SILICOSIS IN THE POTTERIES

SOME OBSERVATIONS BASED ON SEVEN HUNDRED AND FIFTY NECROPSIES

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Manufacture of pottery in Great Britain is largely concentrated in North Staffordshire, where it constitutes the staple industry of the district, known throughout the world as the "Potteries." According to the latest returns of the Ministry of Labour the chief sections of the industry and the respective number of workmen employed, which may be considered representative of the industry in the present century, are as shown in Table 1.

TABLE 1
NORTH STAFFORDSHIRE POTTERY INDUSTRY :
PERSONS EMPLOYED IN VARIOUS SECTIONS

General earthenware	25,387
China	7,200
China and earthenware (mixed) .. .	5,053
Sanitary earthenware	3,062
Earthenware tiles	6,804
Electrical porcelain	5,563
Jet and Rockingham	1,753
All sections	54,822

Women and girls constitute 55 per cent. of all operatives, but they are mainly employed in the manufacture of tiles and in decorating processes.

Potters' rot or potters' asthma, silicosis or silicosis accompanied by tuberculosis, is a well-recognized risk of work in the industry, and each year causes a considerable number of deaths (Annual Reports of H.M. Chief Inspector of Factories).

Over the last seventeen years this represents an annual incidence of 44 deaths, with an average age at death of 59.1 years (Table 2).

During the years 1931-1946 the Stoke-on-Trent panel of the Medical Board for Silicosis, in pursuance of their statutory duties, attended 750 necropsies in local pottery workers. In each case the death of the workman had been reported to H.M. Coroner by a medical practitioner, a Registrar of Deaths,

a relative, or a trade union official, so that inquiry might be made into the cause of death, with particular reference to silicosis. The primary object of the procedure was in relation to claims for workmen's compensation. In practice this meant that almost every death occurring in potters exposed to the risk of silicosis was investigated by post-mortem examination. For various reasons the Medical Board were unable to be present at every necropsy, but attendance was made at 90 per cent. of the total cases. Only those actually attended are included in this paper, otherwise there has been no selection. The series probably represents the largest group which has come under the notice of one observer in any single industry or process in Great Britain.

TABLE 2
SILICOSIS OR SILICOSIS ACCOMPANIED BY TUBERCULOSIS :
FATAL CASES
(Great Britain)

Year	No. of deaths	Average age at death (in years)
1932	53	56.6
1933	53	57.6
1934	43	58.1
1935	54	57.2
1936	42	57.3
1937	63	58.5
1938	52	58.1
1939	46	59.4
1940	48	60.4
1941	41	59.3
1942	40	59.7
1943	32	60.3
1944	30	55.4
1945	32	62.9
1946	35	62.2
1947	43	61.5
1948	45	62.5

The cause of death as certified after full pathological investigation may be summarized as in Table 3. No death occurred in the manufacture of Jet and Rockingham ware, that is the manufacture of brown teapots from local marls; but, as shown below, they were distributed over all other sections.

From these figures it is not possible to compute comparative mortality rates for the separate groups; this has been dealt with by Middleton (1936). It should be noted that the disease occurs in women; clinical experience suggests that the sexes react alike to the risk.

Note on Cases in China (Clay Processes).—English bone china is composed of Cornish stone, china clay, and calcined bone, but unlike earthen-

ware contains no added flint or free silica. Accordingly it has always been difficult to account for cases of silicosis in the clay processes of china manufacture, especially as these workmen are highly skilled and there is little or no interchange of labour between the china and earthenware sections of the industry, or between flint and clay processes. To some extent powdered flint, before alumina was substituted for it (Plant, 1939), was used as a parting powder on the boards on which the ware is carried; and there was universal contamination of all working places by flint from the placing shops, the ovens, and the china biscuit warehouse. Indeed, it was a well-known fact that powdered flint was dispersed into the streets adjoining china manufactories. These are relevant facts, but it is not claimed that they contain the whole explanation for the occurrence of silicosis in this branch of the industry.

TABLE 3
CERTIFIED CAUSE OF DEATH

Cause of death	No. of cases	%
Silicosis	217	28.9
Silicosis accompanied by tuberculosis	241	32.1
Other causes (silicosis present) ..	142	19.0
Other causes (no silicosis) ..	150	20.0
All causes	750	100.0

Certified Cause of Death (Group Analysis and Commentary)

No Silicosis.—In 150 cases there was no evidence of silicosis even after histological investigation by Dr. S. Roodhouse Gloyne (Tables 4 and 5).

The predominance of respiratory diseases is of no statistical significance, as the series did not include all, or even a random sample, of deaths among potters. There was selection in that only such cases as might reveal silicosis were reported to the

TABLE 4
CAUSE OF DEATH ACCORDING TO OCCUPATION OR PROCESS

Occupation or process	Cause of death				All causes
	Silicosis	Silicosis + tuberculosis	Other causes (silicosis present)	Other causes (no silicosis)	
China-flint processes	24 (6)	32 (8)	14	11 (1)	81 (15)
China-clay processes	8 (1)	12 (1)	6	13 (1)	39 (3)
Polisher	12	15	2	6	35
Millman	21	23	10	18	72
Earthenware biscuit placer	7	2	10	28	47
General earthenware-clay processes..	97 (5)	113 (15)	80 (4)	59 (17)	349 (41)
Sanitary earthenware	22	28	19	7	76
Earthenware tiles	22 (4)	14 (10)	1	2 (1)	39 (15)
Electrical porcelain	4	2	—	6	12
All	217 (16)	241 (34)	142 (4)	150 (20)	750 (74)

The bracketed numbers, in this and other tables, indicate females and are included in the totals.

coroner. For the same reason it is not permissible to argue that the high proportion of deaths from pulmonary tuberculosis suggests that this condition may be related to the inhalation of silica even in the absence of manifest silicosis. Chemical analysis

TABLE 5
CAUSE OF DEATH IN 150 CASES IN WHICH THERE
WAS NO EVIDENCE OF SILICOSIS

Cause of death	Men	Women	Persons
Tuberculosis of lungs ..	34	13	47
Primary bronchial carcinoma	10	1	11
Other respiratory diseases	34	1	35
Influenza	4	—	4
Cardio-vascular diseases	29	3	32
Renal diseases	4	1	5
Malignant diseases : other organs	6	—	6
Miscellaneous	9	1	10
All diseases	130	20	150

of the ash of the whole or a part of a lung and micro-incineration of sections were for a time undertaken but were abandoned as of no practical value.

Eleven deaths were attributed to primary bronchial carcinoma ; full reference will be made to this subject later.

The age at death (Table 6) reveals a point of interest. The potter is a highly skilled craftsman, entering his trade on leaving school and continuing it throughout his working life. As will appear later in Tables 7, 10, and 13, the disease, silicosis or silicosis accompanied by tuberculosis, is frequently manifest after the age of forty years, yet, as Table 6 shows, a workman may spend a whole lifetime in dangerous processes without contracting the disease. This conforms to experience in other silicosis-producing industries and processes. The disease involves the problem of soil as well as seed.

Silicosis Accompanied by Tuberculosis.—In this context tuberculosis means active tuberculosis of the lungs (T.B. plus), and in 241 cases the combined disease was the cause of death. The distribution of these by age group and occupation is set out in Table 7.

The relatively high incidence of fatal tuberculosis in late middle life is apparent which accords with

TABLE 6
AGE AT DEATH IN RELATION TO OCCUPATION OR PROCESS (150 CASES)

Age group	Occupation or process									All
	China (flint)	China (clay)	Polisher	Mill-man	Earth. bisc. placer	Gen. earth. (clay)	San. earth. (clay)	Earth. tiles	Elect. porc.	
Under 20 ..	—	—	—	—	1	2 (2)	—	—	—	3 (2)
20-24	—	—	1	—	1	2 (1)	—	1 (1)	—	5 (2)
25-29	—	—	1	—	1	3 (2)	—	—	—	5 (2)
30-34	1	1	1	—	2	3 (3)	—	—	—	8 (3)
35-39	—	1	—	2	1	3 (3)	—	—	—	7 (3)
40-44	2	3 (1)	—	1	2	5 (3)	1	—	3	17 (4)
45-49	3	2	—	1	4	7 (1)	4	—	—	21 (1)
50-54	—	—	3	6	8	13 (1)	—	—	—	30 (1)
55-59	4 (1)	2	—	5	3	7	1	—	1	23 (1)
60-64	—	2	—	2	3	6	—	—	—	13
65-69	—	1	—	1	2	4	1	—	2	11
70+	1	1	—	—	—	4 (1)	—	1	—	7 (1)
All ages ..	11 (1)	13 (1)	6	18	28	59 (17)	7	2 (1)	6	150 (20)

the original observations of Brownlee (1920) on the epidemiology of phthisis in Great Britain among workers in silica.

Reference to Table 3 reveals that there was evidence of silicosis in some degree in 600 cases, and in 241 this was combined with active tuberculosis of the lungs. Tuberculosis is recognized as the most common and fatal complication of silicosis, but this incidence (40 per cent.) is considerably below what is usually accepted. The explanation of this is not easy but there are several possibilities. It may be that some authors have computed the incidence of complicating tuberculosis as a percentage of the deaths actually attributed to silicosis or silicosis accompanied by tuberculosis, thereby omitting those cases in which silicosis was present but in which death was due to "other causes." In this instance 241 cases would thereby be related to 458 cases (silicosis 217, silicosis accompanied by tuberculosis 241), which represents 53 per cent.

On the other hand the estimates may have been based on the clinical diagnosis of the disease, in which tuberculosis or phthisis did not necessarily involve tubercle bacilli in the sputum.

As will appear later (Table 11), in 178 out of 217 cases of silicosis the disease was of the confluent or massive type, a lesion which has been variously described as infective silicosis or silico-tuberculosis. In the overwhelming majority of these, wasting and general physical deterioration were characteristic, so that on clinical grounds, in the absence of post-mortem examination, death might quite rightly be attributed to what the older physicians designated "fibroid phthisis." From this it would follow that 419 of 600 cases, or on the other basis specified, 419 of 458 cases, representing respectively 70 and 91 per cent., were due to fibroid phthisis, though this is not synonymous with silicosis accompanied by active tuberculosis.

There is another fact which may be relevant, namely that nowadays silicosis in potters is, with rare exceptions, a disease of late middle or advanced age, just when death from acute intercurrent or degenerative diseases is most frequent. In such circumstances the disease may not be permitted to pursue its natural course because it is prematurely interrupted by the extraneous condition. In 1892 Arlidge (cited by Collis, 1919) recorded that, "The mean age at death of male potters, aged twenty and upwards, was forty-six and a half years, while that of non-potters stood at fifty-four." Now by contrast the average age at death from silicosis or silicosis accompanied by tuberculosis among potters is fifty-nine years (Table 2). This association of tuberculous infection and pneumoconiosis, the problem of soil and seed, is still the outstanding

unresolved scientific problem in this field. The preceding discussion emphasizes the need for precise definition of the methods used in compiling statistical data bearing on this aspect of the problem.

An interesting subject for consideration is the degree of silicosis associated with fatal tuberculosis of the lungs, especially as it involves the legal significance of 'silicosis accompanied by tuberculosis' under Workmen's Compensation or, as it now is, under the National Insurance (Industrial Injuries) Act, 1946. To examine this in the present group, silicosis has been divided into macroscopic nodular silicosis, confluent or massive silicosis, and silicosis which is not obvious to the naked eye but can be proved by microscopic examination (Table 8).

The conclusion is that tuberculosis may become manifest and may progress to a fatal termination even when the degree of silicosis is minimal, and, what is very important, when it is unlikely to be detectable on radiographic examination of the lungs. There is the further practical consideration that every case of silicosis that has reached a diagnosable stage is potentially a case of active tuberculosis, involving danger to contacts in the home and at work. All certified cases of silicosis should be under periodical medical supervision at a chest clinic.

In those cases in which gross tuberculosis is associated with microscopic or even slight nodular silicosis, it is frequently asserted that the silicosis is merely a coincidental lesion and that the two conditions are not causally related. Furthermore the question is often raised which condition came first. Such nice discrimination is not possible and so far as the legal problem, in respect of Workmen's Compensation, is concerned, the statute has recognized the difficulties and resolved them in the designation, "silicosis accompanied by tuberculosis"; there is no question either of degree or of priority.

During life the physician is frequently confronted with a patient who has been exposed to a recognized silica hazard and in whom the clinical and radiographic picture is one of extensive tuberculosis of the lungs. In such a case it is fatuous to imagine that it is possible to distinguish radiographically between silicotic and tuberculous opacities and it is extremely doubtful whether the age of the patient affords any clue. As questions of Workmen's Compensation or Industrial Injury are involved, the diagnosis must differentiate between simple tuberculosis and silicosis accompanied by tuberculosis. All that is possible is a presumptive diagnosis based almost entirely on a critical assessment of the risk as revealed by a precise detailed occupational history. By this means experts

TABLE 7
AGE AT DEATH IN RELATION TO OCCUPATION OR PROCESS: SILICOSIS ACCOMPANIED BY TUBERCULOSIS

Age group	Occupation or process									All
	China (flint)	China (clay)	Polisher	Mill-man	Earth. bisc. placer	Gen. earth. (clay)	San. earth. (clay)	Earth. tiles	Elect. porc.	
Under 20 ..	—	—	—	—	—	—	—	—	—	—
20-24	—	—	—	—	—	—	—	—	—	—
25-29	—	—	—	—	—	—	—	1 (1)	—	1 (1)
30-34	—	—	—	—	—	—	1	2 (1)	—	3 (1)
35-39	1	—	1	—	—	3 (1)	1	2 (2)	—	8 (3)
40-44	1	1	5	5	—	12 (5)	1	4 (2)	—	29 (7)
45-49	3 (3)	1	2	3	—	12 (5)	3	3 (3)	—	27 (11)
50-54	10 (4)	1	2	5	—	23	6	1 (1)	—	48 (5)
55-59	8 (1)	1	1	4	—	21 (2)	—	—	1	36 (3)
60-64	5	3 (1)	2	5	1	16 (2)	7	—	—	39 (3)
65-69	2	3	2	1	1	22	4	1	—	36
70+	2	2	—	—	—	4	5	—	1	14
All ages ..	32 (8)	12 (1)	15	23	2	113 (15)	28	14 (10)	2	241 (34)

TABLE 8
DEGREE OF SILICOSIS ASSOCIATED WITH FATAL TUBERCULOSIS

Occupation or process	Degree of silicosis			Total
	Microscopic	Nodular	Confluent	
China (flint)	6 (3)	7 (2)	19 (3)	32 (8)
China (clay)	5 (1)	2	5	12 (1)
Polisher	1	9	5	15
Millman	3	8	12	23
Earth. biscuit placer	—	—	2	2
General earth. (clay)	25 (7)	37 (4)	51 (4)	113 (15)
Sanitary earth.	5	11	12	28
Earth. tiles	1 (1)	5 (3)	8 (6)	14 (10)
Elect. porcelain	—	2	—	2
All	46 (12)	81 (9)	114 (13)	241 (34)

achieve almost complete accuracy, as may be proved later by post-mortem examination of patients who have died.

Chronic ulcerative tuberculosis is not uncommon in silicotic cases, but a terminal acute disseminated tuberculosis of the lungs, having its origin in a small localized cavity, is a fairly frequent finding. Tuberculous pneumonia also occurs, and cannot always be distinguished by naked eye examination from non-tuberculous varieties. This also applies to pericarditis in these cases. On several occasions tubercles and tubercle bacilli were demonstrated in the heart muscle. These observations show how important it is that the histological examination should always include sections suitably stained for tubercle bacilli. If the presence or absence of silicosis in cases of gross tuberculosis is to be determined, much depends on the selection of suitable histological material. The hilum glands should always be examined, together with blocks of tissue from the apparently healthy part of the lung. As far as possible these should include the pleura.

Silicosis accompanied by tuberculosis is certainly more rapidly fatal than simple silicosis, but this does not signify that tuberculosis associated with silicosis

is a more fulminating type than simple tuberculosis, as is suggested by Collis (1919), Nicholson (1923), Thompson and Ford (1927), and Heffernan (1926). Beattie (1916) submits the contrary, namely, that the silicotic fibrosis may actually hinder the progress of the associated tuberculosis. The present series did not reveal any difference, which accords with our experience in a group of 310 Sheffield metal and cutlery grinders who were specifically investigated with this problem in view (Meiklejohn, 1929).

TABLE 9
FATAL HÆMOPTYSIS IN TWENTY-THREE CASES

Disease	No. of cases	Fatal hæmo- ptysis
Simple tuberculosis ..	47 (13)	5 (1)
Silicosis + tuberculosis ..	241 (34)	18 (5)

The terminal event in 23 cases was fatal hæmoptysis (Table 9).

Silicosis without Tuberculosis.—There remain for consideration 359 cases (Table 3) in which silicosis

TABLE 10
DEATH DUE TO SILICOSIS: AGE AT DEATH IN RELATION TO OCCUPATION OR PROCESS

Age group	Occupation or process									All
	China (flint)	China (clay)	Polisher	Mill- man	Earth. bisc. placer	Gen. earth. (clay)	San. earth. (clay)	Earth. tiles	Elect. porc.	
Under 20 ..	—	—	—	—	—	—	—	—	—	—
20-24	—	—	—	—	—	—	—	—	—	—
25-29	—	—	—	—	—	—	—	—	—	—
30-34	—	—	—	—	—	—	—	2 (2)	—	2 (2)
35-39	—	—	—	—	—	—	—	—	—	—
40-44	1 (1)	—	1	2	—	1	—	3 (1)	1	9 (2)
45-49	1	—	1	3	—	1	—	—	1	7
50-54	5 (1)	1	3	1	1	11 (1)	1	6	—	29 (2)
55-59	7 (3)	1	4	4	2	18 (1)	5	2 (1)	1	44 (5)
60-64	8 (1)	1	1	6	3	24 (3)	8	4	1	56 (4)
65-69	2	3	2	3	—	29	7	5	—	51
70+	—	2 (1)	—	2	1	13	1	—	—	19 (1)
All ages ..	24 (6)	8 (1)	12	21	7	97 (5)	22	22 (4)	4	217 (16)

TABLE 11
DEATH DUE TO SILICOSIS : MODE OF DEATH AND RELATED DEGREE OF SILICOSIS

Terminal event	Degree of silicosis			Total
	Microscopic	Nodular	Confluent	
Inanition	—	2	46 (3)	48 (3)
Heart failure : sudden	—	1	12 (1)	13 (1)
congestive	2	14	52 (2)	68 (2)
progressive	—	2	14 (3)	16 (3)
Pericarditis	1	—	1	2
Syphilitic mesaortitis	—	—	3	3
Pneumonia	—	15 (1)	31 (3)	46 (4)
Bronchiectasis	—	—	1	1
Spontaneous pneumothorax	—	—	4 (1)	4 (1)
Influenza	—	1	9 (2)	10 (2)
Nephritis	—	1	1	2
Miscellaneous	—	—	4	4
All	3	36 (1)	178 (15)	217 (16)

TABLE 12
DEATH DUE TO "OTHER CAUSES" (SILICOSIS PRESENT) : MODE OF DEATH AND RELATED DEGREE OF SILICOSIS

Terminal event	Degree of silicosis			Total
	Microscopic	Nodular	Confluent	
Heart failure : sudden	12	1	—	13
Cardio-vascular degeneration	18	4	—	22
Syphilitic mesaortitis	2	2	—	4
Pneumonia	17 (1)	—	—	17 (1)
Bronchiectasis	2	—	—	2
Primary bronchial carcinoma	7	1	5	13
Influenza	2	—	—	2
Nephritis	9	3	3 (1)	15 (1)
Cystitis and hydronephrosis	1	1	—	2
Cerebral hæmorrhage and thrombosis	2	3	2	7
Malignant disease : various organs	7 (1)	8	5	20 (1)
Miscellaneous diseases	12 (1)	7	6	25 (1)
All	91 (3)	30	21 (1)	142 (4)

TABLE 13

DEATH DUE TO OTHER CAUSES " " (SILICOSIS PRESENT) : AGE AT DEATH IN RELATION TO OCCUPATION OR PROCESS

Age group	Occupation or process									Total
	China (flint)	China (clay)	Polisher	Mill-man	Earth. bisc. placer	Gen. earth. (clay)	San. earth. (clay)	Earth. tiles	Elec. porc.	
Under 20 ..	—	—	—	—	—	—	—	—	—	—
20-24	—	—	—	—	—	—	—	—	—	—
25-29	—	—	—	—	—	—	—	—	—	—
30-34	—	—	—	—	—	—	—	—	—	—
35-39	—	—	—	—	—	—	—	—	—	—
40-44	—	—	1	1	1	3 (1)	—	—	—	6 (1)
45-49	3	—	1	—	—	5 (1)	2	—	—	11 (1)
50-54	—	—	—	1	2	14	—	—	—	17
55-59	6	—	—	—	1	10	4	1	—	22
60-64	4	2	—	4	2	21 (1)	5	—	—	38 (1)
65-69	1	2	—	1	1	15 (1)	4	—	—	24 (1)
70+	—	2	—	3	3	12	4	—	—	24
All ages ..	14	6	2	10	10	80 (4)	19	1	—	142 (4)

was present without any evidence, macroscopic or microscopic, of active tuberculosis. In 217 of these (Table 10) silicosis was adjudged the primary cause of death, though, as will appear in Table 11, the terminal event or illness assumed a variety of forms.

Death in the remaining 142 cases was attributed to "other causes," such silicosis as existed being considered unrelated and non-contributory (Tables 12 and 13).

The "miscellaneous" group includes pernicious anæmia, myelogenous leukaemia, gangrene of the foot, acute transverse myelitis, malignant endocarditis, extra-dural hæmorrhage, acute alcoholic poisoning, acute appendicitis, acute hæmorrhagic pancreatitis, cirrhosis of the liver, cholæmia (gallstones), intestinal obstruction, and rupture of aortic aneurysm.

Certain matters merit brief comment.

Inanition.—In cases of massive silicosis of long-standing this is a fairly common terminal event. Through lack of sleep, loss of appetite, and the physical-exhaustion associated with harassing cough and distressing dyspnœa, the patient progressively deteriorates; life just fades out. The condition is an entity and should not be classified as cardiac failure.

The Heart and Heart Failure.—The heart and mediastinum are seldom obviously displaced or distorted, this probably being due to firm fixation by the generalized intra-thoracic adhesions that are so characteristic of silicosis. In the clinical assessment of cases the extent and significance of these adhesions are frequently overlooked, a fact that emphasizes the need for fluoroscopic examination as a preliminary to radiography.

The size of the heart in silicosis shows no constant alteration and is not directly related to the degree of lung fibrosis. In the most advanced stages of massive consolidation, where the disease is known to have existed for many years, the heart may be of normal size. Whenever possible the organ was weighed, and while there was a tendency to a slight increase, this seldom exceeded a few ounces except in cases of concomitant disease. The increase is due to hypertrophy of the muscle of the right ventricle and is particularly obvious in cases with emphysema. Gross enlargement with increase of weight is usually associated with hyperpiesia, syphilitic aortitis, chronic endocarditis, or renal disease. The significance of these observations is that cardiac enlargement is seldom to be detected clinically or radiographically in cases of silicosis and when gross

enlargement does appear it is usually due to some other disease.

The classification of heart failure into sudden, congestive, and progressive may appear unnecessarily precise, but it does serve to reflect three well-defined clinical pictures of the disease in the terminal phase and is not without value in prognosis. In sudden death the workman, apparently in his usual health, expires more or less instantaneously and at necropsy the characteristic feature is considerable dilatation of the right ventricle. Cases in which definite coronary occlusion was established as the cause of the event are not included but appear as deaths due to "other causes (silicosis present)." Congestive heart failure denotes those patients who during the last few weeks or months become increasingly dyspnoeic, with congestion and cyanosis of the face and extremities, but in whom dropsy is not present. They manage to keep walking about at home and they are confined to bed only during the last few days. At necropsy the right ventricle and auricle are considerably dilated and distended with blood clot. Finally there are those patients who develop oedema, which, commencing round the ankles, gradually extends and is followed by anasarca, ascites, and even hydrothorax. This is usually a long illness during which the patient is bedridden. Such cases are uncommon nowadays.

Attention was directed to the occurrence of sclerosis of the pulmonary vessels at the hilum, but of this there was no evidence. Extensive atheromatous degeneration of the abdominal aorta and its branches was common, even when the thoracic aorta was comparatively healthy.

Chronic Nephritis.—Collis and Yule (1933) have asserted that in their opinion renal disease is more common in silicotics than among the general population of corresponding age. This is not supported by the present survey and does not accord with clinical experience.

The Lungs and Pleura.—Attention has already been directed to the occurrence of adhesions. These are usually sessile and tough, and often result in complete obliterative pleurisy. Over the apices, particularly in cases of massive fibrosis, the pleura may be one quarter of an inch in thickness and may resemble cartilage. The attachment of the lung to the chest wall is particularly noticeable over the apices posteriorly, which helps to explain the clinical observation of marked impairment of percussion in these zones posteriorly while resonance anteriorly over the clavicles persists. Having regard to the extent and density of the adhesions it is interesting to note how rarely the intra-thoracic nerves are involved. In clinical practice I recall only two cases

of laryngeal and one of diaphragmatic paralysis. Similarly traction diverticula of the oesophagus are seldom revealed at necropsy, though this does not mean they may not be demonstrated more often radiographically during life.

Emphysema, a frequent complication, is of the bullous type in which the bullae appear as bunches of grapes of varying size along the free margins of the lungs, over the bases, and occupying the costo-diaphragmatic sulci. Bullae as large as tangerine oranges are not uncommon. Rupture of a bulla results in pneumothorax, but by reason of the adhesions it is usually localized. In the present series four such cases proved fatal, no doubt because of the associated massive silicosis and cardiac embarrassment. The main bronchi show slight fusiform dilatation, but frank bronchiectasis is exceedingly rare. This recalls the fact that clinically clubbing of the fingers and toes is not a feature of silicosis.

In the early fine nodular stage of the disease, if the pleura is comparatively normal, a very characteristic post-mortem appearance is mammillation of the visceral pleura. Small sago pearls, tiny subpleural silicotic nodules with an areola of carbon pigment, protrude from the surface of the lung. The hilum glands are enlarged, fibrotic, rubbery, and deeply pigmented with carbon. As a broad generalization it may be said that if the root glands are not silicotic then one is unlikely to discover silicotic nodules in the lung parenchyma; on the other hand if the glands are involved it does not follow that characteristic lesions will necessarily be found in the lung tissue; if the lungs reveal nodules then the glands will also show fibrotic changes.

The mature silicotic nodule is usually described as gritty or shotty to the touch, but this is rather misleading in that it tends to suggest palpable aggregates of silica and does not convey the firm rubbery texture of the redundant fibrous tissue. Even so it has not the elasticity of the lung parenchyma, so that when a cut is made in the lung the nodules stand out on the cut surface and are visible as well as palpable.

In the massive infective type of silicosis the individual confluent nodules are not identifiable, and indeed one is impressed in such cases by the paucity of discrete nodules elsewhere in the lung. The centre of these masses is often excavated and the cavity is filled with black, oily debris closely resembling dirty motor lubricating oil. At times there is no actual defined cavity but the fibrotic tissue appears as if it had been gnawed by a mouse. There are many who consider these appearances indicative of tuberculosis. All such cases were carefully investigated, but in many the presence of tuberculosis could not be established even by

guinea-pig inoculation. The blood supply to the central area is often poor and, as revealed by histological examination, associated with vascular degeneration, so that ischaemic necrosis is a possible explanation. On the other hand it may be that the characteristic histological appearances of the tubercle are greatly altered in these cases and so are misinterpreted. While the classical silicotic nodule and the simple tubercle are well-defined entities familiar to the expert histologist, the combined lesion is not so readily identified and often leads to differences of opinion. This was confirmed when portions of the same material were submitted to a panel of expert pathologists.

TABLE 14
PRIMARY BRONCHIAL CARCINOMA: NO SILICOSIS
130 males: 20 females

No.	Sex	Age	Lung	Remote meta-stases	Occupation or process
1	F	40	L	None	General earthenware (clay)
2	M	51	R	None	General earthenware (clay)
3	M	47	R	None	Sanitary earthenware
4	M	59	R	None	Millman
5	M	60	R	None	Millman
6	M	43	R	Kidneys	Electrical porcelain
7	M	65	R	None	Electrical porcelain
8	M	47	R	None	China: flint
9	M	49	R	None	China: clay
10	M	56	R	None	General earthenware (clay)
11	M	53	R	Liver	General earthenware (clay)

Influenza and Pneumonia.—In certain cases of influenza the intense brick red coloration of the parietal pleura was very striking. Death from massive pneumonia, within a few days of onset, occurred from time to time, and necropsy followed within a few hours. In some of these cases the visceral pleura over the consolidation was raised in tiny blebs, of various sizes, like a coarse irregular herpetic eruption. The condition seemed to represent acute emphysema of superficial air vesicles.

Primary Bronchial Carcinoma.—During recent years a good deal of attention has been directed to the possible relationship of primary bronchial carcinoma and the inhalation of silica. Anderson and Dible (1938) submit that: "A group of cases of pulmonary cancer exists, in which the organs contain an excess of silica and show histological evidence of silicotic fibrosis. The conclusion we think is that the role of silica is aetiological."

In this series thirteen cases of bronchial carcinoma among 359 persons were noted in association with simple silicosis, while two cases occurred among the 241 patients who died of silicosis accompanied by tuberculosis. On the other hand eleven cases of bronchial carcinoma occurred among the 150 cases in which there was no evidence of silicosis, though it should not be overlooked that most of these workmen had long periods of exposure to the inhalation of silica, free and combined. On this evidence and the recorded experience of other observers, we are not sufficiently convinced to subscribe to the conclusion quoted.

Brief details in Tables 14, 15, and 16 may be of interest.

Dr. S. Roodhouse Gloyne undertook the histological examination and with the exception of a few cases of squamous or mixed cell carcinoma, all others were reported as oat-cell type.

Other Organs.—There was no convincing evidence of general systemic intoxication, with damage to organs or tissues apart from the lungs, which might be attributed to the inhalation and excretion of silica.

Silicotic fibrosis was occasionally observed in abdominal glands but, though search was made, we were never satisfied that silicotic nodules might occur in the spleen.

Summary

Silicosis is a serious and widespread disease among workmen engaged in the manufacture of pottery in the North Staffordshire area of Great Britain. Each year it causes the death of between forty and fifty persons. Between 1931 and 1946 the Stoke-on-Trent panel of the Medical Board for Silicosis attended the necropsy in 750 cases in which there was reason to suspect that death might have been caused by silicosis or silicosis accompanied by tuberculosis. The findings are analysed and tabulated. Among the subjects selected for special comment are: (1) cases occurring in china clay processes; (2) tuberculosis in relation to silicosis; (3) inanition; (4) the heart and heart failure in silicosis; (5) chronic nephritis; (6) morbid anatomical changes in the lungs and pleura; (7) primary bronchial carcinoma.

TABLE 15
PRIMARY BRONCHIAL CARCINOMA : SILICOSIS PRESENT
339 males : 20 females

No.	Sex	Age	Lung	Remote metastases	Degree of Silicosis	Occupation or process
1	M	56	R	None	Microscopic	Gen. earth : clay
2	M	70	R	Liver	Microscopic	Gen. earth : clay
3	M	64	R	Liver	Confluent	Gen. earth : clay
4	M	50	R	None	Microscopic	Gen. earth : clay
5	M	45	L	None	Miscroscopic	San. earth.
6	M	46	R	Suprarenals and parotid	Microscopic	Polisher
7	M	56	L	None	Confluent	Earth. tiles
8	M	71	L	None	Confluent	Millman
9	M	48	L	Liver	Microscopic	China : flint
10	M	64	L	None	Confluent	China : flint
11	M	64	L	None	Confluent	China : flint
12	M	57	R	None	Nodular	China : flint
13	M	60	R, L	Skull	Microscopic	Gen. earth. : clay

TABLE 16
PRIMARY BRONCHIAL CARCINOMA : SILICOSIS ACCOMPANIED BY TUBERCULOSIS
207 males : 34 females

No.	Sex	Age	Lung	Remote metastases	Degree of silicosis	Occupation or process
1	M	57	R	Liver	Confluent	Gen. earth.: clay.
2	M	58	L	None	Microscopic	Millman

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