TABLE V

DEATHS FROM RESPIRATORY DISEASES* PER 1,000 LIFE YEARS EXPOSED (COMBINED GROUP MORTALITY EXPERIENCE 1922–1930); ALL AGES

INDUSTRY	LIFE YEARS EXPOSED	DEATH RATE PER 1,000	PER CENT RESPIRATORY DEATHS OF TOTAL DEATHS
Steel and iron foundries	450,012	3.39	33.9
Sheet metal products (stamping and pressing)	209,196	1.42	23.0
Light metal products (tools, hardware, etc.)	1,070,598	1.65	22.7
Heavy machinery and other heavy metal products	920,024	1.53	22.1
Bituminous coal mining—underground	153,407	1.54	15.5
All industries	20,353,369	1.45	20.9

* Influenza and tuberculosis (all forms) are included.

TABLE VI

DEATHS FROM RESPIRATORY DISEASES* PER 1,000 LIFE YEARS EXPOSED (COMBINED GROUP MORTALITY EXPERIENCE 1922–1930)

(A) Steel and iron foundry employees—450,012 years of life exposed. (B) All industries—20,353,369 years of life exposed

1	2	3	4	5	6	7	8	9	10	11	12	13
CENTRAL AGE	TOTAL RESPIRATORY DISEASES*			INFLUENZA		TUBERCULOSIS (ALL FORMS)		OTHER RESPIRATORY DISEASES		PER CENT. RESPIRATORY DISEASE DEATHS OF TOTAL DEATHS		
	A	B	A/B	A	B	A	B	A	B	A	B	Per cent A/B
18	1.12	0.76	147	0.14	0.04	0.10	0.45	0.79	0.28	34.8	32.8	106
23	1.67	0.83	201	0.06	0.04	0.48	0.51	1.14	0.27	44.0	32.6	135
28	2.09	0.86	243	0.08	0.04	0.57	0.48	1.45	0.34	48.7	30.8	158
33	2.57	0.97	265	0.11	0.06	0.91	0.45	1.55	0.45	51.7	29.3	177
38	3.25	1.24	262	0.16	0.08	0.87	0.51	2.22	0.65	47.3	27.8	170
43	3.53	1.52	232	0.29	0.10	0.89	0.57	2.35	0.86	40.6	24.7	164
48	4.31	1.91	226	0.21	0.12	1.00	0.64	3.10	1.16	35.8	21.8	164
53	5.08	2.31	220	0.19	0.15	1.36	0.65	3.52	1.50	33.0	18.1	182
58	5.73	2.98	192	0.38	0.22	1.19	0.66	4.15	2.11	26.5	16.1	164
63	7.64	4.09	187	0.47	0.30	1.01	0.80	6.16	2.99	21.9	13.7	159
68	9.60	5.40	178	0.56	0.42	1.55	0.81	7.48	4.17	18.2	12.4	147
73	11.51	7.84	147	0.68	0.78	1.02	0.75	9.81	6.31	14.5	12.2	119
78 and over	15.10	12.40	122	0.79	1.19	0.79	0.77	13.51	10.44	12.7	11.5	110
All ages	3.39	1.45	234	0.18	0.10	0.83	0.54	2.38	0.82	33.9	20.9	162

* Includes tuberculosis (all forms) and influenza.

for influenza, tuberculosis (all forms), and other diseases of the respiratory system, as well as for this group of causes as a whole.

The striking fact brought out by this table is the uniformly high death rates for foundry workers for each of the respiratory diseases throughout the working period of life. Foundrymen have a rate for influenza lower than that for all workers combined only at central age 73, their rate for tubercuymmetrical, small, circumscribed, ense areas throughout both lungs, nd later larger masses accumulate. 'hird stage: this differs from the econd stage only in the extent of lung ıvolvement, indicated by increased umbers of deposits and more massive rouping.

There were 130 employees of the rey iron foundries selected for X-ray xaminations of the chest. Of these 1 'as diagnosed as second degree silicosis, 31 as first degree, 20 as doubtful or silicosis, and 78 negative for licosis; of 62 employees in the steel oundries, 2 were diagnosed as second egree silicosis, 25 as first degree, 6 as oubtful, and 29 as negative; of 18 mployees of the malleable iron found-es, 7 were diagnosed as first degree, as doubtful, and 9 as negative, and f 5 employees of the non-ferrous ıetal foundries examined, 1 was iagnosed as first degree, 1 as doubtful, nd 3 as negative.

The management of each foundry 'as furnished with a table setting orth a detailed description of the :-ray examination of each worker, orrelated with his age, occupation, revious occupation, years of exposure, ıd other pertinent information indi-ating the extent of the health hazard. 'he name of the worker was omitted nd a number substituted in order to void any discrimination.

Tables II, III, and IV give the sults of the X-ray examinations by ;e groups, by years of exposure, and y occupations for the groups ex-nined.

It is obvious that these tables erely indicate what may be expected ıd are of no statistical value because ıe examinations were limited to a few workers only in each group. The individual was classified either according to the department in which he worked at the time of examination or where he had spent most of his time. Many had changed from one department to another and from one plant to another during their years of employment in the foundry industry. Since only the amounts of dust collected at the time of this survey in the various departments are known, there is no way of determining the average amount of dust in the atmosphere inhaled by these people over the years of their employment. Consequently, it is not possible to correlate individual cases with definite amounts of dust exposure.

Mortality Experience Among Foundry Workers in United States and Great Britain

Although this study did not include the collection of information relative to sickness among foundrymen, the Statistical and Actuarial Departments of the Metropolitan Life Insurance Company, in a study of mortality statistics, have supplied the following evidence to show that foundry workers are subject to an unusually high incidence of respiratory diseases.

Mortality statistics both American and foreign, covering a long period of years, agree in recording high death rates for respiratory diseases for foundry workers. These studies, it must be admitted, have been far from complete, giving little indication of the specific processes responsible for the excess mortality from these causes. Nevertheless, the results have been so consistent as to leave little doubt concerning the presence of some condition

TABLE I

Dust Counts by Plants and Processes

Grey iron foundries

Process	Plant A	Plant B	Plant C	Plant D	Plant E	Plant F	Plant G	Plant H	Plant I	Plant J*	Plant K†	Plant L
	million particles	million particles	million particles	million particles	million particles	million particles	million particles	million particles	million particles	million particles	million particles	million particles
1. Coremaking:												
a. Hand	9.3	2.5	1.0		4.5	1.9		6.8	24.2	10.1	5.1	3.6
b. Machine	9.4				6.1	5.7						4.3
2. Corerubbing					47.7							8.7
3. Molding:												
a. Hand bench		10.0			9.4						5.3	
b. Hand floor								10.2	5.1	35.2		
c. Machine and hand bench		11.0	4.5									
1. Sandslingers	14.5	20.3			474.6	16.6		25.4				
2. Jar and squeeze	20.3	9.5	6.0		79.7		15.7	14.5				11.16
3. Bumper									3.2			
d. Roll-over	13.0								6.8	16.4	10.3	7.9
4. Shake-out:												
a. Floor	12.2		5.0				31.2			10.6		
b. Castings suspended on crane, cleaned by hand and air hammer	11.8	8.0		6.6								
c. On continuous line casting machines	22.6	51.0			66.4			10.1				24.3
d. Traveling crane used in combination with continuous line casting machines												11.1
5. Cleaning:												
a. Chipping	4.8											11.1
b. Flexible shaft grinder		50.5		184.5								
c. Stand grinder	5.4			108.8	47.6		7.8			58.4		2.5
d. Swing grinder		55.8			158.1			49.4		9.0		4.0

2. Rotary sand blasting			12.8			
3. Tumbler barrels			5.5		3.2	32.0
4. Blasting cabinets using steel shot (under helmet)		5.2				
5. Rotary blasts using steel shot						
6. Tumbler barrels using steel shot						
6. Sand reconditioning:						
a. Mechanical		20.6				
b. Sandcutters						
7. Conditioning of core sand				8.1		
8. General air sample in foundry	34.3	2.95	5.1	22.3	7.9	13.0
9. General air sample in cleaning room		5.8		1.3	6.9	
10. General air sample in core room	6.4	4.5		5.2		
11. Facing mills	251.0	56.3	274.9	3.6	8.5	

* Plant J has both a grey iron and steel foundry; see table for grey iron foundries.
† Plant Q has both a steel and malleable foundry; see table for malleable foundries.

Malleable foundries. Non-ferrous metal foundries

PROCESSES	PLANT K*	PLANT Q†	PLANT R	PLANT S	PLANT T	PLANT V
	million particles	million particles	million particles	million particles	million particles	million particles
1. Coremaking:						
a. Hand	9.5	2.8	1.7		6.1	10.7
b. Machine				5.6		
2. Corerubbing						
3. Molding:						
a. Hand bench	44.8			10.5		
b. Hand floor			1.4			27.8
c. Machine and hand bench		3.0				
1. Sandslingers						
2. Jar and squeeze	25.8		2.2		28.4	4.6
3. Bumper				3.8		
d. Roll-over						

firmation of American insurance experience is afforded by this comprehensive analysis of English population statistics covering the occupational mortality of males in England and Wales during the years 1921–1923. Three classes of foundry workers were reported upon—metal molders, iron foundry furnacemen and laborers, and brass foundry furnacemen and laborers. Standardized death rates (ages 20–65) were given for each of the important causes of death.

The foundrymen's mortality is shown to exceed that for all occupied and retired males for each of the respiratory diseases. So far as respiratory tuberculosis is concerned, the excess was slight in two of the classes, being but 7 per cent. in excess for metal molders, and 1 per cent for iron foundry furnacemen and laborers. The rate for brass foundry furnacemen and laborers, however, was more than twice that for all occupied and retired males. Brass foundry workers, curiously enough, also had the highest death rates for each of the other respiratory diseases. Their death rate for bronchitis exceeded the average by 99 per cent., that for influenza by 121 per cent., and that for pneumonia by 149 per cent. Iron foundry workers had the next highest death rates for each disease. Their excess mortality ranged from 79 per cent. for influenza to 127 per cent. for pneumonia. Metal molders had the lowest rate for each class except for tuberculosis. Their rates for non-tuberculous respiratory diseases exceeded the average by from 41 per cent. for influenza, to 72 per cent. for bronchitis.

As a protection to the employer as well as the employees, it seems advisable to select not only workers who are skilled and competent, but also those who are physically fit for the work. This can only be accomplished through a physical examination, which should include an X-ray examination when indicated. In view of the serious results frequently following long exposures in dusty atmospheres, all such men should be repeatedly re-examined so that if evidence of disease develops it can promptly be checked.

The Lead Hazard in Foundries Studied

Three of the foundries studied, J, K, and O, have brass foundries for the casting of bearing metal. Air samples taken at the breathing level of the workmen and analyzed for lead showed the concentrations given in Table VII.

Toxicity of lead.—A relatively small number of studies have been published concerning the quantitative aspects of lead poisoning. Legge and Goadby have stated as their belief that 2 mg. of lead was the lowest dose which, inhaled by a worker each day, would in the course of a year set up chronic lead poisoning. Teleky, a distinguished German industrial hygienist, is reported by Oliver as believing that a little more than a milligram per day is toxic. A recent investigation of lead poisoning in a storage battery plant by Russell et al. (14) indicates that the limit of safety under the conditions encountered in the study is an atmospheric concentration of lead dust or fumes of less than 1.5 mg. per 10 cubic meters of air.

For the purpose of such a study as the present, it is necessary to set rather arbitrarily some standard for the minimal toxic dose, and it is presumably fair to assume 1 mg. per day as the minimal toxic dose. It is assumed that a man working ten hours inhales 10 cubic meters of air. All of this air would not reach the alveoli of the lungs, but this air would be drawn into the body and some of the dust or fumes drawn with it might be swallowed if not inhaled.

Men exposed to lead should be examined at monthly intervals. An important part of the physical examination is an examination of the blood. Most of the recent research workers regard the blood and the blood forming system as the anatomical elements earliest affected by lead, and hold that by a microscopical examination of the blood of lead workers, lead absorption may be detected before symptoms develop, and when, therefore, it is possible for actual lead poisoning to be averted. Additional evidence of absorption is the presence of lead in the excreta and the appearance of a lead line in the gums. While neither the presence of lead in the urine and feces, nor the discoloration of the gums demonstrates in itself that there has been any injury to the organism, both signify that lead has been absorbed.

Damage to body tissues may become manifest in many different ways. Lead may cause the early development of arteriosclerosis (hardening of the arteries) or chronic nephritis (kidney disease), as well as other degenerative changes which bear no apparent relation to lead poisoning. There are four signs which most frequently appear during the early stage of the disease: (a) the ashen color of the skin, (b) the lead line on the gums, (c) stippling of the red blood cells, and (d) mild secondary anemia or other evidence of rapid peripheral destruction of blood, such as increased quantity of blood pigment in the plasma or of hematoporphyrin in the urine.

TABLE VII

	Cubic feet of air sampled	Milligrams of lead per cubic foot of air	Milligrams of lead per cubic meter of air	Lead intake in milligrams in 10-hour day on basis of workman breathing 10 cubic meters of air
Plant J	24.3	0.06	2.11	21.1
Plant K	60.0	0.02	0.71	7.1
Plant O	74.5	0.04	1.41	14.1

These conditions can only be discovered by careful and frequent medical examinations of exposed individuals.

Certain measures of hygiene are particularly important. Workmen should wear clean clothes while at work, and always keep them quite separate from those worn at other times. This requires two lockers, for if dusty clothes are hung at night where street clothes hang during the day, contamination can hardly be prevented. An excellent arrangement used by many plants consists in building locker rooms on either side of the shower room. Men are required to leave work clothing in one locker and pass into the shower room. After taking a shower they pass along to the next locker room where they dress in street clothes. Smoking or chewing tobacco, if the hands are at all dirty, involves the danger of ingestion of lead; and as food may also be contaminated in the same way, provision should be made for ample washing facilities and for eating in rooms completely removed from the lead hazard.

The physician or some representative of the company should be given authority to order the transfer of suspicious cases from hazardous positions, or to request a period of rest. Upon re-exposure great emphasis must be placed on the necessary precautions, and the factory physician should be rigorous in his supervision.

Heat, Cold and Wet Hazards

Molders are exposed to the heat of molten metal when pouring and again to the heat of the partially cooled casting on shaking out the molds.

Cranemen and those working at the cupola are exposed to excessive heat from the molten metal, and it is usually the front of the body that is exposed. Here also arises a hazard affecting the eyes due to glare of hot metal and burns from spattering.

As the foundry is of a large area with large entrance doors and, necessarily, has sources of heat unevenly distributed, drafts are set up to which the workmen are exposed. The results of a study of the effects of radiant heat on the skin are reported in Reprint No. 1370 of the U. S. Public Health Service (15). This study demonstrates the actual skin temperatures resulting from exposure to heat sources.

There are few wet hazards, except in certain foundries employing hydraulic pressure in core casting cleaning.

Protective clothing should be worn by workers so exposed.

Plant Housekeeping

Orderliness and cleanliness, in so far as practicable for the type of work, were the rule rather than the exception in the plants studied. The floors were found to be fairly level. Only occasionally were sandy hills and hollows noticed. For cleaning, safety and efficiency, concrete, wooden blocks or granite blocks are preferable, and it is easier to keep them free from excessive dust. It is important to keep the aisles clear and well maintained, and provision should be made for storing equipment and tools not in use.

Personal Service Facilities

Washing facilities.—Separate and modern washrooms are provided for the employees in most instances. In some the washing facilities are scanty and inadequate. Shower baths provided with hot and cold water were found only occasionally.

Lockers. The majority of the foundries furnish lockers of some sort, made either of wood or steel.

When employees change their street clothing in the work rooms, the want of lockers leads to the continued exposure to dust of street clothing, as well as of food and tobacco, as long as they are in the foundry. Because lockers and locker rooms are not provided, the employees in many cases wear their work clothes from their homes to the foundry and back again, and in this manner carry dust into their homes.

engaged in each foundry occupation, assuming that they experienced the same death rate as Standard lives, was computed. The number of expected deaths thus calculated was then compared with the number which actually occurred.

Iron and steel molders, founders, and casters, constitute the largest foundry group represented in the investigation. In fact, this is the only group reported upon which of itself had a sufficient number of deaths to give significant results. It is worthy of mention first that more deaths were recorded from pneumonia among these workers than from any other cause. Where there might have been expected twelve deaths from this cause, there were actually 38, giving a ratio of actual to expected deaths of 315 per cent. Twenty-four deaths were recorded for respiratory tuberculosis where 13 might have been expected, giving a ratio of 179 per cent., while the ratio for influenza was 216 per cent., based on 23 actual as compared with 11 expected deaths. A similar situation was found for molders, founders and casters of brass and bronze, except that the ratios in general were higher than for iron molders and deaths from tuberculosis were more numerous than from pneumonia. The number of deaths, however, were few. There were seven deaths from tuberculosis where 1.3 was expected; five from pneumonia where 1.1 was expected, and four deaths from influenza where one was expected. All the other foundry occupations showed high ratios of actual to expected deaths for each of the respiratory causes. Few deaths were recorded for each class, but taken together the results are significant.

Causes of death by occupation (12).—The occupational mortality of adult white male Industrial policyholders of the Metropolitan Life Insurance Company who died during the years 1922–1924 is reported upon in this investigation. Since the number of living policyholders in each occupation class was not known, death rates could not be calculated. The method of analysis employed was to compare the proportion of deaths due to any one cause in any one specified occupation group, with the proportion due to the same cause among all occupied white males.

Here again we find that pneumonia was the leading cause of death among foundry workers, a condition not true of any of the other 71 occupations included in the analysis. Deaths from pneumonia accounted for 15.9 per cent. of the deaths from all causes, while deaths from tuberculosis accounted for 14.6 per cent. The combined group of respiratory diseases was responsible for slightly more than one-third of all the deaths of foundrymen, compared with slightly less than one-fourth of the deaths of all occupied workers.

When differences in the age composition of the two groups were taken into account, it was determined that the proportion of deaths from pneumonia was 120 per cent. higher for foundrymen than for occupied males generally. In the same way, the proportion of deaths from influenza was found to be 82 per cent. higher, that for tuberculosis of the respiratory system 5 per cent. higher, and that for other respiratory diseases, 17 per cent. higher.

Report of the registrar-general of England and Wales—1921 (13).—Con-

Water supply and drinking facilities.—In the foundries studied city water supply was available. A few of the foundries have "bubblers" or fountains. The water is cooled for use in the warm weather.

Toilets.—The toilets are all connected with a sewer system and are of a modern type. As a rule, they are adequate in number.

Clothing.—Protective clothing and foundry shoes are usually worn by the workers.

Respirators. These are provided where necessary and while a few workers use the old type of helmet, the majority use the newer positive pressure air masks. The chief criticisms to be made are:

1. Poor mechanical maintenance; either the workman does not receive sufficient air or else the face piece or hood is so worn that it does not fit properly.
2. Use of an improper type of respirator—the use of the ordinary pig snout respirator without positive air supply.
3. Positive pressure respirators not supplied with clean air.

Summary and Conclusions

This study has directed attention to the improvements noticed in foundry processes and particularly the progress made in the development of protective equipment for foundry use. It demonstrates also that the available protective equipment either is not used to advantage or is poorly maintained.

Counts of dust particles in the air taken at the breathing levels of the workers are given and indicate a relatively high dust count in practically every department of the foundry. In only two plants (C and L) of the grey iron foundries and three (R, S, and U) of the malleable foundries were the dust counts found consistently low. The dust concentration in many instances was sufficiently high to justify the assumption that workers so exposed over a period of years might readily develop silicosis. More than 56 per cent. of the samples collected exceeded ten million dust particles and nearly 10 per cent. exceeded one hundred million particles less than ten microns in greatest diameter per cubic foot of air, determined by the standard light field method. The advantages of modifying the illumination (dark field method) are discussed and the method described. Both methods were used in this study and it was found that for dusts encountered in foundries the dark field method gave results consistently twice as great as the standard light field procedure. Counts determined by the standard light field method only are listed.

The report emphasizes the harmful effects on the lungs of exposed workers from inhalation of dust and gives the results of the X-ray findings of groups of workers. Sixty-seven of the two hundred fifteen X-ray films taken were diagnosed as positive for silicosis. While advanced cases of silicosis were not found among those examined, sufficient evidence of the occurrence of the disease is presented. The prevalence of respiratory diseases, as indicated by mortality statistics, is discussed.

A section of the report is devoted to a discussion of lead dust and fumes found in a few of the foundries studied. In every instance the lead content of the air breathed by workmen exceeded the limits of safety. Recommendations regarding the control of this hazard are suggested.

Other possible health hazards, such as heat, cold, dampness, etc., have been briefly discussed. Comments regarding plant housekeeping and personal service facilities are made.

Recommendations regarding the isolation of processes, the use of approved equipment, responsibility for maintaining and inspecting equipment, the desirability of a program to insure plant cleanliness, and the protection of workers by means of proper clothing and respirators and by initial and periodical physical examinations have been submitted.

It is believed that this study justifies the conclusion that while foundry work at present may be considered a hazardous occupation, there are available well-designed equipment and protective devices which, if used and maintained, will prevent undue exposure of foundrymen to hazards injurious to health.

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those exposed 20 years and longer, and a large proportion of the workers developed pulmonary tuberculosis. It was not found in this investigation that it would be necessary to eliminate all of the dust to do away with the hazard. A safe limit of between nine and twenty million particles of dust, less than 10 microns in longest diameter, per cubic foot of air could be established. The conditions of atmosphere involved in this investigation, however, are not comparable to those encountered in the foundries.

Table I gives the dust counts by plants and by processes for the various types of foundries.

These counts represent the air dustiness at a given place and for a given period during which the collecting device was in operation, and merely suggest the extent of atmospheric pollution. It must be remembered, however, that these conditions may vary during the working day period and from day to day.

The value of dust determinations lies in their employment as a measurement for the efficiency of devices and equipment designed to control dust, rather than for the purpose of establishing safe limits of air dustiness. It will be noticed that the counts listed under plant L are consistently lower than those under other grey iron foundries, and are entirely due to the progress this plant has made in controlling the dust through well designed equipment and effective exhaust systems.

A safe limit of air dustiness for foundries has never been established, but presumably on account of the high silica content of the dust the count representing a safe limit would be comparatively low and in many instances impracticable to maintain. Protection can best be afforded to foundrymen by isolating dusty processes as far as practicable; by the employment of well designed and well constructed dust-tight equipment; by the substitution, wherever possible, of mechanical cleaning for hand cleaning; by the adequate maintenance of general ventilation and local exhaust systems; by good housekeeping; and by supplying workers exposed to dust, which cannot otherwise be controlled, with adequate respiratory protective equipment. Responsibility does not end with the installation of proper facilities, but these must be adequately maintained through regular and intelligent inspection. A responsible person or persons directly under the supervision of the management should be assigned the task of inspecting equipment and supervising housekeeping conditions.

X-Ray Examinations

Although certain symptoms and signs suggestive of silicosis may be found on physical examination, the diagnosis rests mainly on the X-ray film of the chest. The progress of silicosis has been classified by Lanza and Childs (9) based upon roentgenray findings into three stages. The appearances during the progress of the condition are so strikingly different that anyone is likely to select practically the same classification. The first stage demonstrates a beginning fibrosis; the trunk shadows are increased in density and breadth, with numerous punctate deposits of varying size along them. Second stage: in addition to the foregoing, there are found fairly characteristic picture of advanced silicosis.

An excellent x-ray film of the normal individual's chest represents a projection of the pulmonary structure cast as shadows of varying density. Prominent among these densities are those cast by the blood vessels, which compose the so-called vascular tree. The fibrous changes initiated by pure silica can be detected in the early stages on a good roentgenogram, by the increased densities shown at the root of the lung where the lymph nodes are situated. Further changes throughout the lymphatic system will become evident by an increased prominence of the vascular shadows caused by fibrosis developing in the lymphatics surrounding these structures. Finally the roentgenogram will reveal, as small round densities, the uniformly-distributed, discreet, fibrous nodules present throughout the lung in advanced silicosis, giving the characteristic "snow-storm" appearance described by roentgenologists.

Inert dusts such as coal, hematite, gypsum, alumina, and limestone, produce no stimulation of the phagocytes and hence tend to remain within these cells for long periods without promoting any further action. When mixtures of silica and these inert dusts are inhaled together, the reaction so characteristic of silica is modified by the inert material which tends to slow down the changes which would result if the silica were present alone. These modified reactions are apparent not only to the pathologist, but also to the roentgenologist, and constitute the great bulk of all cases of occupational fibrosis. Experience has demonstrated that individuals with modified silicosis do not suffer from the excessive mortality which characterizes those groups with true silicosis.

If tubercle bacilli are inhaled, they are handled in much the same manner as dusts. Once in contact with the tissues, however, they are either killed and disposed of or they set up localized foci of infection. The organisms are transported by phagocytes into the lymphatics and the tissues then attempt to wall off these foci of infection by laying down an ever thickening mantle of fibrosis. This reaction is much the same as that which follows the inhalation of silica, except that it is generally localized to one or more portions of the lung and may be visualized and interpreted as tuberculosis with remarkable accuracy in a good x-ray of the chest.

Obviously, the lung which has been injured by a pulmonary infection, such as tuberculosis, is far less competent to deal with a dust, such as silica, than is the normal lung. Moreover, it has been proved both clinically and experimentally that the inhalation of pure crystalline silica tends to reactivate a pulmonary tuberculous lesion which would otherwise heal, and frequently renders such infection progressive and fatal. Even if the tuberculous lesion has successfully healed prior to the time when silica is inhaled, a far greater reaction to the dust occurs about the site of the old tuberculous scar than occurs in normal tissue, since the drainage system in that area has already been damaged. The two processes apparently stimulate the tissues to produce an excessive amount of fibrosis.

Recent investigations have disclosed that individuals who have simple silicosis, uncomplicated with tuberculosis, are not generally disabled, even though their condition may be quite advanced. A careful physical examination frequently fails to reveal anything abnormal about such individuals, and the changes which have occurred in their lungs can be detected only by the x-ray.

Silicotic workmen who complain of shortness of breath, chest pain, cough, or other disabling symptoms are generally found to have either a complicating pulmonary infection, usually tuberculous in nature, or some evidence of a previous pulmonary injury which has left a localized scar. These cases can be discerned on an x-ray film by the characteristic appearance of silicosis to which have been added the densities cast by the localized masses of pulmonary fibrosis which exist about the sites of the infection or previous pulmonary injury. Frequently, such cases fail to show tubercle bacilli in the sputum until shortly before death. In many instances, the disease is unusually chronic and only slowly progressive, manifesting itself largely by a progressive shortness of breath. Cases of this type are the prominent feature among the men actually disabled by a modified silicosis hazard.

Widespread misconception of the disabling effects of uncomplicated silicosis has arisen from the studies of early investigators who were unable to distinguish cases of silicosis from those complicated with pulmonary tuberculosis or other infections with the equipment or knowledge then available. These earlier investigations revealed silicotics who displayed shortness of breath, chest pain, cough, and other disabling symptoms which were ascribed to silicosis alone, since tubercle bacilli could not be found in the sputum. It should be realized, at the present time, however, that silicosis assumes a serious position as an occupational hazard largely because of its effect on pulmonary infections, predominately tuberculous in character.

Though the foundry must always be considered as a dusty industry, the nature of its operations are such as to induce, for the most part, only a modified silicosis. Both mortality studies and clinical examinations of foundry workers fail to disclose the type of hazard associated with a pure silica exposure. Many men in advanced age groups who have spent their entire working lives in the foundry industry are still capable workmen, suffering from no occupational disability, although most of them will be found to have some degree of pulmonary fibrosis. The workmen who are disabled by an occupational fibrosis contracted in the foundry are generally those who exhibit evidence of concurrent pulmonary infection or other injury. It must be recognized, in spite of these alleviating circumstances, that a certain occupational hazard does exist in all foundries.

Any working atmosphere which contains more than a certain threshold concentration of silica will induce silicosis in workmen exposed to it over long periods of time. Information gathered from field studies made in many parts of the world indicates that a normal man may work for many years in air containing pure crystalline silica dust without impairing his health, providing the concentration does not exceed 5,000,000 particles per cu. ft. of air as determined by the standard method used in the United States.

This concentration constitutes a special value for the health hazards created by silica which may be designated as the primary threshold. The value of this threshold will be increased for those industries in which the silica hazard is reduced by the presence of modifying factors. The development rate does not always appear to vary directly with the concentration but increases slowly with the elevation of the dust level up to a certain value where the acceleration becomes very marked.

Concentrations of 100,000,000 or more pure silica particles per cu. ft. of air appear to be extremely hazardous and constitute a second special value which may be designated as the secondary threshold. Concentrations of pure silica above this secondary threshold lead to the rapid development of silicosis and men working in these extra hazardous atmospheres have been known to acquire true silicosis in less than two years. Examples of this type can be found among men dry drilling tunnels in quartz rock or sandblasting without protective equipment. Demonstrable silicosis usually develops in workmen exposed to pure silica in concentrations between the primary and secondary thresholds in from five to 30 or more years, depending upon the individual's susceptibility and the degree of the exposure.

Experience has shown that diminishing a hazardous dust exposure results in extending the time required for silicosis to develop and that even when it does occur, there is generally little evidence of disability among the workmen who contract it, unless they have a complicating pulmonary infection or other injury. All of the preceding remarks with regard to dust concentration apply only to those individuals without pulmonary abnormalities. The presence of pulmonary infections or other pathological conditions generally alters the normal susceptibility of dust diseases.

It appears to be true that the individual with arrested tuberculosis might be subjected to a health hazard in an atmosphere containing less than 5,000,000 particles of pure quartz dust per cu. ft. of air; while he might suffer no ill effects from exposure to fairly high concentration of inert dusts, such as coal, alumina, limestone or hematite. Obviously, the values given cannot be used arbitrarily to measure the degree of any hazard or to form the basis for legislative codes of good practice but they serve as one of the aids in bringing a given dust hazard under control.

What then are the responsibilities of the executives of those industries in which the dust hazard is suspected? In the author's opinion, the first duty imposed upon the operator requires that he secure a thorough knowledge of the nature of the disease itself ject, unfortunately, assume the attitude that silicosis is just another "racket" and delegate the duty of keeping the organization out of trouble to minor officials. The subordinate officers, having been impressed with the general attitude of the management, are frequently powerless to inaugurate a comprehensive program designed to cope with all of the existing circumstances and delay constructive action by refusing to recognize that their operations are in any way affected.

The futility of this procedure is evidenced by the fact that claims eventually arise which compel recognition of the disease and the adoption of a proper policy at a time when conditions are much less favorable for its successful application than would have existed at an earlier date.

Some managements apparently regard the silicosis question as a purely legal matter and rely largely on such counsel for determination of policy. This procedure tends to distort the problem by illuminating it largely from a single aspect. Obviously, it is equally inadvisable for a management to depend entirely upon the judgment or suggestions offered by either the medical, engineering or production members of its staff.

The most important requisite to good administration of silicosis problems lies rather in an informed management advised and directed by authoritative opinion representing the legal, medical, engineering and production divisions of the industry and assisted by consultation with some organization qualified bv long experience with the problem, if necessary.

Having divested themselves of preformed conclusions concerning their particular situation, the second responsibility of employers consists in inaugurating a thorough survey of their plant to determine the existence, nature and extent of the dust hazard. A survey of this type may include the physical and x-ray examination of the employees, the taking of occupational records, the determination of the nature and concentration of the dust suspended in the working atmosphere, an analysis of the mortality records in the district, and if possible, postmortem examinations of old employees dying from any cause.

The actual importance of silicosis as an industrial problem has been greatly over-emphasized for several reasons, chief among which has been the reluctance of administrative officers to investigate and reveal the existing facts in their operations. The mantle of secrecy which has shrouded existing conditions wherever many dust hazards are involved, has served to exaggerate their significance. Coupled with this lack of accurate and complete information, there has been, in the United States, an unwillingness to provide well-framed legislation to regulate the compensation of workmen affected by exposure to dust. This, in turn, has resulted in the filing of numerous claims in civil court which allege that a personal injury has been incurred through the negligence of the employer in permitting men to work in a hazardous atmosphere.

The enormous amount of money involved in these civil actions, to- ... confusion created by judicial bodies attempting to deal with this complex question, has given an altogether unwarranted notoriety and importance to this subject. Unfavorable experience with civil actions has prompted the hasty passage of occupational disease legislation in some of the United States where the facts are still unrevealed, and there is every reason to expect that unreasonable decisions based upon poor medical testimony, misinformation concerning the dust hazard, and a general tendency to attribute all ills to industrial conditions, will tend to discredit these laws and thus further prolong the unusual prominence accorded silicosis.

Administrative officers must further recognize that the situation which has been created in the United States is now of an emergency nature, and that there is neither a sufficient amount of reliable information, nor a large enough number of properly trained and informed authorities in many localities to deal with the silicosis problem. Under the press of emergency, many so-called silicosis experts have appeared over night and technical publications have been flooded with silicosis articles, few of which have added materially to the general understanding of the subject, but many of which have served to confuse and confound everyone interested in evaluating the actual issue.

As is true of nearly all diseases known to the science of medicine, certain phenomena associated with dust diseases are not understood or are imperfectly explained by medical authorities. A much more unfortunate difficulty arises out of the fact that many members of the medical profession, whose authority cannot be questioned in their particular field, are erroneously informed on this subject and offer opinions which are accepted as true, to the further bewilderment of all.

The same criticism may be offered against engineers, public health officials or attorneys, whose knowledge of silicosis has not arisen out of long and intimate first-hand experience. For this reason, it may be advisable to consider consultation with some organization competent to analyse the information available so that a proper policy may be determined.

If no hazard is discovered by a thorough survey, both the employer and the employee are protected by the information secured. On the other hand, if a hazard is detected, the original study serves as a guide to the future program of control which should be promptly initiated.

A control program in a dusty industry whose hazard has been defined will include the reduction of the dust concentration in the working atmosphere and the application of protective devices, the establishment of certain physical standards for new employees, the selective placement of old employees on the basis of their physical condition and the adoption of an educational program properly to inform all those vitally concerned with the effects of a dust hazard.

Thoroughly reliable methods of determining dust concentrations are available and engineers equipped to utilize these procedures can discover the sources and extent of the contam- ... ducing the hazard to within safe limits or applying adequate protective devices. A constant check of the dust concentration in the atmosphere should be maintained and records should be kept to show the condition of the working atmosphere, the nature of the protective equipment and the total duration of time each workman is required to spend in a hazardous occupation.

A pre-employment examination, including an occupational history and excellent stereoscopic chest roentgenograms, should be given to every new employee. In general these examinations will serve to classify men into three main groups composed of (1) those whose chests are apparently normal, (2) those who have an occupational fibrosis without any other pulmonary abnormality, and (3) those who have tuberculosis or other pulmonary abnormalities either with or without occupational fibrosis.

In considering the desirability of employing men whose chests are apparently normal, it should be borne in mind that young men, probably up to the age of thirty or thereabout, are not altogether perfect risks for employment in a hazardous dust since they are in an age period during which they may still contract tuberculosis.

In the author's opinion, men who show evidence of simple occupational fibrosis and who are past the age of 30, as most of them will be, are excellent risks since the author does not believe that uncomplicated silicosis is ordinarily disabling and since these men are past the age period during which they are likely to develop tuberculosis. These men may show some progression of their fibrosis after employment in a dusty industry but they will not tend to develop disability if they have been rigidly examined to exclude those showing any x-ray evidence of tuberculosis or other pulmonary injuries.

If this class of persons is to be discriminated against, it will create a most unfortunate social problem, since many skilled craftsmen perfectly capable of a lifetime of useful activity will be thrown out of work to become embittered and the prey of unscrupulous lawyers and doctors who will further complicate the situation by making the workmen claimants and neurotics. It is the author's belief that these men should not be eligible for compensation but if they are made so under the law, then legislation should also be provided to permit them to waive their right to compensation for an occupational disease, so that they may have the privilege which should be accorded to all free men—that of working at the tasks for which they are best suited. Provided that this group is carefully selected to exclude infection and remains under medical supervision while in the dusty industry, their experience should be as favorable as any that the employer could choose.

As to the third group of men, an injustice is done to both the employer and the prospective employee by placing any person at work in a hazardous dust who has tuberculosis or other significant pulmonary abnormalities whether or not occupational fibrosis is present.

In the presence of a known dust