process or group of industries or processes involving exposure to silica dust, who were certified to have suffered death or total disablement from silicosis or silicosis accompanied by tuberculosis, or who, though not totally disabled, were found on medical examination to be suffering from the disease to such a degree as to make it dangerous to continue work in the industry and were for that reason suspended from employment.

The Act required that the scales of compensation fixed by any scheme, in the case of death or disablement from silicosis, should be those prescribed by the Workmen's Compensation Act, 1906, in all other cases such as may be prescribed in the Scheme. The Act further provided for the inclusion in any Scheme of 3 principles: —

(1) The establishment of a general compensation fund (administered either through a mutual trade insurance company or society of employers) to which all the employers in the industries should be required to subscribe and out of which all claims for compensation and all expenses arising under the Scheme should be paid. The burden of compensation would thus be borne by the industry as a whole and no question of apportioning the liability among different employers would arise; further, there would be no tendency to dismiss particular workmen who showed symptoms which might indicate the onset of the disease.

(2) The settlement of claims, and other matters arising under the Scheme, by Committees representative of both employers and workmen with an independent chairman.

(3) The appointment of medical officers with special knowledge of respiratory diseases, who would carry out periodic medical examinations and have power to suspend any workmen from further employment in the industries; and the appointment of Medical Advisory Committees or Medical Referees for the purpose of deciding difficult cases referred

to them by the medical officers on whose certificate only compensation could be paid.

By the inclusion of these three principles the special difficulties in the way of providing compensation for silicosis were met. These had been recognised and pointed out by the Committee on Compensation for Industrial Diseases in 1906. They found there would be difficulty in apportioning liability amongst employers for a slowly developing disease occurring in workmen who had moved from one employment to another; difficulty in diagnosis of silicosis from respiratory affections generally prevalent; and a possible tendency amongst certain employers to dismiss workmen showing any symptoms, in order to avoid liability.

The first Scheme under the Act of 1918 was made for the Refractories Industries and came into force on February 1, 1919. This Scheme embodied the 3 principles outlined above. The medical officers appointed under the Scheme were generally the Tuberculosis Officers of the Local Authority administering sanatorium benefit under the National Health Insurance Act. The duties of the medical officers laid down in the Scheme were (1) to make periodic medical examinations of all workmen in the industries, except those employed over twenty years, at specified intervals of one year in the more dangerous processes, and two years in the others; (2) to examine newly engaged workers within three months of commencing work in the industry; (3) to examine on the warrant of a Joint Committee any workman claiming to be suffering from the disease; (4) to examine at specified intervals workmen in receipt of payments for partial disablement. If at either periodical or initial examination a workman was found to be suffering from silicosis or silicosis with tuberculosis, he had to be suspended from employment in the industry. After a clinical examination a medical officer was entitled to have a roentgenological examination, if neces-

sary. If still in doubt about the diagnosis he could refer the case to the Medical Advisory Committee or Medical Referee, after which he issued a certificate in accordance with their decision. The medical officers forwarded their certificates to the Joint Committee, whose duty it was to determine the awards of compensation.

The Refractories Industries Scheme, 1918, was a new and interesting experiment in Workmen's Compensation, and it appeared to work smoothly and to give rise to no serious dispute.

A Departmental Committee was appointed by the Home Secretary in 1923 [60], to inquire into the working of the Scheme and to advise on any proposals for applying the Act to other industries. This Committee found certain defects for which they suggested improvements, and they considered that the Scheme, if amended in accordance with their recommendations, would form a basis on which to frame similar schemes for other industries in which a risk of silicosis occurs. In particular, they referred to the absence of power to suspend persons suffering from tuberculosis without silicosis; the lack of uniformity in the medical examinations; failure to eliminate workmen showing early signs of disease; and the difficult financial position of the Fund.

In their Report the Committee sought to remedy the defects in the medical provisions, by recommending that a Medical Board be established consisting of two whole-time Medical Officers who should be responsible for all medical examinations; facilities for roentgenologic examinations should be increased and greater use made of this form of examination; the responsibility of suspending a workman on account of silicosis should not be entirely on one medical officer; power should be given to medical officers to suspend workmen found to be suffering from tuberculosis of the lungs (although no compensation was payable); entrants to the

industry should reach a prescribed standard of respiratory physique. The recommendations of the Committee were adopted and included in an amending Act passed in August, 1924, and later in Section 47 of the Workmen's Compensation Act, 1925.

In 1929 The Sandstone Industry (Silicosis) Scheme was made on the lines of the Scheme for the Refractories Industries. The same principles were adopted for the provision and maintenance of the Fund from which compensation and expenses were paid; Joint Committees settled claims and certificates were given by members of the Medical Board who, with an increased staff, also made initial and periodical medical examinations.

These two Schemes, for the Refractories Industries and the Sandstone Industry, are the only Schemes of that type.

In 1927, the Metal Grinding Industries (Silicosis) Scheme was made to apply to workmen employed in the grinding of metals; incidental work in the same room; and the racing of grindstones. In 1928 The Various Industries (Silicosis) Scheme was made to apply to workmen in a large number of industries and processes, not covered by the existing Schemes, in which the risk of contracting silicosis was recognised. The machinery under these Schemes, which at first were limited to cases of death and total disablement, was that applicable to diseases scheduled under the Workmen's Compensation Act, namely, examination and certification by the Certifying Factory Surgeon for the district in which the workman was employed, subject to a right of appeal to a Medical Referee. Except for certain occupations in the pottery industry, no periodical medical examinations were made.

A Departmental Committee was appointed by the Home Secretary in December 1928, to advise as to the medical arrangements which could be made for the diagnosis of silicosis in cases of claims arising under the Workmen's Com-

pensation Act [61], and for carrying out any periodical or other medical examinations of workers which may be prescribed for any industry or process involving risk of silicosis. This Committee recommended that the examinations and certifications in the industries covered by all the Schemes be co-ordinated and a Medical Board set up for the purpose, of which the Medical Board already appointed under the Refractories Industries and Sandstone Industry Schemes would form the nucleus. They considered that where compensation was claimed in fatal cases, a certificate as to the cause of death should only be given after a post-mortem examination, except where the deceased workman was in receipt of weekly payments under the Scheme, and then only if the Medical Board were satisfied as to the cause of death without a post-mortem examination. Power to carry out the recommendations of the Committee was obtained in the Workmen's Compensation (Silicosis and Asbestosis) Act, 1930, which extends Section 47 of the Workmen's Compensation Act, 1925. A Medical Arrangements Scheme followed in 1931 [26], and the existing Schemes were amended to give effect to its requirements as to the Medical Board, Medical Examinations and Certificates, and Medical expenses and fees. The fees payable for examinations and certificates by the Medical Board are prescribed by the Silicosis and Asbestosis (Medical Fees) Regulations [62].

The Medical Board now consists of 9 members: the Chief Medical Officer with a head office and laboratory at Sheffield, and 4 panels each of 2 medical officers, situated at centres convenient to the principal industries to which the Acts apply. These are Sheffield, the centre of the Refractories and Metal Grinding industries; Manchester, dealing principally with the Asbestos industry in Lancashire, and the Sandstone industry of the North of England and Scotland; Stoke-on-Trent, the centre of the Pottery industry; and Cardiff, a con-

venient centre for the South Wales coalfield from which most of the cases of silicosis occurring in the coal-mining industry arise. Besides the whole-time members of the Medical Board, a few part-time members have been appointed to act, especially in fatal cases, in areas at a distance from the centres of the Board. Certificates are issued on the authority of not less than 2 members of the Board, and are conclusive.

The 1930 Act also extended the power of making Compensation Schemes to the disease of asbestosis, and a Scheme on the lines of The Various Industries (Silicosis) Scheme was made for the Asbestos Industry and came into force on 1st June, 1931. The provisions of the Silicosis and Asbestosis (Medical Arrangements) Scheme apply also to examinations and certificates required for the purposes of this Scheme, and the examinations are carried out by the same Medical Board.

TABLE 5

Number and Results of Examinations under the Silicosis and Asbestosis (Medical Arrangements) Scheme, 1931, during the Year 1935.

(A) Initial and Periodic Examinations.

Industry.	Initial Examinations.		Periodic Examinations.			
					Number suspended.	
	Examined	Suspended	Clinical examinations.	Radiological examinations.	On account of the disease +	On account of tuberculosis.
Refractories industries	582	33	605	117	5	1
Sandstone industry	645	44	2,028	385	22	–
Pottery industry	473	31	1,394	215	15	1
Asbestos industry	488	24	1,099	150	32	–
Total for 1935	2188*	132	5,126	867	74	2
Total for 1934	1639	100	6,451	1,058	63	12

+ 540 of these examinations were made by local tuberculosis officers, 23 being referred to the Medical Board for suspension.

(B) Examinations in pursuance of applications for Death and Disablement Certificates.

Industry.	Disablement.		Death.	
	Workmen examined.	Certified to be wholly or partially disabled by the disease.*	Applications dealt with.	Certified to be caused by the disease.*
Refractories industries	14	7	10	7
Sandstone industry	53	41	51	43
Pottery industry	125	66	59	32
Asbestos industry	9	4	2	1
Coal mining industry	492	228	69	51
Masons & stone dressers	73	49	55	23
Metal grinding industries	16	13	10	8
Other industries	51	51	12	10
Total for 1935	836	439	228	175
Total for 1934	690	417	203	149

* The disease means silicosis or asbestosis or either of these diseases accompanied by tuberculosis

Home Office Workmen's Compensation Statistics of Compensation etc., in Great Britain during the year 1935. London. H.M.Stationery Office, 1937.

The scope and amount of work done by the Silicosis Medical Board can be gathered from the preceding Tables, which give details of the examinations in the year 1935, with comparative figures for 1934.

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VII. PUBLIC HEALTH AND ECONOMIC ASPECTS
UNITED STATES

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Introduction

The occupational diseases and the health of industrial workers present one of the important phases of public health. Of the occupational diseases, none is more truly occupational than the pulmonary diseases due to the inhalation of industrial dusts. Lead, carbon monoxide, arsenic, benzol and many other toxic substances associated with industrial processes are also found in circumstances that have no connection with industry. The same cannot be said for the pneumoconioses. They stand as the most perfect type of occupational diseases. Recognized for centuries, only in comparatively recent times have their wide-spread effects been disclosed and their importance to the public health appreciated. More lately still, the inclusion of these disorders in schemes of compensation for occupational disease has emphasized their economic importance and the necessity for thorough and adequate methods for their control.

Silicosis and Compensation

Silicosis and asbestosis burst upon the amazed consciousness of American industry during the period 1929–1930. Previously, the terms "silicosis", "asbestosis", "pneumoconiosis", were practically unknown to industrialists except that in the hard rock mining industry, silicosis, under its various colloquial designations, was well recognized. Knowledge of these

conditions was limited to the small number of those whose investigations of pulmonary dust diseases had made them conversant with the subject.

Arising out of the period of economic depression, the situation with respect to silicosis and asbestosis became manifest as a medico-legal phenomenon of a scope and intensity that was at once preposterous and almost unbelievable. Damage suits, under the common law, were instituted against employers by employees, alleging pulmonary dust diseases, in industrial centers all over the United States, to an amount in excess of 100,000,000 dollars. To understand this situation, both in its economic and public health aspects, it is necessary to review not only the history of silicosis investigations in the United States but also the status of compensation for occupational diseases in the various States.

The reader is referred to the first chapter of this book. Briefly, governmental agencies began studies of silicosis in the mining industry in 1914 and these were carried on until they were interrupted by the entry of the United States into the World War. These studies had for their purpose the detection of silicosis, the extent and severity of the disease in the areas studied and the establishment of methods of control. The question of compensation did not arise, which must seem strange to the non-American student of the subject.

In almost every State of the Union, there is a State Department of Labor and Industry. These State Departments are charged with the administration of the laws pertaining to factories, mines, and workshops. Previous to 1930 only 3 or 4 Labor Departments included in their activities a division of industrial hygiene and these few were not established on a basis that made possible original studies or research. They were mostly concerned with routine inspections and also endeavored to enforce laws and regulations pertaining to

health, whose vague wording often made them almost non-enforceable.

The State Departments of Health, although their functions might be thought to embrace public health in industry, uniformly ignored the subject altogether, with the exception of Ohio and Connecticut, where occupational diseases were made reportable. Following the widespread national attention focussed upon occupational diseases by the silicosis furor, this situation has entirely changed and at present (1937) State Divisions of Industrial Hygiene are, with a few exceptions, located in the State Departments of Health.

The Federal Government embraces several agencies that concern themselves with occupational diseases and industrial hygiene. In the United States Department of Labor, the Bureau of Vital Statistics has been actively engaged in the field of investigation. In the United States Public Health Service, the Office of Industrial Hygiene and Sanitation has likewise been engaged in industrial studies and at the request of and in co-operation with the United States Bureau of Mines investigated dust diseases. These governmental departments have jurisdiction in industrial establishments of a governmental nature only, except that by virtue of recent legislation, the United States Department of Labor may supervise conditions under which work is done under a contract with the Federal Government. The Government officers enter a mine or a factory only with the permission of the owners and usually at their request. The Federal officials have no power to enforce existing State laws nor to initiate new laws or regulations. Reports of silicosis investigations, when published by the department responsible, might and did contain suggested methods for the prevention and control of this disease but they were addressed not to the State authorities nor to the industrialist but to the general public as contributions to the

existing knowledge. Both State officials and industrialists might profit by this new knowledge if they so wished. Usually they did so and a great many improvements were instituted but these were largely confined to those industries that had been studied at first hand. In fact, during the period 1914–1929, silicosis was considered a serious hazard only in certain phases of the mineral industry, with the exception of a few specific occupations, such as sandblasting. Asbestosis was practically unknown.

To summarize, the investigations of silicosis during the period 1914–1930, and of both silicosis and asbestosis for some time subsequently, were scientific (embracing both medical and engineering aspects), informative and non-legislative, with the exception of the study of silicosis among rock drillers made in New York City in 1928 under the auspices of the New York Tuberculosis and Health Association.[1] In this instance, definite recommendations regarding workmen's compensation were made.

Since 1912, in Massachusetts, occupational diseases have been compensated by court interpretation of the wording of the accident compensation law. In 1914, no other State had made provision for compensation for occupational diseases. By 1930, however, 10 States and 3 Territories had enacted laws making occupational diseases compensable.[2] In addition, there were 3 Federal laws, affecting employees of or under the jurisdiction of the United States Government. At present (November, 1937), 21 States have some form of occupational disease compensation and of these, 16 include silicosis and other dust diseases. When the time came to enact legislation bringing occupational diseases within the scope of the compensation acts, some of the States followed British precedent and enacted a schedule of the diseases which were thus made compensable. In the other States, occupational diseases were covered under a general description such as 'diseases arising

out of and in the course of occupation,' without further designation — the so-called 'all inclusive' or 'blanket law.' The Federal Government followed the latter method in providing compensation for its employees.

Between 1914 and 1930, the total amount of compensation paid for occupational diseases was very small, averaging not more than a minor fraction of the accident compensation cost in the various States. Interestingly enough, up to 1935, not one State operating under a schedule included silicosis, asbestosis, or pneumoconiosis in the list of compensable diseases, a situation difficult to understand, considering that silicosis is the most truly occupational of diseases, that reports of studies of silicosis in the United States had been forthcoming for twenty years and that there was available a vast amount of literature embodying the experience of England, South Africa, Australia, and Canada. In the States having 'all inclusive' coverage, the number of awards for silicosis was negligible.

The explanation of this curious state of affairs is, probably, that silicosis was considered as distinctly a hazard of mining. In those mining States, where hard rock mining was a major industry, there was no compensation for occupational diseases nor was there any pronounced demand for such compensation. 'Eating dust' was looked upon by the hard rock miner as a natural danger of his trade. Mining companies usually pensioned older employees disabled with silicosis or saw that they were cared for in one way or another. Also, following the governmental reports, the mining companies concerned started to put their mines in order, spending large sums of money on ventilation and dust control.

Then, with dramatic suddenness, came the era of the silicosis damage suits. Lawyers who specialized in this type of law practice instituted suits for damages under the common law on behalf of employees of various corporations for injury to the lungs due to the inhalation of dust. They were aided not

only by the general and increasing unemployment but by the almost total ignorance of industry — aside from mining — concerning pulmonary dust diseases and by the absence of silicosis in the compensation schedules which enabled them to bring suits for amounts far in excess of the limits of compensation. An interesting exception occurred in one or two States — Ohio, for instance — where the absence of silicosis from the schedule was held to bar suits or claims for this disease either under compensation law or common law. In those States where there were no occupational disease laws, claimants were at liberty to sue under the common law.

Among the first claims for damages were those for asbestosis, a hitherto unheard of disease in the United States.[3] Damage suits multiplied by hundreds, starting on the Atlantic seaboard and extending to the industrial States of the middle West and far West. The terms 'pneumoconiosis,' 'silicosis,' 'asbestosis' were strange and unfamiliar to judges, juries, and industrialists and were enveloped in medical and pathological technicalities. Consequently, the claimant's witnesses and medical experts, as far as their prestige with juries was concerned, carried as much weight as did those of the defendants. So great was the confusion and lack of knowledge on the part of courts, juries, and physicians that awards were made for silicosis to men who had never been exposed to the dust of free silica. Many of those seeking damages undoubtedly had silicosis — many did not. Damage suits were filed against cement companies and against mining companies whose operations were in limestone formations where there could be no possibility of a silicosis hazard.

All of this might be dismissed as a historical and medico-legal curiosity except that it greatly modified existing compensation laws in the United States and stimulated the passage of new laws. Commissions were appointed by several of the States to inquire into and recommend legislation for compen-

sation of occupational diseases and especially silicosis. It was generally felt that it was not sufficient merely to add silicosis to an existing schedule or include it when a new schedule was planned but it was essential to make special provision for regulating and limiting the benefits to be paid for silicosis. Many industries had acquired through the years considerable numbers of employees who had, or might be deemed to have, silicosis; industrialists, insurance companies, and the State funds feared that simply to make silicosis compensable was to invite a deluge of claims that would exhaust existing funds and make insurance rates prohibitively high. In most of the enacted laws, a fixed period of residence within the State was stipulated to prevent silicotics from migrating from a State where there was no compensation to one where there was.

The problem of compensation for a chronic illness as contrasted with an acute one presented difficulties, inasmuch as it did not seem that the insurance principle, on which all compensation in the United States is based, could be successfully applied to disability or to diseases already existent and whose extent was problematical. With business conditions as they were, the industries did not feel that they should be compelled to establish special silicosis benefit funds to provide for accumulated cases which had occurred under conditions where there was no statutory requirement imposing an obligation upon the employer which he had failed to meet. Moreover, it was often evident that silicotics had not contracted their disease in the place of present employment but in a previous one and, perhaps, in another State. The attitude of the average industrial firm was that, being shown that they had a silicosis hazard, they were willing and anxious to clean up and endeavor to control dust and to pay compensation to those who might subsequently contract silicosis but that they should not be required to pay for disability from a disease of whose existence they were previously unaware. The various commissions

and legislative committees endeavored to iron out these complexities as best they could, having in mind their own local conditions.

Some years previously, the Province of Ontario had assumed the attitude that, tuberculosis being a disease common to the human race generally, when silicotics contracted tuberculosis, their compensation benefits for disability should be diminished and such a provision was enacted into law.[4] A similar economic point of view, regardless of its logic or justice, influenced those engaged in drafting legislation in the various States, so that when silicosis legislation was finally enacted, in some of the States the individual disabled by silicosis received less award than one suffering from any other compensable occupational disease. Furthermore, several of the State Committees took the position that uncomplicated silicosis, as observed in American industries, was not disabling and that disability did not occur until infection (tuberculous) had supervened and then the disability was considered total. Hence, in some States, partial disability due to silicosis is not recognized.

The New York law,[5] as in some other States, provides that compensation shall not be paid for partial disability due to silicosis or other dust diseases. For permanent disability or death, the awards are fixed according to a sliding scale as follows: For a total disability or a death claim, presented within the first month in which the Act becomes effective, not exceeding $500; for every subsequent month thereafter, $50 is added, but in no event shall the compensation exceed the aggregate of $3000. The maximum for total disability from other occupational diseases or from accidents may be considerably more, depending upon the age of the deceased and upon the number of dependents.

It was hoped that the sliding scale would have a twofold effect. It would safeguard the continuity of employment by

spreading the economic burden which was expected to result from these laws and it would also tend to induce the workman with an early silicosis to keep on working. In addition, it would stimulate the employer to vigorously attack his dust problem with the hope of averting total disability claims.

In Pennsylvania, the occupational disease law [6] provides that for diseases which develop to a point of disablement only after an exposure of five years (to be determined by the Workmen's Compensation Board), compensation costs for disability or death, arising during the period of ten years succeeding the effective date of the Act, shall be paid jointly by the Commonwealth and the employer as follows: In the first year in which the Act becomes effective, one tenth by the employer and the remainder out of funds controlled by the Commonwealth. In each succeeding year, the employer pays one tenth more, the Commonwealth one tenth less, to the expiration of the ten year period. Partial disability for silicosis, anthraco-silicosis, and asbestosis is not recognized and the total liability of the employer for these diseases is limited to $3600.

In North Carolina, the recently enacted compensation law [7] states that in silicosis or asbestosis, compensation shall be paid as provided in the Act but if either is complicated by tuberculosis, the rate of payment may be reduced one-sixth.

While some of the foregoing might seem to lie in that realm of reasoning so difficult of comprehension to the non-legal mind, the underlying motive was not a desire to deprive working men of their just dues but a feeling that it was necessary to place a drastic check on the expected avalanche of silicotic claims. Undoubtedly, the common law damage suits confused and terrified industrialists and insurance officials. As a matter of fact, many of these suits were never brought to trial, many were compromised by settlements out of court, but those that did come to trial were won by claimants in sufficient number

to inspire dread among all exposed to this type of legal action. If these apprehensions prove to have been unwarranted it is probable that in the next few years, Silicosis Acts may be modified to make their awards more in line with the general trend of compensation.

The North Carolina Act also stated that if an employee is affected by silicosis or asbestosis, he shall be taken out of employment and paid partial or total disability until he can obtain other occupation. The State will train him for other occupation at State expense. If later he returns to a job with a silicosis hazard, he forfeits compensation benefits.

The experience of Wisconsin is very instructive and for a description of the complexities of silicosis compensation in one State, the reader is referred to the informative article by Kossons and Fried,[3] from which the following figures were obtained. Wisconsin is an important industrial State with mines, quarries, foundries, and enamel ware industries, besides many others. During the seventeen year period — 1920–1936 inclusive — 893 claims for disability from silicosis were brought before the Industrial Commission. Of these, 469 claims were allowed (one third of them were death claims) and 55 per cent of these were filed during 1933–1934. A comparison of costs for the fifteen years — 1921–1935 — shows that for the entire period, the cost of silicosis compensation was 2.23 per cent of the total cost, including and in spite of the peak years of 1933–1934, when it was 9.40 per cent and 8.80 per cent respectively.

Extent and Nature of Hazard

It is not possible to estimate accurately the number of persons exposed to the harmful effects of silica dust. Comprehensive statistical information, based upon accurate death records, is lacking. Silicosis is not included in the list of reportable diseases. Many of the deaths due to silicosis with

tuberculosis have been recorded simply as tuberculosis. Neither hospital records nor death records customarily give a workman's industrial history — indeed, it is unusual for even the present or final occupation to be stated with sufficient clarity to be of value to the investigator. Morbidity records are of less avail than mortality records, and physical examination of new employees in industrial establishments, while fairly common, have rarely been of such a nature as to reveal early pulmonary disease. Even when industrial conditions are good, there is considerable movement of labor from place to place and from State to State. When times are bad, this migration is increased. Unemployment then drives men not only from place to place but into new occupations.

Lanza and Vane [9] estimated that there were about 500,000 industrial workers employed in occupations exposed to silica dust. It is more than likely that this estimate errs considerably on the conservative side. This estimate does not take into consideration the thousands of men who have been employed where there was a silica hazard and who are now scattered throughout industry.

The menace in silicosis has always been tubercle infection. The evidence [10] here is overwhelming and has been stressed by investigators throughout the world. In 1927, Watkins-Pitchford [11] stated : "In ascertaining, from our records, what the liability of the simply silicotic miner to become tuberculous has been in the past, account has of course been taken of all instances in which the change has been detected during life ; in addition to this, however, it has been assumed that, in those persons suffering from simple silicosis who have died of their disease without having been again examined, death has been the result of this change. This is an assumption which is warranted in practically every instance. Relying on this assumption, and also bearing in mind that, as already stated, the liability to tuberculous change has appeared less marked

in each succeeding annual batch of cases, one finds that the combined results of seven years' observations show that, by the end of the seventh year, a little more than half of the cases of simple silicosis have either developed overt tuberculous changes or have died as a result of those changes."

Collis [12] also bears witness: "Silica dust alone possesses the further characteristic that it increases the liability to succumb also to pulmonary tuberculosis."

Kettle [13] states the case very clearly: "The silicotic lung appears to be a more favorable medium for the growth of the tubercle bacillus than the normal lung, not because it is fibrotic, nor because its lymphatic drainage is interfered with, but because it contains silica."

Much research and study have been applied to the question of infection in silicosis but in spite of the fact that the nature of the relationship between silica and the tubercle bacillus is still to be determined, the reality of this relationship is affirmed by recent investigators. Irvine [14] and his associates analyzed 543 deaths in 1923, cases originally certified as having simple silicosis. Approximately 75 per cent of these deaths were due to tuberculosis. They note that this inherent predisposition to tuberculosis is as marked in very early (anteprimary) as in later stages (primary).

Simson and Strachan [15] state: 'The importance of the infective factor in many and ultimately in the late stages of most cases of silicosis has always been recognized in South Africa, as elsewhere.' They comment further that many cases are infective from the outset, in others there may be a reactivation and local extension of pre-existing dormant foci of infection or there may be a new infection from outside.

The experience in the United States is similar. Meriwether [16] states for the Picher, Oklahoma District 'The production rate of tuberculosis (exclusive of old cases that progressed) was 0.75 per cent or 750 per 100,000 population,

which, for 1929, is certainly higher than that of the general population of the country.'

The following is quoted from the United States Public Health Service report on Anthraco-Silicosis among Hard Coal Miners : [17] "Several surveys have shown that tuberculosis of the lungs occurs among 1 to 2½ per cent of the general adult white male population of the country. In a study of tuberculosis in Framingham, Mass., it was found that about 1 per cent were suffering from the disease in an active form, and another 1 per cent were classified as having arrested tuberculosis.[18] Physical examination of 100,924 adult white males made by the Life Extension Institute indicated a prevalence rate of about 1½ per cent when suspected cases were included.[19] A somewhat higher percentage, namely, 2½ per cent, was found by the Public Health Service from the examination of 10,000 male industrial workers.[20]

"Among the anthracite workers examined, the clinical tuberculosis rate was below normal in the younger adult ages, but at ages 35 to 44 clinical pulmonary tuberculosis was diagnosed in about 5 per cent of the hard-coal mining employees ; at ages 45 to 54 in 10 per cent ; and at ages 55 to 64 in 20 per cent. No such rise with age occurred in any general population group for which comparable data are available.

"The prevalence of tuberculosis was greatest among the rock workers. The next to the highest rate occurred among anthracite workers who had changed more than five years previously from very dusty to relatively nondusty occupations in the industry. The third highest rate was exhibited among persons who had had appreciable exposure to harmful dusts in other industries. Among the regular miners working at the face the rate was definitely higher than in the control group which showed a prevalence rate of less than 1 per cent.

"When the term of service exceeded twenty years, more than two or three of which involved exposure to heavy concen-

trations of rock dust, about 37 per cent of such employees (classified as rock workers) showed evidence of pulmonary tuberculosis. Service of twenty-five to thirty-four years was associated with a tuberculosis rate of 8 per cent among non-rock workers employed in the haulageways, of 14 per cent among the regular miners, but with a rate under 2 per cent among men exposed to less than 5,000,000 dust particles per cubic foot of air."

As has been pointed out on numerous occasions, the severity of an individual case of silicosis depends upon the extent of dosage of silica; that is to say, upon the duration of exposure together with the intensity of silica dust concentrations in the air. The early investigators of silicosis in the mining industry in the United States were confronted by working conditions of the utmost hazard — that is, a maximum amount of silica dust in the air with no provisions for its control nor for the protection of the men exposed. Hazards of this severity have happily disappeared except, perhaps, in isolated instances; certainly such conditions are no longer industry-wide.

Some recent investigations reveal a degree of exposure which is manifested as a disabling illness after middle age has set in — characteristic of certain phases of the foundry industry.[21] Again other studies have shown the existence of silica hazards sufficient to produce characteristic roentgen-ray appearance but without disability that can be directly charged against pulmonary fibrosis. It seems fairly certain that the industrial hygienist of the future will not see the typical cases of far advanced silicosis, presenting roentgenograms with "snow storm" appearance and areas of massive fibrosis described by early investigators both in this country and abroad.

On the other hand, the tendency to minimize the silica dust hazard which has been manifested on recent occasions is not justifiable. If there is one thing that stands out with con-

spicuous regularity in the vital statistics of this and other countries, it is the high incidence of tuberculosis and other respiratory diseases in the silica dust trades.[9 22] We know that where silica has been inhaled in sufficient quantity to produce its characteristic effect, a definite condition of susceptibility to tuberculosis has been established. We should hesitate to infer, therefore, that exposure to silica dust to an extent insufficient to produce characteristic nodulation may not carry with it implications in terms of tuberculosis and other respiratory diseases. From a public health standpoint and for the promotion of healthful conditions of work, there is demanded constant attention to dust hazards in industry with the utilization of every practical method for the prevention of atmospheric pollution.

Asbestosis

Asbestosis was first described in the United States by Pancoast, Miller, Smyth and Landis in 1918, but its importance was not realized until it was introduced into the damage suit situation which led to the first comprehensive study of this disease in the United States.[3] Recent years have seen an immense increase in the use of asbestos, both for brake linings of automobiles and for heat resisting and insulating materials. With relation to public health, asbestosis is not nearly as serious a problem as silicosis. The number of persons in the industries using asbestos is very much less than for silica and in the United States amounts to about 12,000 factory workers, of whom approximately 25 per cent are women. Not all of these are exposed to dusty processes.

Most of the asbestos used in the United States is imported from Canada. It has been suggested that the various types of asbestos differ in their ability to cause pulmonary disease, but so far no proof of this is forthcoming.

Much of the industrial exposure arises from textile proc-

esses in which dust control measures can be readily instituted. As soon as the hazard was realized, industrial firms fabricating asbestos took energetic steps to control the dust so that it is probable that cases of asbestosis will become uncommon. A recent report from the United States Public Health Service details dust control methods instituted in an asbestos textile plant which illustrates in a striking manner what can be done to alleviate dust.[23]

Asbestosis has not appeared to be as serious a disease in the United States as it has in England, judging from the various reports from the latter country. Asbestos "mattress making," mentioned in the British reports as a serious hazard, is a process not found in this country. The role of infection in asbestosis is not as clearly defined as in silicosis and the clinical evidence available indicates that tuberculosis does not have the intimate relationship with asbestosis that is so conspicuous in silicosis.[24] [25]

Effects of Silicosis upon the Families of Silicotics

From the earliest times, when silicosis was first described as a disease of miners, the fact that the wife did not contract tuberculosis from the husband was mentioned and the many recent investigations have not upset this general conclusion. Hoffman [26] stated in 1922, "The frequency of pulmonary tuberculosis among immediate relatives of granite cutters, but particularly wives, daughters, and mothers, is much less than, as a mere matter of probability, would be assumed to be the case." This was borne out by the later studies of McFarland [27] and Russell.[28]

Cummings of the Saranac Laboratory, who investigated this subject in connection with the Picher Clinic, commented on the fact that, despite the wretched living conditions, and the lack of cleanliness and sanitation in many homes of advanced silicotics whose sputum was loaded with tubercle bacilli, no

adult type tuberculosis was found among exposed children up to the age of sixteen.

Nevertheless, these various testimonies do not exclude the necessity of treating tuberculo-silicosis as a communicable disease and of making follow-up investigations of members of families of advanced or disabled silicotics, to determine the presence of tubercle infection or the desirability of segregating contacts from the diseased member of the family. Sound public health procedure should be the rule and reliance should not be placed upon the supposed immunity of the family because the tuberculosis is complicated by or consequent upon silicosis.

Control and Prevention of Silicosis

The control of silicosis is both an engineering and a medical problem, as are so many other situations that concern the public health. Both the engineer and the physician, with their technicians, have their parts to play. In some instances, the medical phase may predominate; in others, the engineering, but it is seldom that they can be separated or be independent of each other if a thorough job of prevention is to be done.

Engineering Control

The development of silicosis is dependent upon the dosage of silica and the matter of avoiding a dangerous quantity might be thought simple. The lay mind, familiar with the definiteness of the hazard of carbon monoxide, and other toxic substances producing acute effects, usually fails to appreciate the inherent difficulties of establishing a threshold limit for a substance producing a chronic disease whose development is measured in terms of years rather than hours.

From time to time, critical comment is directed toward the industrial hygienist by the engineer because the former has failed to inform the latter of the safe or threshold limit of

silica dust in the air of working places. That is not an unnatural criticism from those whose profession involves dealing with definite and measurable factors. Unfortunately, neither physiology nor pathology in their relationship to the incidence and progress of chronic disease has yet advanced to the point where they are susceptible of expression in terms as definite as those used by the engineer.

The circumstances under which silica dust is introduced into the air of working places varies to an extreme degree. Furthermore, these circumstances and others that, in turn, affect them, vary from day to day and from hour to hour; they are affected by wind and weather, by dryness and humidity. All this would be complex enough if we were dealing only with the dust of pure silica, but in actual practice, the silica dust is frequently combined with other substances which may modify its action and about which little is known. Some industrial processes lend themselves to dust control measures; others do not, and in these latter, an entire change of the process itself may be necessary to overcome the hazard.

Dust Sampling

To deal with any health hazard successfully, its nature and severity must be understood. For silica dust, the two factors involved are the proportion of silica in the particular rock or mineral substance from which the dust originates and the amount of dust present in the air breathed by the workmen exposed. A great deal of study and research has been concentrated on this subject. It is customary to define the extent of exposure by stating the number of dust particles, under ten microns in greatest diameter, in millions per cubic foot of air.

Various methods of counting the dust particles in the air have been devised, later to be discarded, until at the present time in the United States reliance is chiefly placed on the impinger method as defined and practiced by the United

States Public Health Service and the United States Bureau of Mines. The merit of the impinger is that it takes large samples, over a considerable period of time (one-half to one or two hours). The objection to the impinger is that it is cumbersome, time consuming, and demands expert technical skill if the results are to be trustworthy. Simpler devices consisting of smaller portable instruments, taking a small quantity of air — "grab samples" — and necessitating less skill are also used. The objection to these devices is that due to the smallness of the sample, the margin of error is considerable. Both methods have their place, but when serious studies of dust hazards are involved, it is probable that reliance will continue to be placed on the impinger method until a more satisfactory one is evolved. Small electric precipitators, modeled on the Cottrell precipitator, are in use but are mostly restricted to laboratory practice and to standardize the impinger. Other devices are still in the laboratory or experimental stage.

To summarize: While no one method of sampling air for the purpose of making dust counts has proved entirely satisfactory, up to now the impinger is accepted as most reliable in field work. No two methods are quite comparable; even samples taken by the same method in the same location and at the same time frequently show marked differences.

State Departments of Labor are naturally desirous of establishing standards of air dustiness for the control of the dust hazard and for the guidance of factory managers and factory inspectors. To a very limited extent, such standards have been suggested as a result of various government investigations.[28] However, much caution is needed here and too much reliance should not be placed upon the formulation of "standards" of air dustiness and the enactment of factory codes setting forth permissable limits of dust counts. Such threshold limits as have been worked out have very definite value as a guide in endeavoring to secure better working conditions but their

limitations and possible transitory nature should be well understood. They should not as yet be enacted into law, otherwise a situation analogous to that of school ventilation may be repeated. Some of our State laws and regulations controlling ventilation in schools provide for an air change of 30 cubic feet per minute per occupant — a highly expensive and troublesome provision. This standard was based on what was thought at the time these laws were enacted to be a correct conception of "pure" air and "bad" air. Our present knowledge of ventilation and atmospheric control has proved the inadequacy of this carbon dioxide standard but it is the law in many places. If history repeats itself in formulating threshold limits of air dustiness, the result will be not only vexatious but costly.

The first and basic principle in dealing with a dust hazard is to remove the dust at its point of origin and thus prevent its dissemination into the air. This is the only procedure to which the term prevention may be properly applied. Once the dust is in the air, the protection of the individual becomes difficult and often unsatisfactory.

The removal of dust at the point of origin may be accomplished by suction devices working on the principle of the well known vacuum cleaner. In certain processes, such as drilling, water may be used to advantage. In some instances, water and air suction may be combined. So great is the variety of industrial processes from which silica dust may arise that a detailed description is not feasible. Each type of process usually presents its own problems and difficulties to the engineer and what will work satisfactorily under one set of circumstances will not always be successful in another.

Once the dust has been disseminated into the air, its removal may present serious engineering difficulties. Water may be employed, either as a spray to increase the humidity and facilitate the settling of dust particles, or water blasts may be

used to accomplish the same results more rapidly and thoroughly. It is obvious that this method is limited in its application. The dust may be diluted by increasing the quantity of air through forced ventilation — again a method not always applicable and apt to be expensive. The two methods may be combined. Both methods, either singly or in combination, have been widely applied in mining operations.

Some experimentation has been done with the use of hygroscopic substances applied to the surfaces of mine passages to prevent dust from being continually stirred into the air. It has also been proposed to add to silica dust other kinds of dust with the hope of inhibiting the action of silica in the pulmonary tissues. While this method of combatting silica dust may be both practical and valuable under certain conditions, it is not likely that it will be accepted as a final satisfactory solution. The effects of long continued breathing of such mixed dusts are unknown. Boiling or chlorinating infected drinking water may be a necessary procedure but satisfactory hygienic standards require that the community be supplied with water from reasonably pure sources and enormous sums of money are spent to secure such water. Likewise the air that industrial workers must breathe should be reasonably pure. Air containing harmful quantities of an injurious substance plus a counter-acting or antidotal substance would seem to leave much to be desired with respect to purity and proven harmlessness. The industrial age has seen too many miracles of achievement and too many evidences of inventive genius to make one believe that satisfactory dust control is beyond our resources.

It is essential that where dust control devices have been installed that check tests be made from time to time to determine their continued efficiency. Such equipment tends to lose its value unless continuously supervised and maintained in good working condition. It is the common experience of

investigators to find installations of ventilating and dust removal machinery that are of little use due to failure to keep them in proper working order while at the same time they continue to give a feeling of unwarranted security.

Face masks, helmets, and respirators have been developed to protect the individual in dust polluted atmospheres. Their use is justified when the exposure, or the dusty process itself, is intermittent and of short duration. Filter type respirators, which are approved by the United States Bureau of Mines as adequate for protection against silica dust, can be relied on. They may be uncomfortable, especially when the temperature is high, and their continued use calls for a degree of co-operation from the individual workers which experience has shown is difficult to maintain. Positive pressure helmets and masks are generally efficacious when used under conditions for which they are suited. The adequate supervision and maintenance of protective equipment is all important. A faulty device or one improperly used will give a false sense of security that will eventually betray its user.

Medical Control

Pre-employment physical examinations, where a definite health hazard is involved, are an essential public health procedure, definitely important in controlling the incidence of occupational disease. The benefit should accrue impartially to the individual, the industry, and the community. It is also important that the function of the pre-employment examinations be understood so that they may not be abused. It is desirable to place men in types of work for which they are adapted. It is equally necessary not to bar, needlessly, employment to those seeking it. Much of the dispute and ill feeling engendered during the last few years on the subject of physical examinations, both pre-employment and for those already employed, as related to the silicosis furor, might have been

avoided if the basic reasons for such examinations had been understood and if employers and others concerned had thought their problem through. Some misunderstanding was inevitable under the general circumstances.

It is not practicable to lay down definite rules or to assume a dogmatic attitude. Circumstances vary in different occupations and different parts of the country and economic considerations always stand well to the fore and must be recognized.

Obviously no one with active or recently active tuberculosis should be exposed to silica dust, nor anyone suffering from other pulmonary disease, especially if of an infective nature, which would tend to increase the hazard. On the other hand, there is often no good reason for rejecting an applicant who already has silicosis, if the silica hazard in the work place involved is under control and if the workman's physical condition is properly supervised thereafter. This is an important consideration where the industry is a dominant one in its locality and other opportunities for work are limited. Here is where the experienced industrial physician must bring his judgment to bear both upon the individual and upon the work he is to do.

In connection with the recent compensation laws passed in some of the States, the attitude toward pre-employment examinations is interesting. The New York [5] law states, "It is hereby declared to be the policy of the legislature of this State, in enacting this article, to prohibit, through every lawful means available, any requirement to employment which compels an applicant for employment in any occupation coming within the purview of this article to undergo a medical examination."

As contrasted to this, the North Carolina [7] law states, (where the Industrial Commission has found an occupation to have a hazard of asbestosis or silicosis) "it shall be the

duty of every employer . . . to provide prior to employment necessary examinations of all new employees for the purpose of ascertaining if any of them are in any degree affected by asbestosis and or silicosis or peculiarly susceptible thereto; and every such employer shall from time to time, as ordered by the Industrial Commission, provide similar examinations for all of his employees whose employment exposed them to the hazards of asbestosis and or silicosis." At least one member of the Advisory Medical Committee or other physician designated by the Industrial Commission shall make such examination or be present when such examination is made. Further on, the law continues: "The refusal of an employee to submit to any such examination shall bar such employee from compensation or other benefits provided by this Act in the event of disablement and or death resulting from an exposure to the hazards of asbestosis and or silicosis subsequent to such refusal."

Particularly to be commended are the control methods set up in the Province of Ontario. A co-operative agreement is in force between the Workmen's Compensation Board and the Provincial Health Department. Examination centers are established where necessary and pre-employment and periodic physical examinations, with the use of the roentgen ray are made by a physician of the Health Department for the Workmen's Compensation Board. Examination certificates are issued to acceptable workers. Claimants for compensation come before a Referee Board of Physicians of the Health Department. This Board works in co-operation with the industries concerned and the Compensation Board.

Where workmen are exposed to a silica hazard, medical supervision goes hand in hand with engineering control of the dust. Indeed, it is the industrial physician who must finally determine whether the dust control measures in his establishment are efficacious. Annual, or perhaps bi-annual,

medical examinations with the roentgen-ray are usually sufficient with more frequent examinations of those individuals who, the industrial physician feels, need more constant supervision. As in any other circumstance where an occupational health hazard is involved, no mechanical method of prevention can be taken for granted.

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