T R A D E D U S T S.

Thesis presented for the Degree of D.Sc.
by
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THIS THESIS consists of a series of reports on the examination of men exposed to the effects of certain trade dusts, and a commentary on some of the points arising therefrom.

The first report deals with the sandstone industry, the second with mica dust, the fourth with basic slag and the sixth with malthouse dusts. The third and fifth describe interesting cases of pulmonary fibrosis following exposure respectively to dusts of coal and boiler flues.

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REPORT I.

SILICOSIS among SANDSTONE WORKERS in SCOTLAND and THE NORTH OF ENGLAND.

The excessive liability of stone workers to pulmonary disease has long been known. The Report of Drs. Sutherland and Bryson on "The Occurrence of Silicosis among Sandstone Workers", published in 1929, helped to crystalise knowledge regarding the real prevalence of the disability.

It is hoped that the publication of some notes, based on the examination of 1,000 consecutive sandstone workers, may be of interest in supplementing previous research, affording a picture of the industry as a whole in the area under consideration, as distinct from selected groups of men.

Table I sets out certain data classified according to the period of employment of the workpeople in the industry and the particular occupation in which they were employed at the date of examination. It shows for each quinquennial period of exposure the number of men examined, the number found to show clinical evidence of pulmonary fibrosis, the number X-rayed and the number found on radiological examination to be suffering from silicosis.

TABLE/

TABLE I.

RESULTS OF 1,000 CONSECUTIVE EXAMINATIONS OF SANDSTONE WORKERS.

Occupation.	EXPOSURE IN YEARS.																													
	0 - 5				5 - 10				10 - 15				15 - 20				20 - 25				25 - 30				30 +				TOTAL			
	E	F	X	S	E	F	X	S	E	F	X	S	E	F	X	S	E	F	X	S	E	F	X	S	E	F	X	S	E	F	X	S
Foremen	3	1	0	0	2	1	0	0	2	1	0	0	2	1	0	0	6	3	0	0	6	5	2	2	16	16	9	4	37	28	11	6
Masons	12	1	0	0	10	1	0	0	6	4	4	2	4	2	1	0	10	9	8	6	14	12	10	9	16	15	11	10	72	44	34	27
Scapplers and delvers ...	47	7	0	0	45	11	0	0	17	5	0	0	8	4	1	0	23	17	8	5	29	28	16	11	49	46	36	31	218	118	61	47
Grindstone turners	0	0	0	0	4	0	0	0	2	1	0	0	1	1	0	0	3	2	0	0	1	1	1	1	3	3	1	1	14	8	2	2
Planers	7	1	0	0	18	2	0	0	6	1	0	0	6	5	1	0	8	7	4	0	7	7	2	1	13	12	7	3	65	35	14	4
Grindstone holers	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	2	1	1	1	2	0	0	0	5	1	1	1
Drillers	4	1	0	0	5	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	2	1	0
Crushermen	8	3	0	0	5	3	0	0	0	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	14	7	1	0
Rockgetters	23	3	0	0	23	3	0	0	8	5	0	0	11	7	3	1	11	8	4	4	12	10	4	2	37	30	19	9	125	66	30	16
Sawyers	8	0	0	0	4	1	0	0	4	1	0	0	2	1	0	0	2	2	0	0	4	3	1	0	2	2	1	0	26	10	2	0
Labourers and barers	143	25	0	0	53	13	1	0	17	9	0	0	10	5	2	1	7	3	0	0	7	4	4	2	4	3	1	1	241	62	8	4
Wallstone dressers	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	0	0	0	0	1	1	1	1
Cranemen	3	0	0	0	19	5	1	0	7	5	1	0	8	2	0	0	5	2	0	0	5	4	0	0	6	5	1	1	53	23	3	1
Blacksmiths	6	0	0	0	3	2	0	0	2	1	0	0	2	1	0	0	3	0	0	0	2	1	0	0	2	2	2	0	20	7	2	0
Fitters	3	1	0	0	3	0	0	0	3	2	0	0	0	0	0	0	3	3	1	0	2	0	0	0	0	0	0	0	14	6	1	0
Motormen	8	0	0	0	11	0	0	0	4	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	23	1	1	0
Others	36	2	0	0	13	5	0	0	1	1	0	0	1	0	0	0	3	2	0	0	1	0	0	0	7	4	0	0	62	14	0	0
All occupations	311	45	0	0	218	47	2	0	80	38	7	2	56	30	9	2	85	58	25	15	93	77	42	30	157	138	88	60	1000	433	173	109

E = Number examined. F = Number found to show pulmonary fibrosis. X = Number X-rayed. S = Number found to have silicosis.

The precise nature of the occupations mentioned has been described in detail by Drs. Sutherland and Bryson. Skilled masons work to accurate measurements, using wooden mallet and chisel. Scapplers do rougher shaping, using chiefly the pick, while rockgetters procure the stone from the quarry, using mainly crowbars, drills, hammers and wedges. The sawyers examined were all working with stone artificially drenched with water.

A striking point is the high amount of morbidity present. It was impracticable to submit to radiological examination all the workers showing clinical evidence of fibrosis: doubtless further cases of silicosis would have been brought to light had it been possible to do so, but, generally, the cases x-rayed were those showing the most severe fibrosis and those in which there seemed most reason to suspect the presence of silicosis.

From the Table it appears that even workers of less than ten years exposure may show some increase in pulmonary fibrosis. After 10 years exposure there is a sharp rise in the development of fibrosis, while after 20 years exposure there is a correspondingly sharp rise in the development of silicosis. Precise occupation appears to make little difference to development of fibrosis, but does influence development of definite nodular silicosis. In general, the average time interval between the development of fibrosis and silicosis appears to range from about ten years upwards, being shorter in the occupations producing most exposure to dust.

It has to be borne in mind that the figures in Table I are classified according to the workers' occupations at the time of examination. They cannot be held to represent accurately the risk attendant on the several occupations, since many of the men concerned have, in the course of their working lives, carried on several classes of work in turn - particularly

so/

so in the case of small quarries. Table II deals with 420 men whose occupation has, for all practical purposes, remained unchanged during their work in the stone industry. It sets out for ten-yearly periods of employment facts similar to these recorded in Table I: The same abbreviation are used:

Table II.

Men who have worked only as	Exposure in years. 0-10				10-20				20-30				30 +				Total.			
	E	F	X	S	E	F	X	S	E	F	X	S	E	F	X	S	E	F	X	S
Masons.	21	3	0	0	8	4	4	2	21	18	16	13	14	12	10	8	64	37	30	23
Scapplers.	34	9	0	0	7	2	1	0	24	21	15	11	20	19	16	14	85	51	32	25
Rockgetters.	18	3	0	0	7	6	2	0	5	3	2	1	12	12	7	5	42	24	11	6
Labourers.	157	26	0	0	14	11	2	1	7	5	2	0	5	4	0	0	183	46	4	1
Planers.	10	1	0	0	2	1	0	0	6	6	4	1	4	4	4	1	22	12	8	2
Cranemen.	10	3	0	0	5	3	1	0	7	3	0	0	2	1	0	0	24	10	1	0

Generally speaking, the figures in Table II correspond with these in Table I, though the proportion of scapplers found to be silicotic showed an increase, and that of labourers a decrease.

In this series, the minimal exposure among masons showing definite nodular silicosis was 11 years; among scapplers, 20 years; among rockgetters, 21 years; and among planers 28 years. (Drs. Sutherland and Bryson have reported a case of silicosis in a mason of 8 years standing).

The cases examined fall into four broad geographical areas, and Table III summarises the results obtained in each.

Table III. Clinical findings in relation to geographical distribution.

Exposure /

	Exposure in years.																			
	0-10				10-20				20-30				30 +				Total.			
District.	E	F	X	S	E	F	X	S	E	F	X	S	E	F	X	S	E	F	X	S
A.	263	39	2	0	72	36	8	3	107	85	52	37	73	66	47	37	515	226	109	77
B.	56	19	0	0	12	6	3	0	6	4	2	2	4	3	3	1	78	32	8	3
C.	120	19	0	0	25	12	3	0	34	26	6	2	37	33	20	14	216	90	29	16
D.	90	15	0	0	27	14	2	1	31	20	7	4	43	36	18	8	191	85	27	13

Two points must be borne in mind in considering these results. One is that there is no absolutely hard and fast line of differentiation between the areas, and that many quarrymen of the older school are nomadic in their habits, and may have been associated with stone from more than one group. The other is that relatively more fibrotics were x-rayed in district A than in the other three areas - partly, perhaps, because better facilities were available, but chiefly because the results of clinical examination seemed to warrant it. Even after making due allowance for these considerations, however, it is worthy of note that when standardised for occupation and period of exposure the incidence of fibrosis is approximately the same in each of the four areas investigated, while the incidence of silicosis is fairly constant in districts B, C and D, but considerably higher in district A than in the others. This would appear to support the view that the disability due to exposure to stone dust is two-fold: one probably more general in its application (diffuse fibrosis) and the other more specific (nodular silicosis). There is always some measure of diffuse fibrosis associated with silicosis, but in the light of Table III, it is difficult to believe that all the subjects who develope a measure of fibrosis after exposure for a period to dust go on to develope definite nodular silicosis which can be diagnosed radiographically if their exposure is further continued. To what extent is the development of the condition dependent on such other factors as the quality of the stone in

question, the presence of other pathological changes in the lungs, or simply variation in the general health or metabolism of the worker?

The difference in the incidence rate of silicosis in various districts suggests that there are responsible some general considerations peculiar to the district as distinct from the individual workpeople concerned. One such consideration that is self-explanatory is the age of the industry in the area: in a district that has been quarried for many years it is usual to find a high proportion of quarrymen of old standing. So, too, the type of quarrying work carried on is important: broadly speaking, the more highly the stone is finished at the quarry (as in the preparation of grindstones) the higher the risk of silicosis among quarrymen.

Differences in working methods are also of importance. Stone sawing as usually carried out by frame-saw in the area under investigation is essentially a wet process, the stone being kept constantly water-drenched: but it sometimes happens that the sawing is carried on by a slowly revolving saw in the absence of water, when the dust hazard is very considerably increased. Again, rockgetting is performed in several different ways. In some cases the stone is simply levered out with the aid of a crowbar; in others it is blasted out. Sometimes it is hewn out by pick, when the risk may be approximate to that of ordinary rough dressing, while occasionally, though not as often as formerly, it may be got by the process of shearing, the rockgetter isolating his mass of rock by hacking a cleavage round the back of the mass, with the result that he may be working in what is virtually a deep badly-ventilated tunnel with a very high dust concentration.

As regards the nature of the stone worked, varying importance /

importance has been attached to chemical composition, texture and graining.

The composition of four representative sandstones is set out in the Appendix. The stones have been arranged in the order in which silicosis is found in their areas - relatively most in I, least in IV.

The total silica content of I is higher than that of IV, and the difference in the amount of free silica is even more striking, but it is difficult to regard the silica-content as all-important, in view of the high figure shown in III, where the incidence of silicosis is much less than in I. Potash and soda can have little influence, since they are absent in both I and IV, nor can alumina and the oxides of iron. The Table suggests the possible importance of lime and magnesia in association with combined water, which are absent in I but abundant in IV, while II and III present intermediate values.

While all the stones are described in the trade as "fine grained", the size of the quartz grain is found on geological examination to vary widely, being smallest in these stones associated with most silicosis. II and IV are described as "compact" but I is soft and loose-grained, having the lowest crushing stress of the series.

In addition to such general considerations there must be individual circumstances acting to render certain workers more susceptible to the effects of dust than others. In Table I even the highest exposure-groups in the occupations of greatest risk show that some men presented no evidence of silicosis. Several reasons may be advanced to account for these differences in individual susceptibility.

One is the age of the individual in relation to his exposure /

exposure to silica. Table IV deals with this point.

Table IV. The importance of Age and Exposure to Dust in the incidence of pulmonary fibrosis among Sandstone Workers.

Exposure to Dust.									
	Under 5 years.			Over 5 years.			Over 10 years.		
Age.	No. Examd.	No. Fib.	%age Fib.	No. Exd.	No. Fib.	%age. Fib.	No. Examd.	No. Fib.	%age. Fib.
Under 30.	225	18	8.0	127	24	11.0	22	9	40.9
30-40.	42	6	14.3	114	32	29.1	56	20	35.7
40-50.	26	10	38.5	161	102	63.4	128	89	70.0
Over 50.	18	11	61.1	287	227	79.1	265	219	82.1.

It shows that along with an increase in fibrosis associated with advancing years there is in each age group a marked increase with prolonged exposure, but it is difficult to establish any definite influence of age in hastening the development of fibrosis consequent on exposure to silica dust.

Another possible influencing factor is the previous health of the individual. Table V-summarises histories of previous illness given by (a) ascertained silicotics, and (b) all other sandstone workers.

Table V.

	No.	Bronchitis.	Pneumonia.	Pleurisy.	Asthma.	Rheumatism.	Influenza.
Silicotics.	109	23	10	11	2	30	30
Non-silicotics.	891	95	64	49	8	131	224

There is an excessive history of respiratory disease among the workers found to be silicotic, and, curiously enough, an approximately corresponding excess in the amount of rheumatic illness. This latter fact suggests that the increase in the amount of respiratory disease may be attributable ~~largely~~ in part to exposure /

exposure to inclement weather. The incidence of influenza is approximately equal in the two groups.

The habits of the individual probably also play a part. Some men follow their work much more closely than others, and it is a well-known lament in the trade that it is usually the most industrious worker who contracts silicosis.

It seems probable, too, that there are wide individual differences in capacity to deal with inhaled silica. Possibly these differences may prove to be associated with variations in calcium metabolism. This is a field as yet comparatively unexplored, and one which appears to be well worthy of co-ordinated research. The need for such research is emphasised not only by the large amount of chronic ill-health in the industry, but also by the dominance of respiratory diseases as causes of death among sandstone workers, as is evidenced in Table VI.

Table VI. Reputed causes of death among 147 sandstone workers, relatives of the men examined in this investigation.

Cause of Death.	No. of deaths.	Av. Age at death.
Pulmonary Tuberculosis.	6	42.8 years.
Silicosis.	25	53.4 "
Other respiratory diseases.	25	56.2 "
Accidents.	20	50.0 "
Other defined causes.	33	64.2 "
Cause unknown.	38	60.5 "

Clinical Notes:

Of the 1000 workpeople examined, 433 were found to show clinical evidence of pulmonary fibrosis. The relationship of this fibrosis to duration of exposure to siliceous dust has been emphasised, though not all of it is attributable to this cause, since a few men were found to show evidence of definite fibrosis after comparatively trivial exposure.

173 workers showing clinical evidence of pulmonary

fibrosis were x-rayed:

64 were found to show no definite evidence of silicosis.

64 showed silicosis, stage 1 A (early).

33 " " stages 1B and 1C (well-marked).

12 " " stage II (advanced, nodules coalescent).

Table VII summarises particulars relative to duration of exposure and occurrence of symptoms in the several groups.

TABLE VII.

		Not Silicotic.	Silicotic			
			Stage 1A	Stage 1B, 1C.	Stage II.	All silicotics
No.		64	64	33	12	109
Lung most affected	(Right	--	26	8	5	39
	(Left	--	13	1	1	15
(Equal)		--	25	24	6	55
No. showing symptoms.		35	39	24	7	70
Nature of Symptoms.	(Dyspnoea	24	22	15	6	43
	(Cough	22	32	15	6	53
	(Expectoration.	21	23	8	4	35
	(Chest pain.	4	2	3	1	6
Years. Exposure.	(Maximum	42	55	56	61	61
	(Minimum	7	11	21	24	11
	(Average.	27	32	33	34	32.6

These figures indicate that where one lung is affected more than the other by silicosis, the right is likely to be the more seriously involved. 36% of the silicotics were entirely free from symptoms, and even in very gross cases, a high proportion made no complaint. Chest pain was comparatively uncommon. In this series the earliest case of silicosis occurred after 11 years work in the industry: at the other end of the scale it is interesting to note exposures /

exposures as high as 42 years without the development of silicosis. One worker, though showing gross silicosis, was still actively employed after over 60 years in the industry.

On physical examination, retraction of some part of the chest wall was found in 61% of cases of non-silicotic fibrosis, and in 50% of silicotics. Limitation of movement was very commonly observed in both groups of cases. Impairment of percussion note, too, was general, being found in over 96% of both series. Diminution in volume of respiratory murmur was found rather more frequently in the silicotic group than in the other, percentages being 84 and 69. Alterations in quality of the respiratory murmur were often encountered: only in two early cases of silicosis was no such abnormality found, while of the non-silicotics 94% showed similar changes. The alteration most commonly met in both groups was the assumption of a harsh quality. 25% of the silicotics showed in some part of the chest definite bronchial breathing, the proportion being slightly higher in the more severe cases. Bronchial breathing was present in 6% of the non-silicotic fibrotics. Cog-wheel breathing was noted in about 10% of silicotics. Changes in vocal resonance ~~was~~ were common - most frequently the V.R. was increased, sometimes it was diminished, and occasionally it was increased in one area and diminished in another part of the chest. Adventitious sounds of varying character were present in 37% of all the cases submitted for x-ray examination: they were encountered rather more commonly among the cases found to have definite silicosis.

An analysis of the clinical findings suggests that it is not possible to differentiate with any degree of certainty from physical examination between silicotic

fibrosis and that not showing typical radiographic appearances, or to forecast with any considerable certainty the degree of silicotic nodulation likely to be revealed in any particular case. It is comparatively easy to base a diagnosis of fibrosis on the results of physical examination but this investigation confirms the observation of Smith that cases presenting reasonably early silicotic nodulation show no clinical findings which are not present in approximately equal degree in the negative group.

References:

First page. Sutherland C.L., and Bryson S: Report on the Occurrence of Silicosis among Sandstone Workers, H.M. Stationery Office 1929.

Last page. Smith A.R., Silicosis among Rock Drillers, Blasters, and Excavators in New York City. Journal Industrial Hygiene, February, 1929.

Conclusions:

1. The outstanding feature of this investigation is the high amount of pulmonary morbidity found to exist throughout the sandstone industry.

2. There is a pronounced increase in the incidence of pulmonary fibrosis after ten years exposure to siliceous dust, and a corresponding increase in the development of definite nodular silicosis after twenty years exposure. The precise nature of the occupation affects little the incidence of fibrosis but does influence that of silicosis.

3. In this series of examinations the minimal exposure to siliceous dust among masons found to be suffering from silicosis was eleven years, among scapplers twenty years, among rockgetters twentyone years, and among planers twentyeight years.

4. While the amount of pulmonary fibrosis remained fairly constant in four geographical areas, the incidence of silicosis showed considerable variation.

5. It is difficult to determine any definite influence of age in hastening the development of fibrosis consequent on exposure to siliceous dust.

6. The clinical findings suggest that it is not possible to differentiate with any degree of certainty, from physical examination, between silicotic fibrosis and that not showing typical radiographic appearances, or to forecast with certainty the degree of silicotic nodulation likely to be revealed in any particular case.

7. There is need for further co-ordinated research into the factors governing silicosis production; an approach from the angle of individual susceptibility would appear to offer promise of valuable results.

Appendix.

Notes on Chemical Composition, trade description and geological structure of four specimens of sandstone, arranged from I to IV in the decreasing prevalence of silicosis in the districts concerned.

	I	II	III	IV
Chemical Composition:	%	%	%	%
Silica SiO_2	96·22	84·80	95·10	50.66
Alumina Al_2O_3 and	3·61	9.25	2·01	8·29
Oxides of Iron (FeO and Fe_2O_3)				
Lime (CaO)	---	.62	.31	3·22
Magnesia (MgO)	---	.18	.10	1.88
Potash (K_2O)	---	---	1·25	---
Soda ($Na2O$)	---	2·17	.20	---
Carbon di Oxide (Co_2)	---	---	---	5.81
Combined Water (H_2O)	.17	.45	.90	
Trade description:				
Texture	Soft	Compact	Rather soft	Compact
Size of quartz grain	Fine	Fine	Fine	Fine
Shape of quartz grain	Rounded	Angular	Rounded	Angular
Water absorbed by dry stone (%age).	7	4.5	7,5	2.5
Crushing stress (Tons per sq.ft.)	538	800	Not known.	620

Geological Notes:

I. Fairly pure white fine-grained micaceous sandstone composed almost entirely of quartz grains of about 0.1 mm. Similarly sized grains of chert and felspar and subordinate flakes of mica. The rock is a somewhat impure ganister but contains probably not less than 90% of free silica.

II. Somewhat impure fine-grained quartz grit. Composed mainly of irregular /

Geological Notes:

II. irregular grains of quartz and felspar of irregular grading ranging from quite small dimensions to 0.1 mm. or more. Mica is subordinate. The grains are cemented together by a rather copious cement of turbid secondary silica. The percentage of free silica is lower than in (1) but would still be high, probably round about 80 to 85.

III. Fine-grained red quartzose sandstone. Composed of angular quartz grains averaging about 0.4 to 0.5 mm. with subordinate felspar and chert in a copious ironstained matrix of secondary silica. The percentage of free silica is high and would approximate to 90.

IV. Impure highly micaceous felspathic and calcareous sandstone. The grain-size is very variable ranging up to 0.75 mm. in the case of most of the constituents and still larger in the case of the mica-flakes. It is composed of angular quartz with abundant felspar, fragments of fine felspathic and siliceous igneous rocks and schists, small detrital garnets and a little iron-ore in a fairly copious cement of calcium carbonate.

The percentage of free silica would be round about 50.

I am greatly indebted for these notes to Dr. Thomas of the Geological Survey & Museum, London.

Radiogram showing typical silicosis in a sandstone worker.

REPORT II.

A NOTE ON MICA DUST

and the

LUNG CONDITION OF SOME MICA WORKERS.

In 1930 Dr. Zanelli of the Royal Clinic for Industrial Diseases, Milan, published an account of talcum pneumonoconiosis. He concluded that talc must be included among the more dangerous dusts and that it might produce serious lung damage in from five to nine years - though then perhaps only perceivable radiologically.

About the same time, Professor Bragg of Manchester published his review of silicate structure (a concise summary appearing in the Journal of Glass Technology, September, 1930) in which he classified in one group, that of silicon oxygen sheets, mica, talc and kaolin. Comparing mica and talc structurally, he gives the following formulae:-

Talc : $(OH)_2\ Mg_3\ (Si_4O_{10})$

Phlogopite Mica: $(OH)_2\ kMg_3\ (Si_3AlO_{10})$

Muscovite Mica : $(OH)_2\ KAl_2\ (Si_3AlO_{10})$

Talc is rather lighter than mica (specific gravity 2·7:3·0) and much softer.

Phlogopite, which comes chiefly from Madagascar, is darker in colour than Muscovite (from India and Rhodesia) and in powder is grey compared with the white nature of the other. Three types of mica are commonly recognised commercially:- amber, ruby (which is clear) and spotted (which is heavily loaded with inclusions). The former is Phlogopite and the two latter Muscovite.

The processes of manufacture include serrating, grinding, finishing, drilling and punching. The approximate number of hours per week spent on these may be stated as 3, 15, 2, 9 and 20 respectively. The dust produced in the first three or four of these processes may be fairly considerable.

considerable. Most of the powder falls rapidly, but wreaths of very fine dust produced by the individual operator can be seen to rise to his breathing level.

Serrating is done with the aid of a hack saw, the edges of the sheets under treatment being in bundles of approximately 100 at a time. Grinding and finishing are carried out by filing discs on a spindle: drilling also on a spindle. Punching is done usually by a machine which cuts out discs of the required bore.

The clinical findings are summarised in the accompanying table. Most of the workers have only had short exposures to mica dust. In only five of the twelve men examined has the exposure amounted to five years. Of these five, two complained of cough, three of expectoration and two of dyspnoea, the symptoms in all cases being of slight severity except that for the past four years Case No. 1 has had fairly persistent cough. Some of the younger workers also complained of slight cough with sputum while catarrh of the nose and throat is common. One of the men who had been with the firm for 32 years showed well-marked pulmonary fibrosis and emphysema while another, of 8 years, also had quite definite fibrosis - in his case, mostly unilateral. The percussion note generally is high pitched. In almost all cases the breath sounds were of harsh quality. Rhonci were common.

One of the employees is at present in a sanatorium suffering from pulmonary tuberculosis. I did not have an opportunity of examining him clinically but his radiogram shows very extensive tuberculosis, and Koch's bacillus is present in his sputum. This man has worked with mica for the past seven years. He had an attack of pleurisy the year before commencing this work, and another two years later.

Shortly

Shortly after this second attack, he came under the notice of the Public Health Department as a case of tuberculosis. He received sanatorium treatment and remained in fairly good health until about six months ago when he had to re-enter the Institution. In these circumstances, it is difficult to say that this tuberculosis is attributable to employment in the mica industry.

Radiograms were made in three of the cases. Prints of two of these are appended. That of Case No. 3, where the exposure was 32 years, shows gross fibrosis with well-marked emphysema. The fibrosis is largely peri-bronchitis in type with increased hilar shadows, but there is further definite interstitial fibrosis with, at one or two points, nodule formation. The fibrosis is most marked in the pulmonary mid-zonal regions. The other print is from Case No. 1 (eight years' exposure). Here again there is increased hilar shadow with radiate striation from the roots, but there is also a well-marked area of fine diffuse fibrosis in the mid-zone with emphysema below this level. The third radiogram, (Case No. 4), a lad of five years' exposure in whom there was insufficient clinical evidence to warrant the diagnosis of fibrosis, showed definite evidence of early fibrous change with emphysema, having a mid-zonal hand as described above.

The small number of cases at risk preclude the formation of any reliable conclusions but there would appear to be evidence that dust produced in the process of mica manufacture may be capable of causing pulmonary fibrosis even after comparatively short participation in the industry.

Case No. 3.

Case No. 1.

Case No. 4.

S U M M A R Y

OF

CLINICAL EXAMINATION RESULTS - MICA WORKERS.

	Age	Years employt. in mica	Symptoms				Nasal Catarrh	Throat Congestion	Clinical examn. of lungs	X-ray report	Observations, if any.
			Cough	Expectoration	Dyspnoea	Chest Pain.					
1.	27	8	+	Slt.	-	-	-	+	Pul. Fibrosis	Fibrosis:left mid zone.	Worked 1½ years in jute mill.
2.	20	6½	-	Slt.	-	-	-	+	? Slt. Fibrosis	Fibrosis:right mid zone.	-
3.	59	32	Slt.	-	Slt.	-	-	+	Fibrosis & Emphys.	Fibrosis -	-
4.	19	4½	Slt.	-	-	-	+	-	-	-	-
5.	30	5	-	-	Slt.	-	-	+	Chr. Bronch.	-	Flax work - 2 years.
6.	21	5½	-	Slt.	-	-	-	+	-	-	-
7.	19	1½	-	-	-	-	-	-	-	-	-
8.	25	3	Slt.	-	-	-	-	+	-	-	-
9.	16	2	Slt.	Slt.	Slt.	Slt.	-	+	Slt. Bronch.	-	-
10.	17	2½	-	-	-	-	-	+	-	-	-
11.	15	1½	-	Slt.	-	-	+	+	Bronch.	-	-
12.	15	1½	+	+	-	-	+	+	-	-	Poor breather.
13.	14	2/12	-	-	-	-	+	+	Neg.	-	-

REPORT III.

CASE of R.B., aged 39.

Occupational History:

1907 - 1912: Rivetter in Clyde Shipyard.

1912 - 1918: Army.

1918 - 1920: Rivetter.

1920 - 1923: Unemployed.

In 1923, R.B. took up employment as a coal porter at a surburban station in Edinburgh. His work during the mornings consisted of the riddling of coal. In the afternoons he distributed it throughout the town.

For four or five years his general health continued good but thereafter he began to complain of tiredness and shortness of breath, most marked in the evening. This condition became progressively worse and at the beginning of 1930 he was referred to the Tuberculosis Authorities in the city. Repeated examinations failed to reveal tubercle bacilli. He had to give up work and was admitted to Edinburgh Royal Infirmary. His condition there was one of pulmonary fibrosis with dyspnoea, cough and sputum. Repeated examinations of the sputum failed to discover any tubercle bacilli. On radiographic examination the chest showed extensive nodular fibrosis, the film being practically indistinguishable from that of silicosis except that the mottling was possibly a little softer than that usually found in cases of silicosis. The accompanying print shows well the type of fibrosis present.

In hospital, R.B. went rapidly downhill and died some two weeks after admission.

On Post-mortem examination, the lungs were especially firm, particularly the upper lobes which showed the presence of much carbon pigment. There was a pronounced

increase

increase of the interstitial fibrous tissue of the lungs: there was no evidence of tuberculosis or of the typical findings of silicosis. The pathologist summed up his report as follows:- Anthracosis - interstitial pneumonia - bronchitis.

This case is of outstanding interest. It is possible to exclude any of the usually accepted causes of pneumonoconiosis and it is noteworthy that the case proceeded to a fatal issue in as short a period as eight years after the man had begun this work as a coal porter.

At the depot in question, the coal handled is almost exclusively derived from the Lothian Coalfield. The following analysis taken from "Analyses of British Coals and Coke" (Elsden & Griffiths, The Colliery Guardian Co., Ltd., London, 1924) is typical for the coalfield in question:-

Fixed carbon	51·98%
Volatile matter	35·32%
Sulphur	0·70%
Moisture	9·66%
Ash	3·15%

Radiogram of R.B., Coal Porter.

Formerly steel was made on Tees-side chiefly by the basic Bessemer method, (which is, I understand, that still chiefly used in Germany) but for several years it has been replaced by the open hearth (bathos) method. By the courtesy of the Chemist at the Acklam Works I am able to indicate the differences in the slag produced by the two methods at his works:-

	Approximate %age Composition.	
	Basic Bessemer	Open Hearth.
CaO	43·0	34·5
SiO_2	10.0	12.5
FeO	15.0	17.5
Mn	3.3	5.2
P	7.5	8.2
MgO	6.5	4.6
Al_2O_3	1.7	2.2
Oxygen.	Balance.	Balance.

"Basic slag" is a fine greyish powder which on microscopic examination is found to consist of amorphous particles of small size, many of them irregularly rounded. Most of the particles are extremely small, 90% of them measuring less than 5u.

THE PROCESS OF MANUFACTURE.

The slag as it is received from the steel works is collected in large heaps of which the weight is approximately 1 cwt. per cubic foot. The outside of the slag heap is composed of loose clinker-like masses; the inside becomes "perished" and crumbles to a whitish dust. The amount of dust produced from the bank varies with weather conditions and depth of bank being worked.

From the bank the slag is elevated into a hopper, and all the subsequent processes are carried out in a large warehouse

warehouse which may measure 70yards x 40yards x 25feet: the grinding plant occupies almost one-third of this area, the remaining space being used for storage purposes. From the hopper the slag is fed into ball mills, and from these it is conveyed to the tube mill. From the tube mill it is elevated to the bagging machine which weighs it into sacks for delivery to the farmer. Ground slag is not now collected in troughs before bagging, a process which in the old days gave rise to a great deal of dust. The four factories engaged in this work on Tees-side are comparatively modern and fitted with very similar exhaust appliances: [I enclose a print of the dust removal plant in operation at Messrs. Dorman, Long and Company's Acklam Works.] The Manager of one plant employing 34 men told me that he commonly recovered from the dust-house as much as six tons of fine slag dust per month.

The amount of dust in the atmosphere of the warehouse varies considerably from day to day, but under the best conditions there is always a fine haze present. This haze is perceptible throughout the whole warehouse; there is usually a local excess in the vicinity of the ball mills and at the points at which the slag is delivered into bags. Subsequent manipulations attendant on stitching, labelling and storage of the bags tend to result in the production of local puffs of dust which must in the aggregate expose the operatives concerned to considerable dust hazard. At two of the four factories masks are supplied (Siebe Gorman and Willson) and are said to be worn fairly regularly. It is doubtful whether the filter gauze is renewed as frequently as might be desired - one foreman told me that renewal took place "about once a fortnight".

HISTORY/

HISTORY OF ILLNESS AMONG BASIC SLAG WORKERS.

From the history of illness since commencing work on basic slag given by the workers examined, I have prepared Table I.

TABLE I.

History of Sickness among Basic Slag Workers in Middlesbrough District.

		Inside Workers			Outside Workers	Total.
		M.	F.	Total		
Total No. employed.		70	15	85	30	115
Total years' employment		662	23	685	183	868
Workers giving history since starting slag work of	Bronchitis.	4	1	5	1	6
	Pneumonia.	9	-	9	1	10
	Pleurisy.	3	-	3	1	4
	Influenza.	19	-	19	5	24
	Dermatitis.	6	1	7	2	9
	Sore Eyes.	8	-	8	7	15
	Nose & Throat trouble.	7	2	9	3	12

These figures indicate that inside workers, as compared with bankmen, show an increased susceptibility to pneumonia. It is difficult to obtain reliable comparative figures for the general population, but Dr. Dingle, Medical Officer of Health for Middlesbrough, has furnished me with a report on the age-sex distribution of cases of pneumonia (all forms) notified to him during the three years, 1929-1931, and with the aid of his data Table II has been constructed.

TABLE/

TABLE II.

The occurrence of pneumonia in males aged 15 to 65 in Middlesbrough County Borough & among basic slag workers in the Middlesbrough area.

Middlesbrough: Male population 15-65 (1921 & 1931 Censuses)	42,533	Incidence of pneumonia per 1000 years observed.
Average No. of cases of pneumonia (all forms) notified per annum (1929-1931).	163	3·8
All Basic Slag Workers, Middlesbrough: Area. Years of employment observed(males)	845	
Cases of pneumonia reported by workers since starting basic slag work.	10	11·8
Basic Slag Workers excluding Tipmen: Years of employment observed	662	
Cases of pneumonia reported by workers since starting basic slag work.	9	13·6

It is a reasonable deduction that basic slag workers are more susceptible to pneumonia than all employed males in the same area - particularly so since the figures for Middlesbrough as a whole include cases terminating fatally, which must necessarily be excluded in the slag workers series.

The histories of dermatitis usually involved the hands and forearms, notably at sites of friction - between fingers and inner aspect of arms. The lesion produced is commonly roughening, occasionally vesication, of the skin. It is generally transient and associated with first exposure to slag dust.

I have obtained from the Managers of two of the plants particulars relative to time lost through sickness by the men employed there.

In/

In plant "A", the approximate number of days worked during 1931 was 5,000. The total number of days lost through sickness during the year was 36 and these days were all accounted for by one individual sickness, that of a man who was off work suffering from influenza and bronchitis.

In plant "B", the total number of days worked during the six months from September, 1931, to March, 1932, was approximately 3,000 and, of these, 46 were lost through sickness. This sickness was spread over six operatives of the 36 employed. Two of the men were only off for one day and three for two days, the illness in each of these cases being "common cold". The remaining workman had two spells of incapacity, one of 12 days being due to enteritis and the other of 24 days due to influenza and bronchitis, as well as two single days off on account of cold.

Colds are common among workers with basic slag. Often the worker is not incapacitated from work by them, while sometimes, as in plant "B", one or two days' idleness suffice to restore him to working fitness.

RESULTS OF CLINICAL EXAMINATION.

115 workers were examined. Table III summarises the clinical findings.

TABLE III

Results of examination of 115 basic slag workers, summarised according to exposure in years.

Exposure in Years.	0-1		1-5		5-10		10-20		20+		Total	
No. examined.	28	%	35	%	18	%	20	%	14	%	115	%
Cough.	19	70	19	54	13	72	14	70	6	43	71	62
Sputum.	10	36	19	54	11	61	14	70	7	50	61	53
Dyspnoea.	3	11	1	3	3	17	1	5	4	29	12	10
Chest Pain.	-	-	4	11	1	6	1	5	-	-	6	5
Pulmonary Fibrosis.	1	4	5	14	6	33	10	50	10	71	32	28
Conjunctivitis.	1	4	3	9	1	6	3	15	4	29	12	10
Nasal Catarrh.	16	57	15	43	8	44	9	45	3	22	51	44
Throat Congestion.	17	61	16	46	10	56	11	55	8	58	62	54

Length of exposure to basic slag exercises little influence on the incidence of cough, expectoration, chest pain and catarrhs of the nose and throat. These conditions are practically as frequent among workers in the first year of their employment as among those who have been upwards of twenty years in the industry. An analysis of the cases of cough occurring among workers in the earliest exposure group indicates that this symptom is much more frequently associated with throat congestion than with the presence of adventitious pulmonary sounds. Even among workers of older standing, where chest catarrhs are more frequent, cough is commonly associated with throat congestion. Conjunctivitis is more prevalent among workers of longer duration: so, too, with dyspnoea and pulmonary fibrosis.

I have classified some of the findings according to the nature of employment of the operatives concerned.

TABLE IV.

The incidence of Cough, Expectoration & Pulmonary Fibrosis according to nature of occupation.

	Total No. examd.	Total years expos.	Number with			
			Cough	Expecto-ration	Fibro-sis	Hist. of pneumonia.
Crushermen & Millmen.	14	220	13(2)	12(4)	10(3)	2.
Mechanics.	3	55	2(0)	2(0)	2(1)	1.
Bag Fillers.	10	58½	7(3)	3(2)	2(0)	0.
Machine Workers.	27	323½	22(5)	17(6)	14(4)	3.
Bag Stitchers & Stencillers.	20	118½	12(5)	12(4)	2(1)	0.
Warehousemen.	16	73	12(2)	9(2)	4(2)	3.
Loaders.	15	103½	9(4)	9(3)	4(2)	3.
Others.	7	67	5(3)	5(3)	0(0)	0.
Inside Workers other than Machinemen.	58	362	38(14)	35(12)	10(5)	6.
Tipmen.	30	183	21(3)	9(1)	8(3)	1.

The figures in brackets indicate more severe cases.

The average exposure of machine workers is much longer than that of the other two groups, and the incidence of pulmonary fibrosis among them is higher. Cough and expectoration occur with almost equal frequency in the several groups. The two indoor groups give an approximately equal history of pneumonia.

Table V. compares in more detail the results obtained from examination of indoor and outdoor workers.

TABLE V.

A comparison of clinical findings in indoor and outdoor workers. Findings stated as percentage of number examined in each group.

	Outside Workers.	Inside Workers.
Average.age.	42	31·6
Average exposure in years.	6·1	8·1
Cough.	70(10)	71(23)
Expectoration.	30(3)	61(21)
Dyspnoea.	7(0)	12(1)
Chest Pain.	7(0)	5(4)
Pulmonary Fibrosis.	27(10)	28(12)
Conjunctivitis.	13(3)	10(2)
Nasal Catarrh.	27(17)	51(25)
Throat Congestion.	47(13)	56(23)

Figures in brackets indicate more severe, or permanent degrees of conditions recorded.

At first sight there appears to be little difference between the two groups of cases, but, generally speaking, departures from normal are of more severe degree in the case of the inside workers. Conjunctivitis is an exception - outside workers attribute their susceptibility

to

to this to the irritating action of dust-laden winds - while the incidence of pulmonary fibrosis appears to be equal in the two groups. The figures here, however, are scarcely comparable, for the average age of the outside group is much higher than the other. Further, outside workers are to a considerable extent drawn from a class of men who have done a good deal of hard navvying about the Tees-side steelworks, or have worked in the Cleveland ironstone mines. Actually, 8 of the 30 tipmen had been engaged in the ironstone mines for an average period of 16 years, and 6 of them showed evidence of fibrosis. Only 5 of the 85 inside workers had previously worked in ironstone mines, and then only for an average of 6 years, one of them showing pulmonary fibrosis.

COUGH: while very prevalent, is not as a rule severe. At first, it is generally worst when the recruit is exposed to excess of dust (being then commonly associated with throat congestion). Later, it is most marked in the morning, while among the older workers it seems to occur without periodicity and is then probably mainly directed to clearing the chest; among these workers it is almost invariably associated with sputum.

EXPECTORATION is very common in workers who have been engaged in slag work for more than a year. It is usually of a greyish-black colour, obviously heavily laden with slag dust and, on microscopical examination, is found to be essentially catarrhal in type. The catarrhal cells are heavily laden with phagocytosed dust particles in a fine state of subdivision. Bacteriologically, the sputum contains large numbers of organisms - chiefly pneumococci, streptococci and the influenza bacillus.

DYSPNOEA/

DYSPNOEA is not a marked feature of these cases. It is sometimes met with in young workers, being then spasmodic in type and, doubtless, irritative in origin. Later, as gross pulmonary changes supervene, dyspnoea -/not for long of disabling degree - is commonly present, and is then most marked in exertion.

CHEST PAIN is not frequent. Of the six cases showing this symptom four were workmen of from one to five years' standing. In only one case was the pain associated with a pleural friction rub.

CONJUNCTIVITIS, where present, is of a low, chronic type: only one acute case was observed in the 115 workers examined. As noted, conjunctivitis is as common among tipmen as among inside workers.

NOSE & THROAT SYMPTOMS are common and show little variation in the several exposure groups. Throat and pharyngeal congestion is, in the case of younger workers, often associated with enlarged tonsils and some secondary cervical adenitis.

PULMONARY FIBROSIS is found in increasing frequency with the dust exposure of the workers; in these of over 20 years' standing it is present to an extent clinically recognisable in 71% of cases, and is in half of them rather severe. Even when allowance is made for the possible ill-effects of other dusty employments in certain cases there is strong evidence that inside workers in the basic slag industry develop pulmonary fibrosis as a result of that employment.

The most constant clinical finding is a harshness of the respiratory murmur and this is almost constant in its incidence, being often quite well marked in cases where the exposure does not exceed a few months. In workers of longer exposure the respiratory murmur is often broncho-vesicular in type.

Chest/

Chest movement is usually fairly free. The percussion note is commonly of high-pitched quality. Adventitious sounds, especially rhonci, are fairly common in older workmen. There is often abnormality of vocal resonance, usually in the direction of slight increase. Emphysema, though sometimes met with in workers of old standing, is not a prominent feature of the chest condition.

Three of the workpeople whom I examined showed definite signs of systemic intoxication - pallor, loss of appetite, increased pulse rate and a general cahectic appearance. Each of these were young subjects whose exposure to slag dust in considerable amount was only of one to three months' duration. In each of these three cases the systemic disturbance was combined with a catarrhal chest and the clinical picture suggested pulmonary tuberculosis, but sputum examination of two of the cases failed to reveal Koch's bacillus, the sputum in each case being of the catarrhal type above described.

I found no evidence of toxic disturbance among older workers.

BLOOD EXAMINATIONS:

I have examined blood films from six of the workmen whose exposure ranged from two to 28 years. In no case did the red cells show any recognisable abnormality.

A differential count of the white cells gave the following results:-

Percentages

	Max.	Min.	Average.
Polymorphs	60·9	44·0	53·6
Lymphocytes	47·7	33·0	39·8
Monocytes	7·1	2·8	5·4
Eosinophils	2·3	0·8	1·2
Basophils	0·3	0·0	0·1

These cases show some relative excess of the lymphocytes at the expense of the polymorphs: this altered distribution does not appear to be in direct ratio to length of exposure to slag dust.

RADIOGRAPHIC APPEARANCE:

X-ray examination was made in six cases; in five the exposure ranged from 22 to 34 years, while in the other it was 12 years. In each case there was well-marked clinical evidence of pulmonary fibrosis.

On screen examination, the lungs lighted up poorly but fairly uniformly.

The most striking feature of the radiograms was a generalised diffuse fibrosis. The lungs presented a ground-glass appearance. There was an increase of hilar shadow with well-marked striation radiating from the roots. There was, further, a certain amount of fine nodulation, though this latter quality was not constant.

The radiographic findings in this group of workers of long exposure appear to be fairly constant and suggest that radiographic examination may be of value in demonstrating a characteristic type of fibrosis among basic slag workers.

CONCLUSIONS.

Basic slag workers are apt to show some toxic disturbance during their first few months in the industry, but among workers of longer standing there is no evidence of any parallel toxic effects and the general physique of older workers is good, probably above the average.

From data supplied by the Managers of two of the four plants visited there does not appear to be excessive incidence of incapacity for work among the operatives; there is probably less illness among these workers now than formerly (a fact generally attributed to the installation of improved exhaust plant) though "common colds" and "bronchial colds" are very prevalent, sometimes compelling the workman to lie off work for a day or two but more commonly not associated with absence from work.

There is evidence that slag workers show a susceptibility to pneumonia in excess of that prevailing among the employed males in the general population of Middlesbrough.

A large proportion of workers in the basic slag industry suffer from cough, and the proportion so affected does not appear to vary widely with the precise nature of the occupation, though the severity of the cough is more marked among inside workers than among tipmen. The presence of cough is to a considerable extent independent of length of exposure and in the younger group of workmen is chiefly associated with congestion of the throat and the upper respiratory passages.

Sputum is common and of a catarrhal type, usually heavily laden with particles of slag dust; there is nothing characteristic in its bacteriology.

Blood changes usually show a reduction in the proportion of neutrophil leucocytes. There are no recognisable changes in the red blood cells.

There is clinical evidence of pulmonary fibrosis among workers in this field of the industry, the fibrosis being more prevalent among those of old standing, and among machinemen, than among other classes of workers.

The radiograms, characterised by a fine, diffuse fibrosis with well-marked radiations from the roots, suggest that X-ray examination may be of value in the recognition of pulmonary fibrosis due to the dust of basic slag.

REPORT V.

CASE of E.C., aged 46.

Occupational History:

		Yrs.	Mths.
1899.	Labourer in Woollen Mill.	1	6
1901.	Rope Worker.	1	-
1902.	Unemployed.	1	-
1903.	Carter.	11	-
1914.	Army Service.	5	-
1919.	Boiler Fireman at Messrs. Coats, Paisley.	2	-
1921.	Boiler Fireman at Messrs. McLardie's, Paisley.	3	-
1924.	Labourer in Starch Making Wks.	1	-
1925.	Boiler Foreman in Blackland Mill, near Paisley.	1	9
1927.	Unemployed.	-	3
Sept. 1927.	Builder's labourer, employed only in digging drains.	2	7

Subsequently unemployed.

C.'s employment as a boiler fireman at Messrs. Coats involved little cleaning of flues or scaling of boilers. At Messrs. McLardie's he had only a few weeks' scaling in all and no flue cleaning, while at Blackland Mill in addition to stoking duties his work consisted in cleaning flues for four or five hours per week, and scaling boilers for about four weeks per annum.

In 1931, he was referred to the Tuberculosis Clinic as a phthisis suspect. He gives a history of dyspnoea extending back for the past two or three years, and of cough and sputum of 4½ years' duration. He has had occasionally blood-stained sputum while at work during the past year or so and has suffered, very occasionally, praecordial pain. The only history of previous illness is of measles in infancy and rheumatism and sciatica more or less chronic for the past 20 years.

The chest shows an impaired percussion note with relative dulness on the left side. The respiratory murmur is diminished in volume on the left side with faint crepi-

tations

crepitations at the apex. Repeated sputum examinations have failed to reveal the tubercle bacillus.

Wassermann examination - negative.

On radiographic examination, the lungs show a pronounced general fibrosis with enlargement of the hilar shadows and some coarse mottling which is rather suggestive of silicosis, but this area is of a circumscribed nature and the extensive amount of fibrosis present in the remainder of the lung tissue is not of a typically silicotic character.

The accompanying print demonstrates the type of fibrosis present.

Radiogram of E.C.

REPORT VI.

MALT HOUSE DUSTS
and the
HEALTH OF MALTMEN.

Evidence given before the Departmental Committee on Compensation for Industrial Disease in 1906-7 indicated that there was among dock labourers handling grain cargoes a well marked excess of inflammatory changes in the throat and chest conditions at that time chiefly attributed to the inorganic dust content of the wheat and barley. Dr. Middleton, in a report on dust arising in the processes of discharging and handling of grain cargoes in 1924, described the dust present in the atmosphere as being of two kinds (1) sharp spike-like hairs and (2) fragments of vegetable and mineral matter, spores, etc. He concluded that the hairs derived from the grain appeared to be capable of causing irritation of, and inflammatory changes in, the respiratory passages. Cases have since been described in America in which there were radiological signs suggestive of miliary lung disease associated with occupations involving handling of grain; in the sputum of these patients fungi, notably aspergillus niger, were identified. Grain infected with common fungi, penicillium glaucum and aspergillus fumigatus has been shown by Professor Storm Van Leeuwen to produce experimentally symptoms of allergic reaction.

In 1926, Dr. Bridge investigated some cases where complaint had been made that excessive dust gave rise to cough among maltmen, and found that the dust of the malthouses consisted largely of spores derived from a fungus. Efforts to cultivate a similar fungus from the sputum were at that time unsuccessful. Further examination of malthouse dust by Dr. Middleton in 1929 led him to conclude that there were two possible causes of the alleged trouble (1) moulds

and

and (2) spicular hairs. Writing in "La Presse Medicale" of sporomycosis in grain maltmen, Messieurs Pasteur Vallery-Radot and Paul Girond have described an outbreak of tracheo-bronchitic symptoms characterised by cough, expectoration and a sensation of tightness in the chest associated with aspergillus fumigatus.

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74 malthouses have been visited in Scotland and the north of England; 38 were worked in association with breweries, 19 with distilleries, while 17 were "dry maltings", selling their product in the open market or for the manufacture of malted breads, malt extract, etc. In all but one case, barley was the grain malted; the exception handled wheat. All the brewery maltings and the majority of the others were ordinary "floor" maltings.

The grain handled may be of home or foreign production, and arrives at the malthouse either in bags or, more rarely, in bulk in railway wagons.

In modern practice, the grain is emptied into a hopper and carried by elevator to the screen from which it is taken to the barley loft: home barley generally undergoes kiln drying to a temperature of 100-105°F. before storage. From the barley loft the grain is taken to the steep. After "wetting" it is spread out on the malt floors where it may be kept for anything from nine to fourteen days. It is then shovelled by the maltmen into buckets and sent to the kiln. There its temperature is gradually raised till it reaches 190-205°F. or even higher. Sometimes the kiln is stripped at these high temperatures but more commonly the temperature is allowed to fall to 130 or 140°F. before stripping is commenced.

commenced. The malt is kept for a short time in cooling chambers and subsequently screened. Thereafter it is stored in bins till required.

Maltings vary widely in the extent to which machinery replaces manual effort and in the care which is given to dust control. In some old barns little change in working conditions has been effected during the past two hundred years, while others of more modern construction are highly mechanised. Barley and malt are essentially dusty, and every point at which they are handled is a potential source of dust escape. Thus, the emptying of the grain into the hopper when first it reaches the malting produces a shower of dust, as does the passage of the grain on to the conveyor belt which carries it to the barley screen. The screening processes may be prolific sources of dust. Hand-screening and the use of "fanners" are largely relics of byegone days. Only in two small maltings of the 74 visited were they used, and then very intermittently. Adequate enclosure of the screens can do much to reduce the amount of escaping dust. In 12 of the maltings visited no screening was carried out. It is a common practice to "trim" the barley lofts, turning the grain over at weekly intervals.

In filling the steep, most maltings first pour in the barley, subsequently covering it with water, and the dust produced during the filling process may be very considerable, particularly when, as usually happens, the grain is delivered by a spout from a higher floor. In a minority of maltings, notably where screening is not carried out, the custom is to plunge the grain into the tank already filled with water, and this method produces much less dust than the other.

From the ninth day onwards the malting grain is liable to be mould infected, and clouds of mouldy dust may result

result from the daily turning of such grain and the handling attendant on its transfer to the kiln. All the kiln processes are dusty - filling, turning and stripping. Turning is usually done by the men, though in some maltings machines have been installed for the purpose. Methods of stripping the kiln vary: sometimes the grain has to be carried out in buckets, some times the floor of the kiln is provided with holes through which the grain can be removed, while a few kilns have a mechanical device for collecting the grain on the floor, designed to reduce handling to a minimum.

The bins in which the manufactured malt is stored prior to use are sources of serious dust production. In older maltings these bins have often to be filled by hand and even where they are screw-filled the final levelling (trimming) of the bin involves the entry of a workman into an atmosphere often heavily dust laden, and particularly so, when the trimming is done while grain is still being allowed to run into the bin. The smaller the individual storage bins the greater the relative amount of time which must be devoted to trimming. Removal of the malt from these bins prior to despatch is also attended with considerable dust production, whether, as in some small maltings, the grain is panned out in buckets by men who enter the bin, or,as often happens in large plants,the grain is discharged on to an open belt along a chute, often from a considerable height.

In 5 of the malthouses visited drum malting had superseded the ordinary system of floor working; here the grain is kept in a cylindrical drum at a temperature of approximately 65° F.for the prescribed number of days before being sent to the kiln as in the other method. The system of drum malting obviates exposure to mould-laden dust during the

the turning of infected grain.

To a certain extent maltmen may be regarded as a selected population, the nature of the work sufficing to exclude any but the physically robust. The majority of maltmen have worked only as outside labourers before taking up this trade. In addition to dust hazard, malting involves exposure to rapid changes in temperature and to the physical strain of hard manual work. Under normal trade conditions the malting season lasts for about nine months per annum, from September to May, and the work necessitates a few hours Sunday labour.

In all except the largest maltings no strict subdivision of labour is possible, and each worker takes his share in the whole range of malthouse duties. A typical day's work might be described something as follows:- 7 a.m. - 9 a.m., turning kilns and floors: 9.20 a.m. - 10 a.m. turning floors: 10 a.m. - 12 noon, working in barley loft, odd jobs: 1 p.m. - 5 p.m., turning floors, loading, odd jobs: 5 p.m. - 5.30 p.m., turning kilns.

The particular types of work which the men find most objectionable are those involving heavy exposure to dust. Some workmen are most affected by barley, some by the mould laden dust from ripe floors, and others by the dust of malt. A majority of workmen professed to find most troublesome the processes of stripping kilns and trimming malt bins.

MALT HOUSE DUSTS:

Microscopical examination reveals three characteristic types of dust as demonstrated in the accompanying microphotographs:-

Barley/

Barley dust contains much vegetable and mineral debris, the particles being irregular in outline and often small in size; they range from 1 u upwards. Spores are numerous and of varying sizes, one group measuring about 4u and another about 8·5u, while occasional strands of mycelium are to be found.

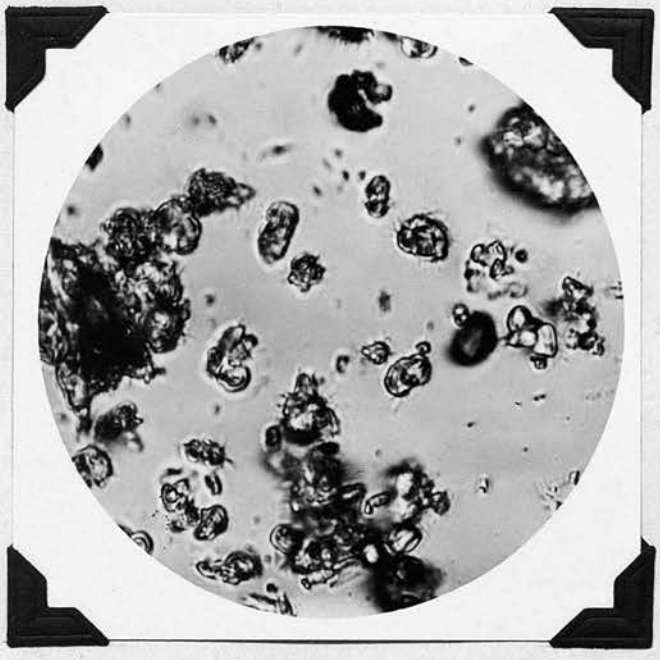

Fig. 1: Barley Dust x 1080.

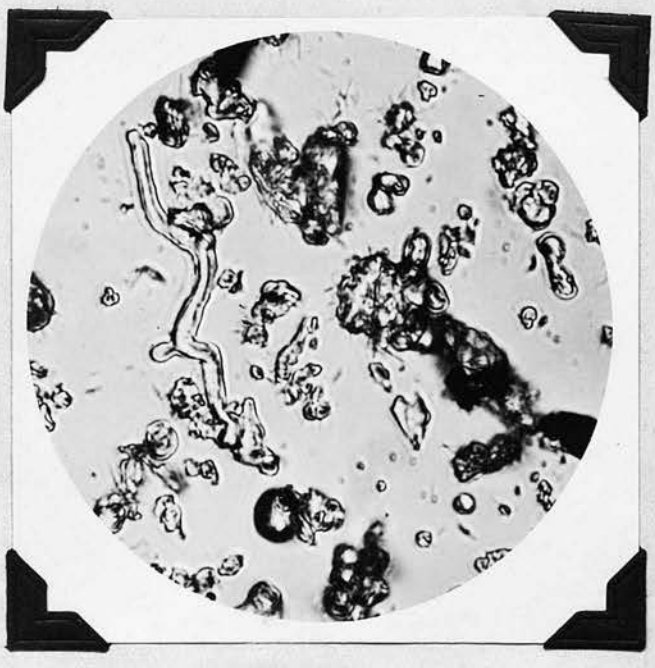

Fig. 1a: Barley Dust (Chilian) x 1080.

Dust produced in manipulation of "ripe" malt consists chiefly of spores, some very fine granular material being also present. The spores are commonly about 4u in diameter, some of them budding.

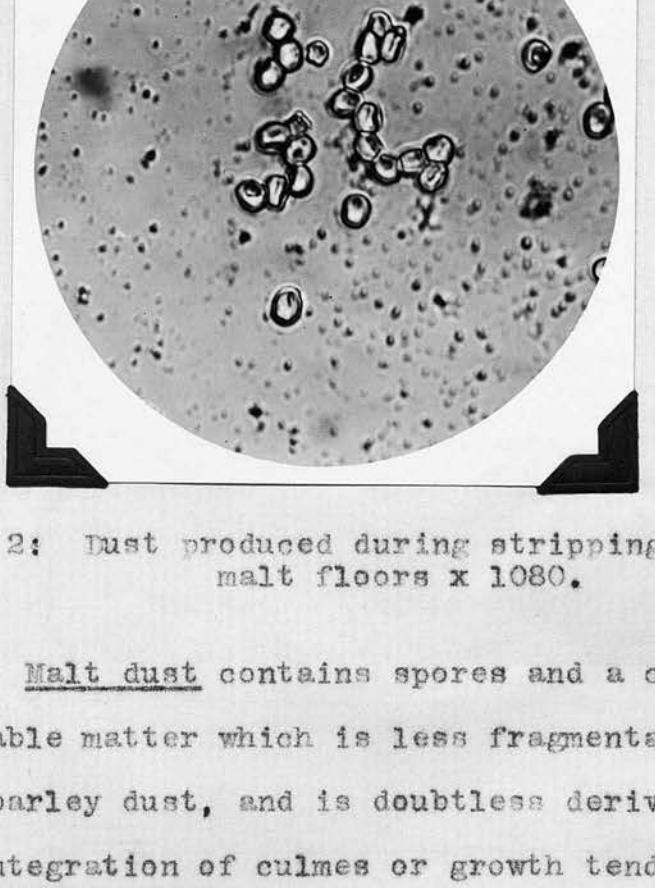

Fig. 2: Dust produced during stripping of malt floors x 1080.

Malt dust contains spores and a considerable amount of vegetable matter which is less fragmentary than is the case of barley dust, and is doubtless derived chiefly from the disintegration of culmes or growth tendrils from the malt.

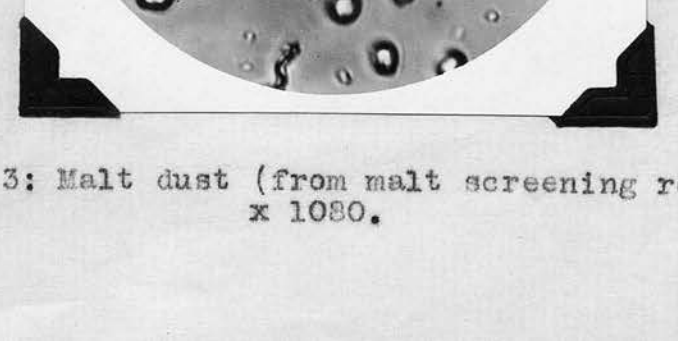

Fig. 3: Malt dust (from malt screening room) x 1080.

The prevalent mould is the ordinary green mould of the malthouse. On culture it grows well at room temperature on maltose agar, but not at 37°C. There are also present on malt floors smaller numbers of spores which grow on maltose agar at blood temperature. Dr. Butler of the Imperial Bureau of Mycology has examined cultures from these spores and his report on them is reproduced in Appendix "A". (follows p 20.

Dr. Farquhar of the Shirley Institute has made a chemical examination of barley and malt dusts with a view to determining their content of histamine-like substances. He concludes that probably barley dust contains rather less of these bases than cotton dust, while malt dust contains still less, though even here small quantities of histamine-like substances are present. As has been suggested in the recent Report of the Departmental Committee on Dust in Card Rooms in the Cotton Industry, the presence of histamine or allied bodies in trade dusts may be of importance in determining the symptomatology presented by workers among these dusts.

Dr. Dunlop, the former Registrar General, has discussed the expectation of life of maltmen in Scotland. Working on the census figures of 1901, he found that the life of maltmen was better by 2·6 years than that of all males. English observations also have shown the occupation in quite a favourable light. Dunlop from his Scottish figures found the expectation of life of maltmen at 25 years to be 6·1 years better than that of brewers. Seeking to explain this difference, he states that the occupation of maltster is a skilled and well-paid trade, that it contained picked men, that great strength was required for heavy

lifting

lifting and that the work is done in well-ventilated dry buildings; while, on the other hand, men working in the breweries proper do not form a skilled occupation; they as a class are not picked men. As a rule they are not so highly paid and they are required to work in less healthy atmospheres.

An analysis of the certified cases of death among maltmen in Scotland since the beginning of this century throws some new light on the subject. Table I sets out the percentage of deaths of maltmen due to certain defined diseases and the average age at death from these causes. For purposes of comparison there are also set out corresponding figures for brewers in Alloa, and mean figures for all males over the age of 15 years in Scotland as a whole during the same period.

TABLE I.

Analysis of causes of death and ages at death among maltmen, brewers, and all males over 15 years of age in Scotland.

	Maltmen (Scotland)		Brewers. (Alloa).		All malesover 15 years in Scotland.	
	%age of deaths.	Av.age at death.	%age of deaths.	Av.age at death.	%age of deaths.	Av.age at death.
Pulmonary Tuberculosis.	8	42·4	14	36·3	11	38·9
Bronchitis.	17	63·0	5	58·9	7	65·7
Pneumonia (all forms).	18	45·7	8	47·0	8	52·5
Other Respiratory Diseases.	1	--	1	--	2	57·4
All Respiratory Diseases.	44	52·4	28	44.4	28	50·7
All Respiratory Diseases, excluding Pulmonary Tubercle.	36	54·6	14	53·0	17	58·8
Cardio Vascular Dis.	19	59·2	30	62·7	16	63·2
Av. Age at Death. (all causes).		55·1		53·1		57·4

These figures suggest that while the average age at death of maltsters is higher than that of brewers it is at least no higher than that of all males, a fact which assumes some importance in view of the selected nature of the population at risk. There is a marked excess of deaths from respiratory disease among maltmen, and the distribution of the causal respiratory diseases is not that prevailing among brewers or among the general population. Thus, fewer deaths are attributed to pulmonary tuberculosis and the average age at death from that cause is rather above that prevailing in the country as a whole. Bronchitis and pneumonia on the other hand are each responsible for twice as much mortality among maltmen as among the general population, and in each case (and notably in pneumonia) the average age at death is less than that among all males. When pulmonary tuberculosis is excluded, the average age at death from respiratory disease among maltmen is some four years lower than that prevailing among males in the general population.

It is difficult to draw reliable conclusions from the histories of illness since joining the industry given by maltmen. According to data available from interrogation of the men examined, the incidence rate of pneumonia per 1000 years observed was 3·1; the corresponding figure for all males in the insured population (Scotland, 1930-31) was 1·3. Bronchitis presents particular difficulty since, notably in the case of workmen of older standing, many attacks of this condition and of bronchial colds may recur in the same individual, often associated with incapacity for work, and yet not be adequately reflected in the history offered. The figures returned for other respiratory diseases show excesses over those for the general population, notably pleurisy, of which the incidence was 4·8 per 1000 years observed, and asthma, where the figure was 0·5.

There is little difference in the history of sickness obtained from the several classes of malting, though distillery maltmen appear to suffer rather less from respiratory illness than do the others. Workers in maltings where no screening is done appear to suffer rather more from respiratory diseases than do those where screening is carried out.

Results of Clinical Investigations:

585 maltmen have been examined, and Table II summarises the chief respiratory findings in relation to duration of the workmen's employment in the industry.

TABLE II.

Clinical findings in relation to duration of employment.

Exposure in Years.	0 - 5		5-10		10-15		15-20		20+		Total.	
No. examined.	115	%	130	%	134	%	51	%	153	%	585	%
Cough.	53	46	76	58	92	69	38	75	124	81	383	65.
Expectoration.	36	31	52	40	60	45	29	57	91	60	268	46.
Dyspnoea.	15	13	17	13	22	16	8	16	50	33	112	19.
Chest Pain.	6	5	2	2	3	2	3	6	8	5	22	4.
Pulmonary fibrosis.	16	14	23	18	35	26	25	49	103	67	202	35

These figures include all workmen examined. From the histories obtained it was found that 24 had previously been employed in some other industry which might, from its dusty nature, have exerted some influence on the clinical picture, while 61 had suffered from one or more attacks of respiratory illness before entering the malting industry. Each of these groups, when compared with the men presenting no complicating history, shows an excess of dyspnoea, chest pain

pain, and pulmonary fibrosis. In an effort to obtain an undisturbed view of the pathology associated with work as a maltman, Table III has been prepared by excluding the records of the two groups mentioned.

TABLE III.

Clinical findings in relation to duration of employment: Workers who have not been engaged in other dusty trades, and who give no history of respiratory disease prior to becoming maltmen.

Exposure in Years.	0 - 5		5-10		10-15		15-20		20+		Total.	
No. examined.	94	%	103	%	111	%	46	%	146	%	500	%
Cough.	38	40	60	58	77	69	34	74	116	79	325	65
Expectoration.	24	26	41	40	49	44	28	61	85	58	227	45
Dyspnoea.	10	11	8	8	18	16	7	15	44	30	87	17
Chest Pain.	3	3	1	1	2	2	3	7	7	5	16	3
Pulmonary Fibrosis.	9	10	12	12	25	23	22	48	95	65	163	33

Generally, the incidence of abnormality increases with duration of work as a maltman; this is particularly marked in the matter of pulmonary fibrosis.

An old-established industry like malting tends to have a higher proportion of elderly workers than does one of more mushroom growth, as asbestos. Age and duration of employment are apt to run parallel, and it becomes increasingly difficult to dissociate their influences. Thus, when the clinical data is analysed in terms of age, there is found an increasing morbidity with advancing years.

TABLE IV.

Clinical findings in relation to age.

Age group.	15-25		25-35		35-45		45-55		55+		Total	
No. examined.	39	%	158	%	134	%	133	%	121	%	585	%
Cough.	9	23	85	54	85	64	112	84	92	75	383	65
Expectoration.	9	23	69	44	45	34	81	61	64	53	268	46
Dyspnoea.	1	3	20	13	21	16	35	26	35	29	112	19
Chest Pain.	2	5	6	4	2	1	7	5	5	4	22	4
Pulmonary Fibrosis.	3	8	18	11	28	21	70	52	83	69	202	35

The importance of duration of employment in the industry rather than mere age is borne out by an examination of the average duration of employment for each age group of men showing pulmonary fibrosis as compared with men in whom this has not developed.

TABLE V.

Development of Pulmonary Fibrosis.
Average duration of employment of maltmen in relation to age.

Age group.	Average duration of employment of maltmen showing No Pulmonary Fibrosis	Pulmonary Fibrosis
15 - 25.	3·1 years.	5·0 years.
25 - 35.	7·3 "	8·9 "
35 - 45.	10·1 "	13·5 "
45 - 55.	18·1 "	20·4 "
55 +	23·7 "	31·0 "
All ages	11·4 years.	23·4 years.

The duration of employment is in each group longer among the men in whom pulmonary fibrosis has supervened than among the others.

An/

An attempt has been made to correlate the results of clinical examination with working conditions in respect of such factors as the type of malting carried on, the source of the grain used and the kiln temperatures reached. The number of variables involved interferes seriously with the value of such an analysis. Neither the type of malting done nor the source of the barley malted appears to play much part in determining the incidence of respiratory disease. Cough and dyspnoea were found more commonly when the operation of kiln stripping was carried out at high temperatures. The frequency with which the men examined had changed their place of employment rendered it almost impossible to estimate the value of adequate exhaust ventilation where this had been installed. Even where, as in the larger maltings, some attempt at sub-division of labour may exist, there is no evidence that any class of operative escapes the prevailing respiratory mischief.

The most striking feature of the clinical findings is the frequent occurrence of symptoms. Thus, cough is encountered in over 60% of maltmen, a figure similar to that prevailing among basic slag workers but, while in the latter case the incidence remains fairly constant in the several exposure groups, in the case of maltmen it increases with exposure till the 10-15 year period is reached, after which it remains practically constant. Initially, cough appears to be associated with catarrh of the throat and upper respiratory passages, but among older workers there is no mistaking the characteristic deep-seated "barley hoast". The incidence of expectoration is parallel to that of cough; the characteristics of the sputum are described in detail at a later stage in this report. The incidence curve for dyspnoea is

interesting.

interesting. It shows that even in the earliest exposure group over 10% of workers exhibited this symptom, and that, while there was a slight fall in the second group, the curve thereafter gradually swung upwards till among workers who had been engaged in the industry for over 20 years more than 30% exhibited some degree of shortness of breath. The type of dyspnoea present among workers in the first group is generally spasmodic, and may possibly be an allergic manifestation; among older maltmen it is rather associated with exertion, and is then doubtless a reflex of the prevailing emphysema and tendency to dilatation of the right heart. 3% of the men examined complained of chest pain, which seemed to be without significant relation to duration of employment in the industry. The incidence of fibrosis increases with the duration of participation in the industry. The curve rises steeply after 15 years' exposure; two-thirds of workers of over 20 years' standing exhibit clinical evidence of pulmonary fibrosis. The fibrosis is associated with emphysema to a striking extent - much more so than in silicosis, asbestosis or the fibrosis of basic slag workers.

Congestion of the throat is common and varies little in its incidence with duration of employment. Nasal catarrh is also prevalent and crusting of the nostrils is commonly met with. Many of the older maltmen have blunting of the sense of smell - in some cases amounting to complete anosmia.

About 8% of the men examined gave histories of skin irritation since commencing work as maltmen. Most commonly this took the form of itching of the arms, neck and other friction sites: in only very few cases did persistent eruption result. The irritation was usually associated

with

with the dust of raw barley rather than of malt. Most of the victims appeared to find home grain more irritating than foreign, and discomfort was most marked on first exposure to the dust.

Blood films were prepared from 20 of the men examined, and Table VI summarises the results found.

TABLE VI.

Differential count of white blood cells of maltmen.

	Percentages		
	Maximum	Minimum	Mean
Neutrophil leucocytes.	72·1	40·2	55·0
Lymphocytes.	50·4	21·3	37·5
Monocytes.	12·2	1·5	5·0
Eosinophils.	4·5	0·4	2·0
Basophils.	1·7	0·0	0·5

There is a slight reduction in the percentage of polymorphs, and comparable increase in that of lymphocytes, but no evidence of eosinophilia. The blood findings bear no relation to duration of employment in the industry or to the development of pulmonary fibrosis.

EXAMINATION OF SPUTUM:

The typical sputum of maltmen is mucopurulent, frothy and abundant, being more purulent in workers of older standing. It is of a distinctly greyish colour. On microscopic examination, the sputum contains dust fragments and vegetable debris (many of the particles being phagocytosed), pus and many catarrhal cells and bacteria of all kinds, pneumococci being particularly prominent. Spores were found in from 40% to 50% of sputa examined. These spores varied

in

in size. No definite evidence of mycelium formation in fresh sputum has been found, though extensive growth may take place in sputum or on maltose agar of $P_H 6$ in from 24 to 48 hours at room temperature, but not at 37°C. Spores have been recovered from the sputum of maltmen who had not worked in the industry for 4 months. Dr. Butler of the Imperial Bureau of Mycology has identified three fungi grown from the sputum of maltmen - (1) Sporotrichum carnis, (2) Scopulariopsis brevicaulis (penicillium brevicaule) and (3) another species of penicillium. Dr. Butler is not inclined to regard any of these three organisms as having pathogenic properties. Spores have been recovered from the respiratory tract on bronchoscopic examination.

Figures 4 to 7 are micro-photographs showing the typical appearance of spores in fresh sputum and the mycelial formation produced on standing at room temperature.

X-RAY APPEARANCES:

On screen examination, the lungs generally light up brilliantly. The radiogram shows well-marked emphysema; this is indeed often the most striking feature of the picture. After as little as 10 years' exposure to malt-house dust, there is definite evidence of pulmonary fibrosis which is peribronchitic in type and characterised by radiations from the root to the lung periphery. In advanced cases, this fibrosis may be so exaggerated as to suggest a more diffuse element. The radiographic association of peribronchitic fibrosis with emphysema is characteristic but not sufficiently specific to differentiate between such a condition due to the inhalation of malt dust and a similar picture which might arise independently of it.

CONCLUSIONS/

Fig. 4: Spores in freshly voided sputum x 1080.

Fig. 5: General low power view of extensive mycelium formation in a 3-day old sputum kept at room temperature x 100 .

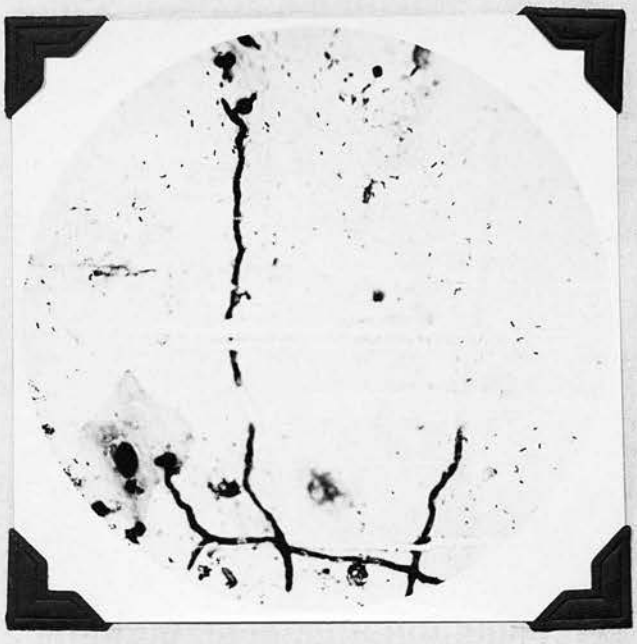

Fig. 6: General low power view of extensive mycelium formation in a 3-day old sputum kept at room temperature x 420.

Fig. 7: Spores and mycelial growth in 24-hour old sputum x 900.

CONCLUSIONS:

There is evidence of an excessive incidence of respiratory disease among maltmen. This is borne out by analysis of the clinical histories of men examined in this investigation and by the causes of death recorded on certificates. The excess is chiefly attributable to bronchitis and pneumonia.

Examination of 585 maltmen reveals an excess of respiratory pathology. Cough, expectoration and dyspnoea are common symptoms. Bronchial colds are frequent, while generally the incidence of bronchitis, pulmonary fibrosis and emphysema increase with duration of employment in the industry. Catarrhs of nose and throat are common, and complete anosmia is sometimes found.

The red blood cells show no recognisable abnormality. A differential count of the white cells shows a slight excess of lymphocytes.

The radiogram reveals pulmonary fibrosis, peribronchitic in character and often associated with marked emphysema.

The sputum is catarrhal in type and in addition to large numbers of micro organisms, and particles of grain contains in 40% - 50% of cases spores which commonly develop mycelium on standing at room temperature for 24 - 48 hours.

Some workers describe a degree of irritation of the skin, generally transitory and not associated with serious ill effects.

Malting demands heavy physical exertion and exposes operatives to rapid changes in temperature and to a definite dust risk. Three types of dust have been described; the power of each to inconvenience the workers appears to vary

with

with individual susceptibility. There can be no doubt that the dust present contributes largely to the excess of respiratory disease found among maltmen, though whether its harmful effect is to be attributed to such factors as the presence of spores, histamine-like bodies or simply mechanical action is not quite clear. There is need for increased attention to dust removal in many maltings. The stripping of the kilns while these are still at very high temperatures and the custom of sending men to trim storage bins while grain is still pouring into them would appear to aggravate unnecessarily the dust hazard.

* * *

I have to acknowledge the very great assistance rendered to me in the preparation of this report by Dr. Butler of the Imperial Bureau of Mycology for examining dust and sputum: to workers at the Shirley Institute, Manchester, for determining the histamine content of barley and malt dusts, and to the staff of the Royal College of Physicians' Research Laboratory, Edinburgh, for carrying out the routine laboratory examinations involved - Colonel Liston, Bacteriologist, Colonel Harvey, Histologist and Mr. Hamilton, to whom I am indebted for micro-photographs of dust and sputum.

* * *

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MM./

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APPENDIX "A".

Extract from Report by Dr. Butler

on

Cultures submitted from Malthouse Dusts.

The fungus would ordinarily be referred to Penicillium expansum Link, but on detailed study it was found to show the following cultural differences from P. expansum freshly isolated from rotting apples (the typical habitat of the species):-

(1) It produced a yellow colour in nutrient 15% gelatine instead of a colourless liquid.

(2) It liquified nutrient gelatin more rapidly.

(3) On Czapek agar, it formed more or less floccose and restricted colonies with outgrowths of yellowish mycelium, instead of spreading rapidly.

(4) It formed a yellowish to orange instead of a brown reverse.

Another species of the same subsection ('Glauca' in Thom's classification of the Penicillia) as that to which P. expansum belongs, which shows points of similarity to that under examination, is P. aurantio-grisseum Dierkx, which differs only in having elliptical conidia, 3 to 4.5 by 2.5 to 3 μ whereas the cultures that you sent had globose to elliptical conidia, 2.6 to 4.2 μ or 2.5 by 3.6 μ.

As previous records have gone under P. expansum, I think this specimen might be so named, though it differs from the strain on apples in the above cultural characters.

(sgd) E.J. Butler.

The past twenty years have seen a great widening of interest in the ill-effects of inhalation of trade dusts in this country. For long the spotlight was focussed on silicosis which, by its demoralising fatality, compelled attention; and much painstaking research work has been directed to its subjection. Successive theories of silicosis-production have in turn held the field, and silicosis has come to be the standard by which other dust diseases are judged. There has, perhaps, been some danger of the whole problem of pneumonoconiosis being merged too completely in considerations of the free silica content of the materials handled, and recently Collis - who more than anyone else has helped to systematise our knowledge of those things - has published a useful review of the wider field of trade dusts.

Silicosis is but a specialised type of pulmonary fibrosis, chiefly notable for its association with tuberculosis and for the fact that the radiogram of the condition, in the presence of clinical evidence of fibrosis and a history of exposure to siliceous dust, may be so characteristically nodulated as to render more precision of diagnosis possible. The association of silica dust and the tubercle bacillus is well established. It has been emphasised in recent years by the experimental work of Gardner, and confirmed by the clinical observations of many workers. Policard and Martin, for instance, found from their examination of rock drillers in the Loire basin that while a fairly high proportion of the men could work for ten years without the development of gross fibrosis, the number of cases with open tuberculosis was considerable. It occasionally happens - especially when environmental conditions are otherwise good, as in hillside quarries - that an

an excessive incidence of tuberculosis is not encountered. Hayhurst found among stone workers in the Buckeye Quarry, Ohio, no higher incidence of pulmonary tuberculosis than among other industrial workers: 26% had silicosis, but of these only 5% had tuberculosis in any form. The recent work of Wood and Gloyne has shown that asbestosis may be associated with a prevalence of tuberculosis previously unsuspected, and while other dusts so far investigated have not been found to go hand in hand with excessive liability to tuberculosis there has almost invariably been a co-existing catarrhal process.

The radiogram of silicosis is regarded as characteristic, so much so that it has, for administrative purposes, received the official imprimatur. But the radiogram only retains its specific character within a fairly narrow range. Advanced cases often lose their characteristic features, while superadded tuberculosis may completely alter the picture; in the early stages, most valuable from the viewpoint of preventive medicine, there may be little to distinguish fibrosis due to silica from the fibrosis of such an organic dust as grain. Further, as has been demonstrated, the inhalation of coal dust may produce a skiagram practically indistinguishable from that of silicosis.

It is almost impossible to differentiate clinically between silicosis and pulmonary fibrosis of other origin, unless, it may be, the presence of a considerable degree of emphysema simplifies matters, for silicosis is rarely associated with pronounced emphysema, which may add to the fibrosis of other dusts a very disabling element. Analysis of the results of various investigators' work, as summarised in

in Table I shows that there is substantial agreement between the exposure-incidences of fibrosis in silicosis-producing industries and in others, and that even where there is wide difference in the silicosis attack rate there is no comparable difference in the incidence of pulmonary fibrosis.

T A B L E I.

Percentage incidence of pulmonary fibrosis in various industries.

Industry.	Investigators.	Exposure in Years.				
		0 - 9	10-19	20-29	30+	20+
Slate.	Sutherland & Bryson.	14	27	39	79	64
Granite.	Do.	19	31	62	92	81
Sandstone.	Do.	17	42	76	95	85
Sandstone.	Author.	17	50	76	88	81
Malt.	Do.	24	49	62	72	64
Asbestos.	Merewether.	16	37·5	-	-	81
Basic Slag.	Author.	15	50	-	-	71
	Mean	17·5	41	63	85	75·5

It has already been noted in relation to the sandstone industry that whereas the precise nature of employment is of great importance in determining the incidence of silicotic nodulation it does not appear to influence to anything like the same extent the development of less specific fibrosis. Different geographical areas, too, show differing incidences of silicosis, though the occurrence of fibrosis remains almost constant in the several areas.

T A B L E/

T A B L E II.

Percentage incidence of fibrosis and of silicosis in certain geographical areas. Sandstone workers.

Area	Fibrosis	Silicosis.
A.	44	15
B.	41	4
C.	42	8
D.	45	7

The relation of fibrosis to nodulation in the silicosis-producing industries is of interest and importance. From a review of the examination of 1,000 sandstone workers it has been concluded that probably not all subjects who develop a measure of fibrosis after exposure to dust for a period go on to develop definite nodular silicosis capable of radiographic recognition if their exposure is further continued. For the industry as a whole there is a striking parallelism between the curves of incidence of clinical fibrosis and radiological silicosis, the curve of fibrosis rising steeply after ten years' exposure and that of silicosis after twenty years. It seems possible that the general action of siliceous dust (and in this respect siliceous dust would resemble other dusts) is in the direction of producing a diffuse, non-specific fibrosis - a response to irritation - and that later under certain circumstances there may follow another more specific action, probably biochemical in nature, as Hefferman has suggested, resulting in the formation of the nodulation of silicosis.

Within the past two years three papers of the first importance have been published on the subject of histological changes following dust inhalation. In 1930, Kettle reviewed the

the relation of dust to infection. He recalled that in necrotic foci induced by silica tubercle bacilli gather and multiply far more than they do in foci brought about by any other substance, and recognised that the presence of non-siliceous dusts favoured the growth of other organisms. He concluded - and this is of special importance for our present thesis - that there is really little difference in the behaviour of phagocytes to different dusts. In 1931, Heynes, from his experimental work on guinea pigs, was able to arrange a series of dusts in the order of their capacity for producing fibrosis, his list ranging from precipitated silica down to carborundum; but he concluded that heavy inhalation of any dust is liable to cause pulmonary damage and that the phagocytic response to all inhaled particles is along similar lines. Policard, working on white rats, made an important histo-chemical research into the initial lesions of experimental pulmonary silicosis. He confirmed the observations of earlier workers, Mavrogordato, Carleton, Gye and Kettle, that besides common dust cells, the pulmonary tissues contained cellular masses of a special type enclosing siliceous particles the so-called "plaques" - vacuolated masses of cells with little affinity for stain and little line of demarcation. On account of their virtual insolubility with their large surface they lend themselves to attack by the cytoplasmic fluids, and the products of this attack ultimately petrify the cytoplasm. The plaques are no longer capable of elimination by the usual channels: they remain in place, provoking fibrous reactions in the surrounding pulmonary tissue, the genesis of silicotic nodules.

These experimental findings appear to agree with the results of clinical observation. The conception of the

lesion

lesion of silicosis as a twofold entity may be of medico-legal importance, for while Germany restricts payments under the Workmen's Compensation Acts to "severe silicosis" other States (e.g., Ontario) compensate a condition much less advanced, and definitely ante-dating the radiographic appearance of nodulation. It has generally been the custom in this country to delay compensation - and suspension from the industry - till the appearance of nodulation, by which time the preventive value of exclusion is largely reduced. Earlier action presents very grave administrative difficulties and necessarily implies extremely rigorous examination of entrants to silicosis-producing industries.

Sometimes there is encountered a radiological condition very closely resembling the classical picture of silicosis (as described in the supplement to the proceedings of the Johannesburg Conference) where the exposure to silica dust - certainly to free silica - is negligible. The case of the coal porter which has been described is a good illustration of this. Here was a man only 39 years of age, an ex-regular soldier and therefore, presumably, a selected life whose sole exposure to trade dust was in the course of his employment, not as a coal miner, but as a coal porter working only above-ground riddling coal at a railway depot for a period of nine years. With this employment his health steadily deteriorated. His radiogram showed extensive mottling consistent with the nodulation of silicosis. There was little emphysema, and repeated sputum examination failed to reveal the tubercle bacillus. The case proceeded to a fatal issue and, post mortem, the lungs were fibrous, densely studded with carbon pigment, but showed evidence neither of silicosis nor of tuberculosis. This may have been an

isolated

isolated case, and it is possible that despite the apparently clear medical history there may have been some predisposing pulmonary factor or metabolic disturbance, though post mortem examination showed no evidence of these. Investigators in South Wales, reporting on Coal Miners' Lung there, have concluded that coal-mining (notably anthracite) is associated with alterations in the lungs which, on X-ray, are comparable with films from persons exposed to silica dust, and other dusts capable of leading to pneumonoconiosis. Collis and Gilchrist, studying the effects of dust on coal trimmers in South Wales found that these tended to succumb in excess from bronchitis and pneumonia, but not from phthisis, while their lungs, on X-ray examination, showed signs similar to these widely regarded as characteristic of silicotic fibrosis. Other observers, Greenhow, Tattersall, Cooke, Cummins and Sladden in this country, Husten in Germany and Moore in Australia have rather insisted on the essential association of coal and silica from work in "hard headings" as determining the pulmonary pathology, but the case here recorded suggests that coal dust itself may not be so harmless as has generally been supposed.

Another case presenting somewhat similar difficulty is that of the man who had been engaged, for a period of about three years, as a boiler fireman and cleaner, his work involving also the periodical cleaning of flues. Here again the clinical condition is one of gross fibrosis with definite impairment of general health, and the radiogram, while not so definitely of rounded nodular silicotic type shows fibrosis and irregular mottling of a character not very far removed from that of silicosis. Cooke has described a similar condition of pneumonoconiosis due to flue

flue dust and boiler scale, of which he furnishes the undernoted chemical analysis:-

TABLE III.

Percentage Composition of Boiler Scale and Flue Dust (Cooke).

	Boiler Scale	Flue Dust.
Insoluble siliceous matter.	6.40	26.40
Soluble siliceous matter.	3.90	6.00
Total siliceous matter.	10.30	32.40
Ferric oxide.	3.42	27.17
Alumina.	1.68	14.12
Calcium sulphate.	57.13	27.14
Calcium carbonate.	3.60	Trace
Magnesium hydrate.	17.80	3.18 *
Combined water.	4.60	Nil.
Carbonaceous matter.	1.00	Nill
Phosphoric anhydride.	0.074	0.16

* Magnesium oxide.

Cooke concludes that work with these dusts undoubtedly caused pneumonoconiosis in his subject, and from the case now described and one or two others of a similar nature which have come to light there is reason to believe that such dusts may produce a definite pulmonary fibrosis.

The insoluble siliceous matter in flue dust in addition to quartz grains contains many acicular crystals and flat plates probably of micaceous and feldspathic origin. This occurrence of micaceous dust is of particular interest in view of the cases which have been recorded suggestive of the occurrence of a trade fibrosis among mica workers, relatively early radiograms tending to show diffuse shadows in the mid-zonal regions. Mica, as has been noted, is a complex

complex silicate, and the recent work of Professor Bragg on silicate structure offers a new conception for that systematic classification of the silicate dusts which has so far proved difficult. Bragg emphasises that the fundamental feature of silicate structure is the position of silicon at the centre of a regular tetrahedral group of oxygen atoms. The tetrahedral groups link up by sharing oxygen atoms. The linking is characteristic: two tetrahedral groups only have one oxygen atom in common (i.e., they are linked by a corner, and not by an edge or face). The lower the ratio of oxygen to silicon the greater is the extent to which this linking takes place. In this way a range of structures is built up with a successive extension in space of the silicon-oxygen linking, represented at one end by the ortho-silicates with independent groups $(SiO_4)^{4-}$ and at the other end by the forms of silica such as quartz (SiO_2) which Bragg and Gibbs first showed to be a structure where every oxygen atom is shared by two silicon atoms. The following types of silicon-oxygen complex have been found:-

(a) Ortho-silicates, which have independent groups $(SiO_4)^{4-}$

e.g., Olivine $(MgFe)_2SiO_4$: Garnet $Ca_3Al_2(SiO_4)_3$.

(b) Self-contained groups, formed by linking a finite number of tetrahedral groups. Such groups are $(Si_2O_7)^{6-}$, $(Si_3O_9)^{6-}$, $(Si_6O_{18})^{12-}$, the latter two groups being formed by linking three or six tetrahedral groups in a ring.

e.g., Melilite $Ca_2Mg(Si_2O_7)$: Beryl $Be_3Al_2(Si_6O_{18})$.

(c) Silicon-oxygen chains - endless chains of SiO_4 groups, each sharing an oxygen atom with its neighbour on either side

side, so as to reduce the oxygen-silicon ratio to 3:1. Silicon may be partly replaced by aluminium. Such minerals often assume a characteristic fibrous form, asbestos being an example, and the fibres are parallel to the silicon-oxygen chains.

e.g., Diopside $CaMg(SiO_3)_2$: Termolite $(OH)_2Ca_2Mg_5(Si_4O_{11})_2$.

(d) Silicon-oxygen sheets: If three oxygen atoms of each tetrahedral group are shared, the resulting ratio will be represented by $(Si_2O_5)^{2-}$. In this way a two-dimensional sheet of tetrahedral groups is built up. Such a sheet has a hexagonal outline and forms the basis of the minerals with a platey texture, e.g., mica, talc, kaolin. The atoms within the tetrahedron may be either all silicon or silicon and aluminium.

e.g., Talc $(OH)_2Mg_3(Si_4O_{10})$:
Phlogopite Mica $(OH)_2KMg_3(Si_3AlO_{10})$.

(e) Three-dimensional silicon-oxygen metworks: If every oxygen of each group is shared between two silicon atoms, the resulting structure has the composition of silica, SiO_2. If some silicon atoms are replaced by aluminium, there results a silica-like arrangement of linked tetrahedra which has a negative charge and into which in consequence metallic ions can be incorporated. This is the basis of such compounds as ultramarine and the felspars.

Discussing the average silica-content of igneous rocks, Morton states that the total silica content of granite may be taken as 70%, that of syenite as 60% and that of gabbro and basalt as 50% while the free silica contents are respectively

respectively 30%, 0 - 20%, and nil. Taking felspar as an example, he represents the process of hydration of a combined silicate in the lungs by the equation -

$$K_2OAl_2O_3.(SiO_2)_6 + 3H_2O = 2KOH + Al_2O_3(SiO_2)_2.2H_2O + SiO_2$$

Felspar — Clay — Colloidal Silica.

and concludes that if crystalline silica can become hydrated in the lungs to form colloidal silica it should be equally possible for felspar and mica to become similarly hydrated.

In silicate structure the oxygen atoms linking two tetrahedral groups have only a slight residual attraction for the metallic ions: the oxygen atoms attached to one silicon atom, on the other hand, behave as if they had a single residual valency charge and an attraction to the metallic cations. It has been suggested that the active nature of an oxygen atom bound to one silicon atom, and so only half saturated, might account for the ill-effects of quartz and asbestos dusts. In a mica flake there are only these unsaturated oxygens on the edges, the loose ends having been tucked in, as it were, over the surface, whereas the active oxygen atoms are all over the surface of a quartz fragment and along an asbestos fibre.

The placing of the silicon-oxygen sheet complex, Si_2O_5, in Bragg's classification between the group of chains, SiO_3, Si_4O_{11}, (of which asbestos is an example) and three-dimensional networks (SiO_2, quartz) is at least suggestive. Typical examples of the complex are talc, mica and kaolin. Zanelli is of opinion that all silicates are injurious to the lungs, and that talc must be included among the more dangerous dusts. The cases now recorded suggest that mica dust may also be a considerable source of pulmonary fibrosis, and those experiences of talc and mica indicate that it might be worth

while

while to investigate further the effects of kaolin, another member of the family widely used in the china trade, an industry long associated with excessive respiratory morbidity which has, in the past, generally been attributed to the use of quartz in the manufacturing process.

The effects of inhalation of dust of basic slag are of great scientific interest. The chemical composition of the dust is intriguing. Nearly half of it is lime, to which recent work in Italy (Bianchi, Loriga, Turano, Sorrentine) and in America (United States Public Health Service) has directed some attention. Silica, almost entirely combined, accounts for some 14%. Manganese, another ingredient, has been thought by Schopper to be capable of producing pneumonoconiosis, while among the other constituents present may be alumina, iron, sulphur and fluorine, all capable of irritating the pulmonary tissues.

Another factor of importance is the extremely fine state of subdivision to which the particles are reduced. Eighty per cent must be capable of passing through a sieve of mesh 1 - 10000th of an inch, which involves a maximal particulate size of 2·5μ, so that nearly all the dust particles are capable of reaching the ultimate pulmonary tissue. The dust of basic slag manufacture is ground to a size not aimed at in the manipulation of other known pathogenic dusts, and this extreme fineness is of importance alike from the viewpoints of dust control (which presents great practical difficulty) and of pathology, in the light of Traube's recent physico-chemical discovery of the relation between size of particles and their action - that pharmacological activity decreases with decrease in the degree of dispersion, i.e., with increase in the size of the particles.

It has long been known that basic slag workers in the Middlesbrough area were excessively liable to pneumonia of severe type. This investigation confirms the excessive prevalence of pneumonia: Table IV sets out the relative frequency of incidence of pneumonia per 1000 years observed among workers in the sandstone, malting and basic slag industries, the figures in each case being derived from histories obtained in the present investigation. It must be remembered that the incidence of pneumonia among the general population of Middlesbrough is high, but even when allowance is made for this the excess among basic slag workers is striking.

T A B L E IV.

Incidence of pneumonia per 1000 years of observation among maltmen, sandstone and basic slag workers.

Industry.	Area of Investigation.	Incidence rate.
Malting.	Scotland: N.E. England.	3·1
Sandstone.	Do.	5·1
Basic Slag.	Middlesbrough district.	11·8
All insured males.	Scotland 1930 - 31.	1·3

The continued inhalation of basic slag results in the production of pulmonary fibrosis of severe degree, and the dust also produces well-marked changes in the mucous membranes of eyes and upper respiratory tract after quite short exposures. Basic slag dust, probably on account of its composite nature, is an exception to the generalisation that the intensity of initial reaction to a dust, is in inverse ratio to the degree of eventual damage which it causes.

The/

The radiogram raises several interesting points. It is probably as nearly characteristic as any pneumonoconiosis film with which we are at present familiar. Its most outstanding feature is a diffuse fibrosis, very similar to that seen in asbestosis and so well-marked as to give the negative a ground-glass-like haze. There is invariably enlargement of the hilar shadow with marked radiation to the lung periphery. In cases of old standing, it is common to find nodules of fairly large size and of the type encountered in established silicosis.

Figures I and II illustrate the development of the X-ray picture. The 'ground-glass' appearance is well-marked after 10 years' work in the industry, possibly earlier. Enlargement of hilar shadow and radiate striation precede this; nodulation, when present, is a later development. Such a complex radiogram, occurring following exposure to a composite dust containing so many ingredients naturally prompts the question whether the final picture is the result of gradual uniform development due to the action of dust qua dust or whether some of the individual elements present in the dust superadd a pathology of their own. The radiological picture is at all events as characteristic as those of silicosis and asbestosis, and the physical signs are no less definite than in the others.

Conditions found among maltmen are different. The ultimate picture here is one of peri-bronchitic fibrosis and emphysema, but in its early stage there is nothing to distinguish the radiogram of the fibrosis of grain dust from that of an early stage of any other, such as silica. Figure III shows the lung of a maltman of 10 years standing:

while

Fig. 1: Basic Slag Worker, employed for 10 years as mechanic.

Fig. 2: Basic Slag Worker, employed for 30 years as loader.

Fig. 3: Early fibrosis in a maltman of 10 years' standing.

while it lacks the well-marked diffuse fibrosis of the basic slag worker shown in Figure I, it has definite increase of hilar shadow and radiations to the lung periphery: it might well represent the lung of a scappler in the sandstone industry after a similar exposure.

Maltmen suffer from respiratory diseases to a greater extent than the general population, and these diseases contribute largely to their causes of death. Other circumstances of their work, notably exposure to rapid variations in temperature and the strenuous nature of the physical effort demanded, doubtless contribute to the respiratory pathology, but it is the general opinion of the men concerned that dust is the most dangerous factor. Several types of malt house dust have been described, but the composite nature of the maltman's work makes it very difficult to determine which element in the dust is chiefly causal. Four suggestions may be put forward: (a) that the dust acts simply as an inert foreign body, (b) that its histamine content is of importance, (c) that the spores present produce some specific pathology, and (d) that the respiratory phenomena are essentially allergic in type.

The possible influence of histamine, or bases allied to histamine, in the production of respiratory symptoms has been raised in the recently published Report of the Departmental Committee on Dust in Card Rooms in the Cotton Industry. Dr. McDonald and workers at the Shirley Institute in Manchester have demonstrated the presence of histamine-like bodies in aqueous extracts from various kinds of cotton dust, and it has been suggested that those bodies may be responsible for the dyspnoea of card room workers. Barley dust has been found

found to contain almost as much histamine as cotton, while malt dust contains appreciably less. Is it possible to correlate with this the general opinion of the men that barley dust is "heavier" and more "catching to the breath" than malt?

It seems probable that something of the nature of allergic reaction may play a part in determining the initial symptomatology. The common experience of young entrants to the industry has been described. Dyspnoea and cough are common for the first two or three weeks, and tend to recur in a modified form at the beginning of succeeding malting seasons: but a somewhat similar state of affairs is found among young basic slag workers. The classical "maltman's cough" is a later manifestation, probably the result of established bronchitis. Maltmen of older standing, even in the presence of pronounced respiratory distress, do not show any evidence of eosinophilia: systematic blood examination of entrants to the industry during the first few weeks of their employment might be helpful in elucidating the nature of the early dyspnoea.

Spores have been found in nearly 50% of maltmens' sputa examined. French observers (Vallery-Radot and Giroud) describing tracheo-bronchitis among maltmen have insisted on the specificity of infection with Aspergillus fumigatus which they demonstrated by intra-dermal and precipitin reactions. In the present investigation it has only been possible to carry out intra-dermal reactions to an inconclusive extent. It seems probable that sharp bronchitic attacks occurring among maltmen are associated with the presence of spores in the sputum to an extent greater than usual, but it has to be remembered that such an attack may equally well have been induced

induced by exposure to specially high dust concentration. No evidence has been found of mycelial growth in vivo, though this is common in sputum standing at room temperature.

It is difficult to resist the conclusion that, in the majority of cases at all events, the ill-effects of the inhalation of malt house dusts are largely attributable to non-specific qualities of the dust concerned - that it is capable of producing severe symptoms, cough and dyspnoea, with recognisable pulmonary fibrosis and emphysema in its role simply as an inert foreign substance. The widespread distribution of the respiratory abnormality, the tissue cellular reaction to dust particles, as evidenced in the sputum, and the absence of any blood findings suggestive of allergy, lend colour to this view. It is impossible to exclude completely the possibility of operation of such factors as spore or histamine content, which may, and, notably in the case of initial symptoms, probably does play some part, but there is considerable evidence that the well-developed progressive disabling condition - the classical "barley hoast" - is essentially a response to dust concentration as such.

It is generally contended that grain dusts produce no true fibrosis. Pancoast and Pendergrass, in their recent work, repeat this view. Clinically, it is impossible to differentiate between the condition produced by malt house dust and that of silicosis, except that the former is generally associated with emphysema. Radiologically, the fibrosis is found to be essentially peri-bronchitic in nature: but in the absence of masking emphysema it may be difficult to exclude the presence of a measure of diffuse fibrosis. Figure 4 - from a maltman of old standing, is a good illustration of this.

In/

Fig. 4: Radiogram from a maltman of 30 years' standing.

In the study of effects of inhalation of trade dusts it may be useful to consider these as being possibly two-fold in origin - a general factor common, though possibly in slightly varying degree, to all dusts, and a more specific element dependent on some particular attribute of the dust under review, such, for instance, as the nodulation of silicosis. This implies that, inhaled in appreciable quantity, no dust is harmless, and evidence has been produced to indicate that over a fairly representative range such is the case. Many dusts still await study, notably alumina and those of the artificial abrasives, but the trend of recent work has been to incriminate many dusts previously considered to be above reproach. The group of silicates urgently requires study: the work of Bragg has opened up a new line of approach here, and such work as has already been done suggests that some members of the group may present pictures as striking as that of silicosis, possibly even sharing its association with tuberculosis. The co-existence of emphysema with fibrosis is of great practical importance, since it introduces a grave disabling factor. Biochemistry ought to be able to contribute much to our knowledge. Why do some few workers escape the development of fibrosis even after prolonged exposure, while their mates, under identical working conditions, succumb? What metabolic considerations govern individual susceptibility? These are questions of great importance in preventive medicine. Radiology can help, particularly in detecting the beginnings of disease: as our knowledge grows we may be able to adopt a systematic classification of pneumonoconiosis on a radiological basis.

No/

No field of science offers a more fertile ground for research. The statistician, the physicist, the chemist, the geologist, the mycologist, the pharmacologist, the pathologist, the bacteriologist, the radiographer and the engineer must all co-operate with the physician in tackling the problem of trade dusts. The methods of approach are legion. Such a team, observing a large unselected block of the population at risk, could achieve results of paramount importance, not only to industrial hygiene, but to industry itself.

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