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in silicosis. Early asbestosis must be differentiated from acute emphysema.

Treatment of Silicosis and Asbestosis

The treatment of both of these conditions is preventive and symptomatic.

Early removal of the affected worker from the inciting cause of his disease is imperative. When the disease has progressed beyond the early stages, removal is useless. The fibrosis continues to build up whether the worker is exposed or not and eventually leads to incapacity. For this reason unless the silicotic worker has signs of respiratory infection, tubercular or otherwise, it is inadvisable to remove him from his work after nodular fibrosis is present. The man will gain nothing and will lose several additional years of productive work at tasks with which he is familiar and at which his earning capacity is highest. The same may be applied to asbestosis.

In the recent report of the Special Industrial Disease Commission of Massachusetts it was

recommended that "no finding of physical unfitness shall be made except in evidence of active pulmonary tuberculosis." In the Picher Clinic, held in connection with the Picher mines, workers are not barred from employment unless they are infected.

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it was noted that foundry workers were particularly susceptible to pneumonia, "about one fourth of all foundry men being found to succumb to this disease."

Tuberculosis may result from the activation of an old quiescent process, or it may be an infection superimposed upon the silicotic fibrosis. Thus according to Kettle [98] "harmful dusts if inhaled into the lungs may excite to activity a latent tuberculosis infection, they may exaggerate an active tuberculosis lesion or a coincident infection; and they may render the lung less able to cope with a superimposed infection."

The pathology resembles that of fibroid phthisis, the middle and basal areas of the lungs are more frequently involved and tubercular broncho-pneumonia more common. Cavity formation may occur and the whole picture resemble that of an advanced case of pulmonary tuberculosis [28]. Tubercle bacilli are usually not plentiful but may be found in the centers of areas of necrosis (Fig. 22). At any time there may, through a breaking down of a necrotic area containing tubercle bacilli, be a rapid spread to

other parts of the lung. The course of silicosis with a secondary tuberculosis is, however, usually slow, and "without the usual symptoms of intoxication and may be carried for years without serious impairment of working capacity" [147].

Respiratory infections other than tuberculosis are frequent. "On the Rand pneumonia is the most common cause of disability and death among native laborers." Proske and Sayers [139] have confirmed Cummings' discovery of fuso-spirochetal organisms as a cause of infection among miners in Picher. Of the pneumonias, broncho-pneumonia is the more frequent, lobar-pneumonia being relatively rare.

Asbestos and Asbestosis

The commercial article known as asbestos is not a distinct mineral but is a name applied to any mineral which can be separated readily into more or less flexible fibers. The most important variety is that obtained from chrysotile ($H_4Mg_3Si_2O_9$) which is mined extensively in Canada. Sufficient exposure to dust of asbestos in any

stage of its processing may cause asbestosis. It should be noted that there is no free silica in asbestos although the total silica in pure chrysotile is 44.1 per cent.

Symptoms and Physical Signs of Asbestosis

The symptoms and physical signs of uncomplicated asbestosis are suggested by the pathology. After 5 to 10 years' exposure, the patient usually complains of slight dyspnea and a cough which is dry and annoying. The expectoration if present is scanty. As the condition advances the dyspnea becomes more marked and may appear on the slightest exertion. With the dyspnea are pains in the chest. There is rapid loss of weight going on to emaciation. Cyanosis is frequently present and the complexion is "earthy." Inspection shows an emphysematous type of chest with poor nutrition. Expansion is limited frequently to less than 1 inch. The percussion note all over the chest is one of dull tympany reaching dullness at the bases. On aus-

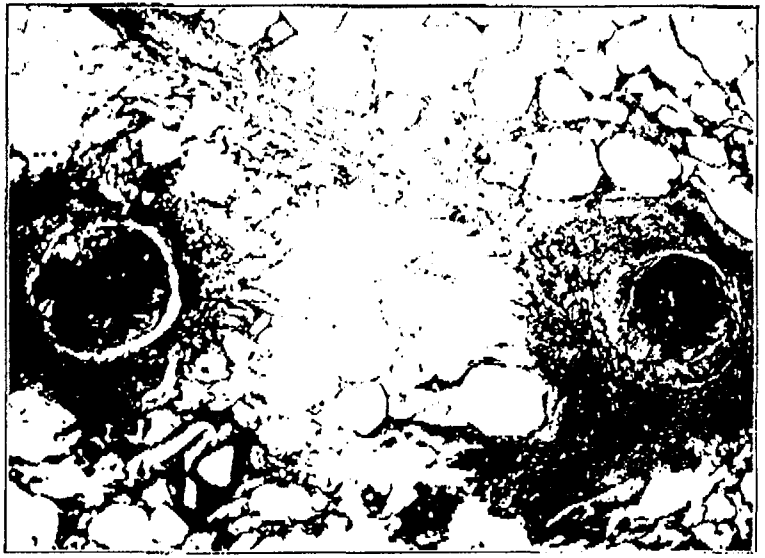

FIG. 22. Barre granite cutter. Two isolated silicotic nodules. Cellular connective tissue borders and hyaline fibrous centers. Thickened interlobular septum extending upward to the left of the right nodule. Note dilated lymph vessels in septum. (*Courtesy of Dr. Gardener and U. S. Public Health Service* [145].)

which the engineer welcomes as an objective of cleanliness for which to strive. Some of these figures are founded upon reliable data and some are frankly estimates.

Legge and Duckering [104], [46] suggested 0.5 mg. per cu.m. for lead dust which Russell and his colleagues [146] lowered to 0.15 mg. for litharge indicating that this figure might be scaled up or down with changes in the solubility of the lead compound in serum.

The South African authorities, for their high quartz rock in the Witwatersrand gold mines, have gradually arrived at a figure of about 1 mg. per cu.m. and silicosis, under their conditions, has not been eliminated (although greatly reduced). Higgins, Lanza, Laney and Rice [81] suggested 10 mgs. per cu.m. for the high quartz rock of the Joplin, Missouri, zinc and lead district. In both of these examples the standards suggested are both practicable and attainable.

Russell et al [145] in their granite study in Barre, Vermont, suggested 9 to 20 million particles per cubic foot by the impinger sampling

technic and light field counting. Here the dust contained about 35 per cent quartz. In sandstone working, where there is a high percentage of silicates, Badham, in Australia [5] advocated 200 particles per cubic centimeter by Owens' jet dust counter, but hinted that 100 would be better. In Great Britain, perhaps wisely, no figures for permissible dustiness in connection with silicosis have been suggested.

In their cement dust study Thompson and his associates [164] investigated one of the most harmless inorganic dusts of modern industry. The effects upon the chests of workers with abundant dust exposure were in no way comparable to the chests of the granite workers depicted by Russell. Nonetheless, Thompson advocated 10 to 20 million particles per cubic foot as compared with 9 to 20 million for granite.

In the case of asbestos dust no figures have as yet been suggested but on the basis of abundant experience McConnell [116] of the Metropolitan Life Insurance prefers to see the dust count below 5 million and welcomes still

lower figures. Merewether [120] gives figures on asbestos dust concentrations but no indication of permissible dustiness.

In studying metal fume fever caused by breathing freshly formed zinc oxide (Fig. 10), Drinker, Thomson, and Finn [43] found that concentrations of 14 mgs. of zinc per cu.m. for 8 hour exposures or 45 mgs. for short exposure could be tolerated without causing the "shakes" to the average worker. Drinker believed that figures could easily be obtained for other metallic fumes but the required experiments have never been done. Prodan [138] found that cadmium oxide fume, which is close to zinc oxide metallurgically, was far too toxic to permit breathing measurable amounts.

To insure the avoidance of trouble from chromic acid mist Bloomfield and Blum [15] suggest that continuous daily exposures be kept below 1 mg. per cubic meter and show in their report that this figure is readily attainable by proper transverse ventilation.

Cummings [32] sees no need to require the manufacturer of materials with well established

harmless effects to maintain air as clean as that demanded in granite cutting. However, there is no longer any excuse for excessive dustiness in any process—it merely represents slovenly practice. A few years ago it was not uncommon to see workmen employed in an atmosphere so thick with dust that a 50 watt lamp was obscured at a distance of 10 feet. In a recent lawsuit a witness testified that he had to sweep up every hour because if he waited longer it was necessary to use a shovel! Industrial physicians and engineers have seen these conditions but they cannot defend them.

The only justifiable conclusion to be drawn from such apparent inconsistencies is that generally we lack data for defining rigidly permissible dustiness. The application of medical and engineering knowledge and common sense to dust control is highly commendable but the point has not been reached where a manufacturer can be told with certainty that his plant will have no silicosis, no asbestosis, or no lead poisoning if he keeps dustiness down to some definite figure. He can be told only that the maintenance of certain

degrees of air cleanliness represents the best present practice.

The question is asked frequently whether 10 million quartz particles per cubic foot breathed for 8 hours is equivalent to 70 million for 1 hour plus 1 million for 7 hours, the total amount entering the respiratory system in both cases being 80 million. On this point Mavrogordato [113] in discussing his "dust floods" says: "Lesions of silicosis in a mild degree can be produced in an animal by 30 hours' exposure to intense dust clouds, and one is inclined to suspect that it is intermittent exposure to relatively dense clouds that is the deciding factor in pro-

TABLE 6

AVERAGE DUST COUNT IN CERTAIN DUSTY TRADES

Industry	*Dust count in millions of particles per cubic foot of air*
Slate finishing mills	
Floormen	1598.0
Loaders	1276.0
Disc crusher operators	312.8
Talc mining	
Jackhamer drillers	2159.8
Muckers	44.8
Talc finishing mills	
Crushers and cylindermen	14.0
Packers	50.1

Industry	Dust count in millions of particles per cubic foot of air
Marble carvers	19.1
Marble cutters	32.8
Granite quarrying	
Leyner drillers	144.4
Jackhamer drillers	112.1
Plug drillers	36.9
Cement mill, average of all operations	26.0
Granite cutting	
Hand pneumatic tool operatives	59.2
Machine pneumatic tool operatives	35.9
Attendant labor	17.0
Anthracite coal mining	
Mining and miners' helpers	231.5
Attendant labor	31.1
Bituminous coal mining	
Coal cutters and coal loaders	112.3
Attendant labor	3.9
Silverware manufacturing	
Dusty processes	5.2
Non-dusty processes	1.7
Municipal dust (street cleaners)	
Congested district	4.1
Residential district	1.8
Cotton industry	
Carding room	8.6
Weaving and spinning room	4.5

ducing the disease in susceptible human subjects." All medical experience is in accordance with Mavrogordato's statement and after all, it is only physiological common sense—a subthreshold stimulus for a long time produces no reaction whereas a relatively brief super-

threshold stimulus may cause a reaction. It is not enough to find that the *average* dust concentration is below a desired figure: occasional exposure to excessive dustiness should be avoided.

Industrial Dust Concentrations

Granting the advisability of maintaining the concentrations indicated, it is just as well to know something of the concentrations one actually finds in sampling. In this country Bloomfield [14] of the U. S. Public Health Service, and Fehnel [117] of the Metropolitan Life Insurance Company, have assembled and personally determined dustiness in a large number of industries. Some of Bloomfield's data are given in Table 6. Harrington [72], [73] gives figures of dustiness in mines and the early mining investigations by Higgins et al [81] are still useful.

CHAPTER IX

LEAD AND METAL FUME FEVER

LEAD

LEAD IN SMALL QUANTITIES is being ingested daily by most people. Kehoe [95] has shown that even in isolated non-industrial communities normal individuals excrete a certain amount of lead daily.

Workers in lead or where the process involves the use of lead are exposed to abnormal amounts of the metal and may suffer from lead poisoning. While in the case of exposure to tetraethyl lead, absorption is through the skin [70], in the majority of cases lead is inspired as a dust or fume [71]. Although a small amount of lead may be taken in by mouth from the worker's unwashed fingers, the amount in most cases is too small to be of importance [71].