred to on page 114 of the main volume) wherein the drill steel operates through an artificial collar held against the face of the rock; and through which ejector induced suction led the dust produced in drilling into a dust trap or filter. This apparatus was said to be very effective and popular in certain collieries to which laws relating to silicosis had recently been applied.

(2) *Masks.* — It appeared from the experience of members that workmen submit readily to their use only when discomfort from the inhalation of noxious dust could thereby be avoided.

In some circumstances loose fitting masks of the pressure type wherein a constant supply of fresh air under positive pressure is led in through a flexible tube, have proved very efficacious. Such masks, however, are useful only when the wearers can perform their work without the necessity of moving from place to place. The same applies to tight-fitting masks supplied with air at normal pressure through a tube from a distant source.

Other masks wherein air was inspired through a filtering medium such as cotton wool, sponges, etc., and expired through a light non-return valve, were also described.

Reference was also made to masks in which the air to be inspired is made to pass through a tortuous path and impinge on damp surfaces which will retain the dust.

The feeling of the Conference was that while the masks at present available may be of some value in special circumstances, and particularly in those cases where the formation of dust (and the consequent necessity for precautions) is intermittent; they are so unwieldy or interfere so much with respiration that their constant use is impracticable during hard work and especially in a hot and humid atmosphere.

In regard to (*d*)—Ventilation—there was but little direct discussion, it being agreed that good fresh air ventilation was desirable, and indeed essential. It was emphasised, however, that to be effective the ventilation currents must be properly split and directed so as to sweep all dust-laden air out of the mine or works, as the case may be, in much the same way as dangerous gases are swept out of collieries.

With regard to (*e*)—Other Methods—mention was made of the fact that some years ago an endeavour had been made on the Witwatersrand to prevent the roof and sides of main intake airways from drying up (and, incidentally, to secure the "fly paper" effect referred to in 4 (2) and in the remarks thereon) by spraying those surfaces with solutions containing molasses, calcium chloride, and other hygroscopic substances, but it had been found that these preparations absorb moisture so readily that they soon trickle down into the gutters.

In discussion on this matter it was pointed out that if there really are any advantages to be derived from the "fly paper" effect, these solutions, and other sticky substances, could again be tried in the event of it being found possible at a later date materially to reduce the humidity of the ventilating currents. It was also suggested that these solutions might be used instead of plain water, for preventing the formation of dust in drilling, blasting, and the handling of rock.

In dealing with the dust formed by blasting, especially by blasting in development ends, a suggestion was put forward that it might be possible to project into the air at the time of blasting relatively large particles of some innocuous flocculent dust which in its settlement or progress through the mine would catch the harmful dust in much the same manner as micro-organisms are caught in water purification plants.

A further suggestion put forward was that saturated steam might be of some value, it having been found effective in industry in certain special circumstances.

A still further suggestion put forward was that the escape of dust from drill holes might be prevented by the use of a preparation producing a foam.

5. During the course of the discussion, reference was made to the difficulties experienced by investigators in the different countries in properly appreciating each others findings. Some of those difficulties arise from there being no accepted standards for comparisons in regard to various conditions, dust counts, and so on; and others, through lack of a uniform terminology. The Conference, therefore, decided to put forward the following suggestions in the hope that those investigators who were in a position to do so, and particularly the Research Division of the International Labour

Office, would take them up so as to pave the way for some decisions and recommendations at a future Conference.

(1) While the methods of conducting and other details relating to the routine sampling of air are best left to each local authority, it seems highly desirable that for certain special critical and scientific studies of dust particles in air and their effects, there should be established some standard method which for this special purpose would permit of inter-industrial and inter-national comparisons; in this connection it is suggested that the instruments at present approved by the various experts should be taken into consideration. The results of these investigations should be communicated to the Research Division of the International Labour Office for correlation.

(2) That as photographic and photo-electric cell methods of dust determination have been successfully applied in certain special circumstances, research should be undertaken with regard to such methods, with a view to ascertaining their adaptability in other circumstances.

(3) In view of the chemical theory of the causation of silicosis, the importance of estimating the size frequency of particles has increased owing to the fact that the surface exposure (which varies greatly with different sized particles) is the chief factor in the amount of silica which goes into solution. It is suggested, therefore, that investigators should include in their work determinations of the size frequency of particles.

(4) (*a*) The Conference urges that the investigations suggested in paragraph (1) should be undertaken with the least possible delay in all countries which are interested in the problem.

In view of the thoroughness and outstanding work of research already carried out on the Witwatersrand, and in view of the special facilities which exist in that area, the Conference attaches special importance to the investigations which may be undertaken on the Witwatersrand and ventures to express the hope that they will be initiated at the earliest possible moment.

(*b*) The Conference recommends that as soon as the standard method referred to in paragraph 1 has been perfected it should be applied for the purpose of making at least one complete survey of the dust concentration in dusty industries throughout the world. The results of this survey should be communicated to the International Labour Office.

(*c*) The Conference considers that the survey recommended in (*b*) should include an investigation into the relative size frequency of the dust particles.

Every effort should be made to emphasise the fact that the prevention of silicosis must be achieved by means of a whole series of provisions relating to hygiene in mines—viz. chiefly by reducing production and diffusion of dust, by maintaining the purity of the air, and by means of personal hygiene.

(5) That no opportunity should be lost of stressing the importance of general and localised ventilation as one of the best hygienic measures in dusty industries.

(6) That the personal protection of the workers should not be exclusively confined to such protective measures as, for instance, the wearing of masks, but should be supplemented by secondary measures such as the provision of suitable change houses and shelters, and by the regulation of working hours, etc.

(7) That many of the points raised in the prevention and control of dust call urgently for investigation by the physicists.

Note. — The present report does not concern itself with medical methods of prevention of silicosis.

III. Report on Prognosis, After-Care and Compensation [1]

Reporters: Dr. Cunningham, Professors Hall and Koelsch, together with Dr. Badham (co-opted)

In presenting our report it has seemed best to deal with each subject separately.

Prognosis

This subject may be considered under four headings:

Question 1: What is the prospect of a man exposed to free silica dust as regards acquiring silicosis ?

This has been considered to depend on various factors:

(*a*) The nature, silica-content, size of particles, and concentration of the particular dust to which he is exposed.

[1] Adopted by the Conference at its Twelfth Sitting, 26 August 1930.

Concerning many of these points exact information is not forthcoming and it is desirable that further scientific investigations should be carried out and the results carefully compared with the incidence of silicosis amongst the workers.

(*b*) Period of exposure to dust.

(i) Length of service.

That this is a factor of importance is in accordance with the views expressed by members of the Conference from every country represented.

The length of service necessary to acquire silicosis may be considerably prolonged by improvement in other factors.

(ii) Intermittence of exposure.

On this point the evidence forthcoming was not conclusive.

(*c*) Age of worker.

There is no evidence that *per se* this plays any important part.

(*d*) Physique of worker.

This is a factor of primary importance. An initial medical examination to ensure a certain standard of physique should be generally adopted in those industries in which the risk of exposure to silica dust is great.

Periodic medical examination of such workers is also essential.

(*e*) Race.

There is no evidence that this is a factor of importance.

Question 2: What is the prognosis in a case of silicosis if the affected man leaves the industry at the first stage of the disease (ante-primary stage of South African legislation)?

The evidence on this point as regards various industries and from different countries is somewhat conflicting.

In South Africa on the whole the evidence shows that the downward progress of the disease is in most cases not arrested on leaving the industry.

In this connection the questions of so-called infective cases, of reduced economic conditions of life, and of the associated mental worries probably play no inconsiderable part.

The view taken by the Medical Bureau in regard to the so-called "infective types" of silicosis is that they do not come under the classification of tuberculosis with silicosis unless the conditions in respect of tuberculosis as laid down in the Act are complied with.

The prognosis in such cases of infective silicosis is much less serious than in cases of tuberculosis with silicosis as the term is used in the Act. Such cases may live for many years in comparative comfort unless active tuberculosis intervenes. The preceding evidence points to the urgent necessity of further experimental study of the exact conditions connected with silicosis of infective type.

Question 3: *What is the prognosis in a case of simple silicosis if he remains in the industry after the first stage (ante-primary) declares itself ?*

The evidence from South Africa suggests that in so far as mining is concerned the continuation in underground employment of sufferers from silicosis will aggravate the progress of the disease, except in certain selected mining occupations.

As, owing to economic factors connected with compensation, only a very small number of the silicotics in South Africa do remain at work underground after the disease has declared itself, the evidence on this point is somewhat indefinite. It is stated, however, that there are at present about 150 men in this position, and it is said that their progress is no worse than those who have left the mines. Among these 150 men, however, are included a considerable number of higher officials whose duties do not now expose them considerably to dust and whose economic position remains as good as before.

It is desirable to obtain exact information as to how far continuation at work in occupations involving exposure to silica dust will influence the progress of the disease.

Question 4: *What is the prognosis in a case of silicosis with tuberculosis ?*

(N.B. Before attempting to summarise the views of the Conference on this point it is desirable to make clear exactly what we mean. According to the terminology used in South African legislation "tuberculosis means tuberculosis of the lungs or of the respiratory organs" and is deemed to be present "wherever it is found by the Bureau either (*a*) that such person is expectorating the tubercle bacillus, or (*b*) that such person has closed tuberculosis to such a degree as seriously to impair his working capacity and render prohibition of his working underground advisable in the interests of his health".)

This is always serious.

It is worse:

(i) when the tubercular infection occurs at the outset of silicosis;

(ii) in younger than in older subjects;

(iii) than in cases of tuberculosis alone.

Recommendations

Prognosis of Silicosis

1. Exact information is not forthcoming concerning many of the points relating to the nature, silica-content, size of particles and concentration of dust to which a man may be exposed and it is desirable that further scientific investigations should be carried out and the results carefully compared with the incidence of silicosis amongst the workers.

2. The physique of the worker is a factor of primary importance. An initial medical examination to ensure a certain standard of physique should be generally adopted in those industries in which the risk of exposure to silica dust is great.

Periodic medical examination of such workers is also essential.

3. The evidence points to the urgent necessity of further experimental study of the exact conditions connected with silicosis of infective type.

4. It is desirable to obtain exact information as to how far continuation at work in occupations involving exposure to silica dust will influence the progress of the disease.

Compensation from the Medical Point of View

1. Silicosis complicated or not by tuberculosis constitutes an occupational disease which may involve reduction of working capacity.

2. It should be left to competent authorities to decide, in accordance with their particular conditions, whether other forms of pneumonoconiosis should be regarded as occupational diseases.

3. In establishing the amount of disability, account should be taken of the clinical and functional condition as a whole.

4. The determination of disability should be entrusted to an independent medical expert, or body of experts, possessed of the

requisite clinical and technical knowledge, and having at his or their disposal suitable apparatus for effecting the examination.

5. It is suggested that removal from all industrial occupations involving exposure to noxious dust should be enforced in all cases of open tuberculosis.

6. Where legislation provides for the compulsory removal from occupations involving exposure to silica dust of workers affected by silicosis, it is suggested that such compulsory removal should not necessarily be applied to workers who have been in the same industry for a period of not less than fifteen years and have reached the age of forty-five years.

After-Care

1. Sanatorium treatment should be provided for suitable cases.

2. Hitherto most of the rehabilitation schemes have been unsuccessful. Further investigation into this problem is urgently called for.