U. S. DEPARTMENT OF LABOR
BUREAU OF LABOR STATISTICS
ROYAL MEEKER, Commissioner

BULLETIN OF THE UNITED STATES BUREAU OF LABOR STATISTICS . . . WHOLE NUMBER 231

INDUSTRIAL ACCIDENTS AND HYGIENE SERIES: NO. 17

MORTALITY FROM RESPIRATORY DISEASES IN DUSTY TRADES

(INORGANIC DUSTS)

BY FREDERICK L. HOFFMAN

JUNE, 1918

WASHINGTON
GOVERNMENT PRINTING OFFICE
1918

CONTENTS.

BULLETIN OF THE
U. S. BUREAU OF LABOR STATISTICS.

WHOLE NO. 231. WASHINGTON. JUNE, 1918.

MORTALITY FROM RESPIRATORY DISEASES IN DUSTY TRADES.

CHAPTER I.—GENERAL INTRODUCTION.

The administrative control of tuberculosis in American States and cities has heretofore been concentrated chiefly upon legislative enactments, and their enforcement, for the registration of existing cases, the voluntary or compulsory segregation and detention of tuberculosis patients, the establishment of Federal, State, county, and municipal tuberculosis sanatoriums, and the enforcement of sanitary ordinances against indiscriminate expectoration in public places. Some progress has been made in the direction of labor legislation aiming at the control of tuberculosis in industry, principally in the so-called dusty trades, but the results have been far from satisfactory, chiefly because of an inadequate realization of the seriousness of the situation. The statistical evidence that certain trades or occupations are distinctly more unfavorable to health and longevity than others is so entirely conclusive that no additional proof seems to be necessary to reemphasize the earlier conviction that the State regulation of industry with special reference to the dusty trades and tuberculosis is a National and State labor problem of the first order in practical importance, yet there continues to prevail a lamentable degree of apathy and indifference to the urgency of necessary changes and reforms.[1]

THE DECLINE OF TUBERCULOSIS.

The mortality from tuberculosis, it is true, has gradually declined from an average rate of 32 per 10,000 for large American cities for the five years ending with 1884, to 16.1 per 10,000 for the five years

[1] Especially suggestive as regards modern efforts in the direction of administrative control of the dusty trades are "The Labor Law and the Industrial Code," of the New York State Department of Labor, Albany, 1916; "The Sanitary and Engineering Industrial Standards," published by the Department of Labor of the State of New Jersey, 1916; Special Bulletin No. 82 of the Department of Labor of the State of New York "Hoods for Removing Dust, Fumes, and Gases," and the extended discussion of dusty occupations in the annual report of the Department of Labor of the State of New Jersey, for 1916, Trenton, N. J., 1917.

ending with 1914. This reduction in the death rate has, however, only to a limited degree affected the persons most seriously concerned—the workmen and workwomen employed in the so-called dusty trades. On the basis of a conservative estimate it appears that of the 44,130,000 American wage earners of both sexes, approximately 4,000,000, or 9.06 per cent, work under conditions more or less detrimental to health and life on account of atmospheric pollution or the relatively excessive presence of atmospheric impurities predisposing to, or accelerating the relative frequency of, tuberculous and nontuberculous respiratory diseases.

WAGE EARNERS IN DUSTY TRADES.

Table 1 presents the details of this estimate for the seven recognized branches of industry more or less exposing to health-injurious dust and fumes.

TABLE 1.—AMERICAN WAGE EARNERS EMPLOYED IN DUSTY INDUSTRIES, TRADES, AND OCCUPATIONS.

[Compiled from Report of Bureau of the Census on Occupation Statistics, 1910. For occupations included, see pp. 46–50.]

Trade group.	Males.		Females.	
	Number.	Per cent.	Number.	Per cent.
1. Metallic dust	258,454	7.9	33,255	4.9
2. Mineral dust	514,693	15.8	15,332	2.3
3. Mineral industries	844,897	25.9	550	.1
4. Vegetable fiber dust	336,323	10.3	296,135	44.0
5. Animal and mixed fiber dust	183,937	5.6	149,262	22.2
6. Organic dust	531,911	16.3	177,545	26.4
7. Mixed organic and inorganic (public) dusts	594,285	18.2	1,399	.2
Total	3,264,500	100.0	673,478	100.0

This formidable array of employments with exposure, more or less, to health-injurious conditions, attributable chiefly to the single factor of dust in its varied forms, suggests the practical importance of consideration, by those qualified, not only of the evidence itself, but also of the methods and means by which a truly deplorable situation can be brought effectively under administrative control.[1]

[1] It has been pointed out in this connection that the "importance of dust of various kinds as a causative factor in respiratory diseases is being borne in upon us with greater weight. Heim and Agasse-Lafont (*Arch. gen. de med.*, 1914), after reviewing the various ill effects of industrial dusts, came to the conclusion that the classification should not rest upon the origin of the dust, but rather upon the nature of its harmful influence. They recognize dusts of an active and of a passive nature. The effects of the first are toxic, predisposing or infectious, while the dusts acting passively act by their mere presence as foreign bodies upon the surfaces of the respiratory system. These passively acting materials may be of soft or hard consistency. The latter are more effective in bringing about the common chronic pneumoconiosis. They point out that the active agents are by far the most important in bringing about the acute respiratory diseases of which pneumonia and acute bronchitis are the most frequent. They do not follow the chronic lesions resulting from passive agents to a conclusion to illustrate the increased [illegible] tissues to other secondary processes."

RELATION OF ATMOSPHERE TO LIFE AND HEALTH.

The relation of the atmosphere to human life and health has been made the subject of numerous scientific investigations. For a number of years prize essays have been published by the Hodgkins Fund of the Smithsonian Institution, established for the purpose of increasing human knowledge regarding a problem of great practical and every-day importance. In 1896, through the medium of the fund, there was published an essay by Francis Albert Rollo Russell on "The atmosphere in relation to human life and health,"[1] in which, among other basic facts, the following is laid down as a prerequisite for the rational understanding of the scientific questions involved in a consideration of the atmospheric influence on health and longevity:

The average volume of air breathed in at each breath is about 30 cubic inches, and the volume of air which may be breathed in by an effort, and by expanding the chest, is about 130 cubic inches, or about four times as much. After a very full inspiration about 230 cubic inches can be expired by a man of average height and in good health. The total capacity of the lungs, however, is much more than this—about 330 cubic inches. Thus in ordinary quiet breathing we only fill about one-tenth of the available air space of the lungs. After every outbreath, or expiration, a quantity of air is left in the lungs. This residual air amounts to about 100 cubic inches. An adult at rest breathes about 686,000 cubic inches in the course of 24 hours; a laborer at full work, about 1,586,900 cubic inches—more than double. The amount of air passing into the lungs per diem has been estimated at 400 cubic feet in a state of rest, 600 in exercise, 1,000 in severe exertion. The number of air cells in the lungs is estimated at 5,000,000 or 6,000,000 and their surface at about 20 square feet. The epithelium or membranous film between the blood and air is exceedingly thin, and in many parts the capillaries are exposed, in the dividing walls of cells, to air on both sides. The weight of air inhaled in the course of the day is seven or eight times that of the food eaten. The mechanical work of breathing represents energy expressed by the lifting of 21 tons 1 foot in 24 hours. From every volume of air inspired about 4½ per cent of oxygen is abstracted, and a somewhat smaller quantity of carbonic acid gas is at the same time added to the expired air.[2]

PRACTICAL IMPORTANCE OF ATMOSPHERIC PURITY.

The foregoing extract emphasizes the importance of atmospheric purity under working conditions, since, as said in the statement quoted, the amount of air passing into the lungs in 24 hours in a state of rest is about 400 cubic feet, in normal exercise 600, and in

[1] See also in this connection "The atmosphere in its relation to the human mechanism," by R. C. Holcomb, surgeon, U. S. Navy, in U. S. Naval Medical Bulletin, vol. 10, No. [illegible] Washington, 1916.

[2] See also an article in the Scientific American Supplement, July 1, 1916, on "[illegible] air," by Prof. John F. Norton, Ph. D.

severe exertion 1,000. Considering this fact in connection with conditions of work in metal mining, for illustration, brings out in a startling way the strikingly injurious effect of the continuous inhalation of air grossly polluted by minute particles of mineral and metallic dust, aside from gaseous impurities which, under given conditions, may add materially to the health-injurious results of dust exposure. As observed in the same essay, "The deficiency of oxygen and excess of carbonic acid, which are common to nearly all living rooms, schools, churches, theaters, and workshops where many persons are gathered, are very favorable not only to the spread of various infectious diseases, but to the maintenance of a number of minor ailments; and where the exposure to foul air is prolonged, as in workshops, offices, and mills, to a continued depression of vitality." In the same connection it is pointed out that the normal requirement is the supply of about 3,000 cubic feet of fresh air per head per hour, which, it is safe to maintain, is rarely met with in any of the dusty trades in which the mortality from tuberculosis materially exceeds the average for out-of-door occupations.[1]

AIR CONTAMINATION AND DISEASE RESISTANCE.

Aside from atmospheric impurities of an inorganic nature, of which dust in the more restricted sense of the term is chiefly constituted, the air is frequently contaminated by living germs, the microbes, bacteria, fungi, and molds, which may, or may not be, of a pathogenetic, or disease-producing, nature. Experiments have conclusively proved that microbes are much more abundant in the town than in the country, and, as a general rule, they are more frequently present in dwellings and workshops than immediately outside of the habitations or buildings concerned. Most of the germs and spores which are inhaled are not directly injurious, as far as known, but there are reasons for believing that the vitality is always reduced by a contaminated atmosphere, irrespective of the nature of the inorganic or organic impurities. Russell, in his discussion of "The atmosphere in relation to human life and health," concludes that—

Many severe forms of disease, especially of the respiratory organs, are caused by the dust inhaled in various trades and occupations. These are generally proportionate to the sharpness and angularity of the dust and its quantity. Coal dust is among the least harmful. Among lead miners, bronchitis and lead poisoning; in copper mines, gastric disorders; in pottery works, in stonecutting, steel grinding, in flax and cotton factories, in shoddy works, and in metal polishing, lung diseases are common, and the death rate is high. Thus the

[1] See a paper by Miller and Cocks on "Effects of changes in atmospheric conditions upon the upper respiratory tract," in Transactions of American Climatological and Clinical Association, 1915.

mortality of file makers was 300, compared with 108, that of gardeners; of earthenware makers 314, compared with 139, that of grocers; of cutlers and scissors makers 229, compared with 129, that of paper makers. The dust of soft woods and of flour seems to have little bad effect. As regards phthisis and lung diseases the figures of several trades are as follows, when compared with fishermen, 100: Carpenters, 170; bakers, 201; cotton workers, 274; file makers, 396; stone and slate quarrymen, 294; pottery makers, 565; northern coal miners, 166. The injuriousness of the dust in cotton mills is increased by the use of mineral substances for sizing. The mortality of cutlers, etc., from these diseases is almost as great as that of fishermen from all causes put together, including accidents. The comparative exemption of colliers in well-ventilated coal mines deserves investigation, for there would appear to be some ground for the supposition that it may be owing to the inhibitive action of this particular dust upon the development of tuberculosis; on the other hand, it may be simply through living in fairly good air of an even temperature, where the specific germs of phthisis are few or absent. The homes of the men are generally comfortable, and much larger fires are kept up than in the South, so that their rooms are dry and well ventilated.

CHEMICAL ASPECTS OF ATMOSPHERIC POLLUTION.

Within recent years there has been an important change of qualified opinion regarding the health-injurious consequences of atmospheric pollution due to chemical causes. In a publication of the Hodgkins Fund, issued by the Smithsonian Institution in 1913, on "The influence of the atmosphere on our health and comfort in confined and crowded places," by Leonard Hill, Martin Flack, James McIntosh, R. A. Rowlands, and H. B. Walker, an effort is made "to demonstrate that no evidence has yet been brought forward which shows that the chemical quality of the air has anything to do with these ill effects, and that, apart from the influence of infecting bacteria, the ventilation problem is essentially one of temperature, relative humidity, and movement of the air." This important conclusion is diametrically opposed to the principles generally laid down in elementary textbooks on hygiene that the chemical aspect of atmospheric pollution is of fundamental importance, and that the effects of life and work in ill-ventilated rooms or workshops are attributable to changes in the chemical quality of the air, whether it be want of oxygen, or excess of carbon dioxide, or the addition of some exhaled organic poison, etc. The authors maintain that the terms "devitalized" or "dead" air are misleading, and, differing from the prevailing opinions, that the health-giving properties of a pure atmosphere are "primarily those of temperature, light, movement, and relative moisture." None of these observations or conclusions, however, bears upon the broader problem of atmospheric pollution by dust in any of its many varieties, which to a measurable degree

duces vitality and predisposes to respiratory and tuberculous diseases, but chiefly tuberculosis of the lungs.[1]

THE INFECTIOUSNESS OF TUBERCULOSIS.

As early as 1881–82, when the infectiousness of tuberculosis had just been determined by the discovery of the bacillus of the disease by Koch, Dr. Arthur Ransome, in an address before the Manchester and Salford Sanitary Association pointed out that—

Wherever people are collected together, the death rate from consumption is in direct proportion to the degree of crowding together, and to the deficiency of ventilation. I will give only one instance of this, that was first remarked by Dr. Guy, with reference to letter-press printers. He found that of 104 compositors who worked in rooms of less than 500 cubic feet for each person 12.5 per cent had had spitting of blood; of 115 in rooms of from 500 to 600 cubic feet, 4.35 per cent showed this sign of consumption; and in 100 who worked in rooms of more than 600 feet in capacity, less than 2 per cent had spat blood.[2]

LUNG INJURY FROM IRRITATING DUSTS.

The same author, in an address on the "Prevention of consumption," delivered on September 22, 1887, before the Sanitary Congress at Bolton, directed attention to the relation of the inhalation of irritating substances, or dusts, arising from various kinds of industrial activities, such as steel grinding, glass cutting, brush making, etc., to the relative frequency of the disease, and he amplified his observations by quotations from the medical reports made by Dr. Headlam Greenhow to the Privy Council in 1860 and 1861, in which attention was called to the large mortality from tuberculous complaints among "those who worked in an atmosphere impregnated with dust consisting of fine particles of metal or of sandstone, etc." Granting that no statistical evidence can materially aid in disclosing the immediate causative factors of the disease, Ransome observes that—

No one, indeed, who has studied the vital statistics of these occupations, or who has medically attended the workpeople, can doubt

[1] Bandelier and Roepke, in their treatise on A Clinical System of Tuberculosis (London, 1913, pp. 14, 15), mention among the acquired predisposing influences favorable to the disease "slight injuries to the smallest bronchial tubes from the inhalation of particles of mineral, metallic, vegetable, or animal dust." They add thereto that "the harder, sharper, more pointed the dust particles, the more likely are they to injure the lung tissue, to open the way to tubercle bacilli, and to favor their development by setting up chronic inflammation. Likewise some substances, as corrosive vapors and gases, cause chemical injuries." They conclude that:

"As anatomical lesions may be caused by various fine mechanical irritants, so gross traumatic injuries from direct or indirect violence (punctures, shots, blows, falls, and crushing) produce injury to the lung tissue and favor possible infections. But much more frequently it will happen that a latent inactive focus, usually in the bronchial glands, is brought into activity by an injury, or a latent but active tuberculosis made evident, which, however, is the same thing from the legal point of view."

[2] A Campaign Against Consumption, by Arthur Ransome, M. D., London, 1915, p. 9.

the power of irritating dusts in inducing a state of the lungs that is favorable to the reception of the specific organism.

He, therefore, concludes that—

Just as in the case of lungs otherwise injured tubercle may readily be ingrafted upon a miner's or a needlemaker's lung; but the disease that is first caused by the particles these men inhale is not tuberculous at all. It is simply a chronic inflammation, affecting chiefly the connective tissue and causing the formation of a fibroid tissue in the alveolar walls. It leads ultimately to a contraction, and, so to speak, a strangling of certain portions of the lung tissue. But no bacilli are found either in the tissues or in the expectoration of such patients, as I can testify from frequent stainings.[1]

This conclusion, which is of great practical importance, is frequently ignored in superficial discussions, particularly of miners' lung diseases, which in their origin are not tuberculous, but rather a fibrosis ultimately terminating in a true tuberculosis in consequence of a subsequent infection. Ransome is, therefore, apparently quite justified in his statement that "Dusts, although they are a serious danger, and though they ought on this account to be kept away from workpeople as a preventive measure against consumption, are yet only remotely a cause of the disease." It, however, has probably never been seriously maintained by anyone familiar with the subject that the inhalation of health-injurious dust is to be considered a primary cause of tuberculosis, but it is rather to be looked upon as a more or less injurious contributory causative factor, largely amenable, within reasonable limits, to effective methods of administrative sanitary control.

VARIED FORMS OF PULMONARY TUBERCULOSIS.

Pulmonary tuberculosis exists in many and varied forms. As said in a treatise on The Expectation of Life of the Consumptive after Sanatorium Treatment, by Noel D. Bardswell—

The disease, for instance, may be very acute and prove fatal in a few weeks (miliary tuberculosis), it may commence very acutely and gradually develop into a more chronic process; or, again, it may from its commencement run a slowly progressive course, extending in all over a great many years. This last form, by far the commonest type of the disease, is generally spoken of as "chronic" pulmonary tuberculosis. It has for long been recognized that the prognosis, or expectation of life, in these various types of pulmonary tuberculosis is widely different; hence the necessity for considering them separately when dealing with statistics as to the curability of the disease as a whole.

[1] A Campaign Against Consumption, by Arthur Ransome, M. D., London, 1915, p. 26.

Unfortunately, the mortality statistics, as a general rule, do not permit of such a precise differentiation, and least of all in their practical application to tuberculosis as an occupational disease. The five forms of tuberculosis generally distinguished are tuberculosis of the lungs, acute miliary tuberculosis, tuberculous meningitis, tuberculosis of other organs, and disseminated tuberculosis. In the United States registration area, during the period 1911 to 1915, the mortality per 100,000 of population, from these five groups was as follows: Tuberculosis of the lungs, males, 139.8, females, 109.5; tuberculous meningitis, males, 8.8, females, 8.1; tuberculosis of other organs, males, 9.9, females, 9.7; and disseminated tuberculosis, males, 1.3, females, 1.2. It is therefore shown that tuberculosis of the lungs is of primary importance; but the different forms of pulmonary tuberculosis are not disclosed by the general mortality returns.

COMPARATIVE MORTALITY STATISTICS.

The term "phthisis" is generally used as a convenient expression for the term "tuberculosis of the lungs."[1] Extreme caution is necessary in the use of international tuberculosis statistics, since there are reasons for believing that the same terms have not an identical meaning in foreign usage. The mortality from phthisis in England and Wales, for illustration, is invariably lower than in this country; in contrast, the mortality from bronchitis, both acute and chronic, is decidedly higher. In England and Wales the mortality from tuberculosis during the period 1911 to 1915, per 100,000 population, was as follows: (1) Tuberculosis of the lungs, males, 115.8, females, 80.0; (2) acute miliary tuberculosis, males, 11.2, females, 9.3; (3) tuberculous meningitis, males, 15.3, females, 12.7; (4) tuberculosis of other organs, males, 16, females, 13.1; (5) disseminated tuberculosis, males, 6.9, females, 5.3. In other words, all the nonpulmonary forms of tuberculosis are more common in England and Wales than in the United States registration area. In the latter the mortality from bronchitis was 17.1 for males and 19.5 for females; but in contrast, the corresponding mortality for England and Wales was 114.7 for males and 109.4 for females. These and many other statistical facts should be kept in mind in an effort to interpret with at least approximate accuracy the comparative international statistics of tuberculosis with special reference to occupation and the incidence of tuberculosis in the dusty trades.

The table following shows the comparative international death rates for tuberculosis for the years 1911 to 1915, inclusive.

[1] The strictly technical medical aspects of the questions involved in the precise definition of tuberculosis versus phthisis are summed up by Maurice Fishberg, M. D., in his treatise on Pulmonary Tuberculosis, Philadelphia and New York, 1916, p. 103.

TABLE 2.—DEATH RATE PER 100,000 OF POPULATION FROM PULMONARY AND ACUTE MILIARY TUBERCULOSIS, 1911 TO 1915.

Year.	United States registration area.		England and Wales.		Scotland.		Ireland.		Australia.[1]	Holland.[1]	Norway.[1]	Switzerland.[1]
	Pulmonary.	Acute miliary.	Pulmonary.	Acute miliary.	Pulmonary.	Acute miliary.	Pulmonary.	Acute miliary.				
1911	132.5	5.5	99.1	9.3	110.1	6.9	169.4	3.6	70.5	118.8	176.0	161.5
1912	124.8	5.0	94.3	10.3	108.1	5.8	164.1	5.9	67.7	110.7	176.0	152.3
1913	122.8	4.9	91.3	9.9	104.3	5.4	163.4	4.8	67.7	106.4	173.7	147.2
1914	123.1	4.7	94.5	10.0	100.6	4.4	160.5	3.0	63.2	107.3	175.9	143.6
1915	123.0	4.7	106.6	11.3	107.9	4.0	172.2	1.8	62.1	110.1	175.5	141.1

[1] Includes both forms.

INDUSTRIAL LUNG DISEASES.

In this connection it has been appropriately said by J. M. Beattie, M. D., in an address on the "Hygiene of the steel trade," contributed to the Transactions of the Royal Sanitary Institute of Great Britain (Vol. XXXIII, 1912, p. 501), that—

> A great deal of attention has been centered on the dust problem, and much of the legislation relating to the industries with which we are dealing is concerned with the protection of the workers from dust inhalation. A much more serious problem, however, is the prevention of infection with *B. tuberculosis*, which has not received justice at the hands of factory inspectors and factory legislators. During a five years' experience in Sheffield it has been abundantly demonstrated that cutlers and grinders die from tuberculosis and not from nontuberculous fibrosis of the lungs.

Dr. Beattie therefore strongly protests against the loose use of the word "phthisis" and remarks—

> Rightly or wrongly, phthisis is now understood by medical men to mean tuberculosis of the lungs, with cavity formation; and the term "grinders' phthisis" should be confined to that condition of the lung in which tuberculosis is added to the interstitial fibrosis. For the condition which is produced by the inhalation of dust, the term "fibrosis" is perhaps the most suitable; I shall therefore describe the condition resulting from the inhalation of dust as fibrosis. The misuse of the term "phthisis" makes it difficult to obtain entirely satisfactory statistics, and we can only, therefore, regard the usual data as an approximation to the truth.

LIMITED VALUE OF OCCUPATIONAL MORTALITY STATISTICS.

Dr. Jacques Bertillon, in a paper on "Mortality and the causes of death according to occupations," contributed to the Transactions of the Fifteenth International Congress on Hygiene and Demography (Vol. I, 1912, p. 339), points out that—

> The frequency of phthisis varies much with the occupation. If a man is poisoned either by alcohol or by lead, phthisis is very common.

It is common, also, in most occupations in which the man is exposed to dust, especially mineral dust. It has an average frequency in occupations pursued in confined quarters. It is infrequent with shopkeepers, in the liberal professions, and especially among farmers, as well as in most occupations carried on in the open air and involving muscular exercise. It is very uncommon among iron and coal miners. These are the general conclusions indicated by my figures and the diagram. They are subject to many exceptions which should be examined more closely.

These cautious observations regarding the general use of occupational mortality statistics apply to English and American as well as to French, German, and other continental data. The same qualification applies to the terminology of the disease and the contributory atmospheric conditions such as dust and gaseous impurities. Simeon Snell, M. D., in an address on "Coal mining and the health of colliers," contributed to the Transactions of the Sanitary Institute of Great Britain (Vol. XVI, 1895, p. 110), directed attention to the fact that—

The influence of dust, whether metallic or nonmetallic, in the production of phthisis is now well known, and the subject received attention in these lectures last year. A collier passes a third of his day in an atmosphere which is laden with fine particles of coal dust. Mines differ very much in the prevalence of this dust. Thus men speak of the mines in which they work as being dusty or not. A dry mine will be dusty, and a wet one not so much so. That colliers will be constantly breathing these fine particles can not be questioned, and yet Dr. Ogle says that "Be the explanation what it may, there can be no possibility of doubt that the mortality of coal miners from phthisis is remarkably low."

DUSTS AND FUMES, FOES TO INDUSTRIAL LIFE.

The relative immunity to pulmonary tuberculosis of coal miners seems to be conclusively established; but in contrast to a low death rate from tuberculous disease, coal miners almost invariably experience a high death rate from nontuberculous lung diseases. Among the important contributions to the subject are the results of the investigations of Sir Thomas Oliver, M. D., included in an address on "Dust and fumes, foes to industrial life," published in the Transactions of the Fifteenth International Congress on Hygiene and Demography (Vol. I, pp. 309, 322, 327, 332), restated, in an abbreviated form, as follows:

Dust, smoke, and fume are the products of industrial activity to be feared. In what relation do these stand to each other? Dust is usually regarded as matter in a state of fine division, but modern research shows that dust, from a medical point of view, is something more than this. Smoke and fume differ from dust in being the products of heat, and these two again differ from each other in this respect, that smoke is the outcome of incomplete combustion of

hydrocarbons, such as coal, wood, and oil, while fume is, firstly, the gaseous form of metals, nonmetals, and their compounds, and, secondly, the return of these from the gaseous to the solid state, as seen in the flue deposit of a lead smelting factory. Soot, on the other hand, is a hydrocarbon, which has not completely combined with oxygen to form gases.

Although we are more immediately concerned with the effects of dust upon the lungs, yet the whole body, including the skin, mucous membranes, and the internal organs, suffers in due course by exposure to dust. We seldom think of the part which dust and smoke have played indirectly in shaping the social habits of a people. How to get rid of dust and fume in the factory, of smoke in the atmosphere, and of the incidence of all these upon the skin and the respiratory organs of man has formed not only the subject of many a scientific discussion, but has stimulated enterprise and encouraged manufacture. In trying to combat their begriming effects we have become a well-washed people. The dispersion of these waste products has led to the manufacture and use of soap in proportions hitherto unparalleled in the history of man, while these again have indirectly added to employment, wealth, and health. Frequent ablution has become the rule, so that baths, a luxury to the Romans in the palmy days of empire, and unknown in even large houses in my own country four or five decades ago, are now a necessity, for they find a place in many of the modern houses of the working classes. Dust and fume, begriming agents as they are, have therefore done something to socialize mankind, to promote health, and to advance civilization, for those nations are leading in the path of progress to-day whose workers not only require soap and water for themselves, but who, by the factory dust and smoke they create, oblige all of us to resort to similar usages.

What are the possible remote effects of carbon monoxide? Pneumonia sufficiently frequently develops in miners who have been exposed to the firing of explosives as to suggest a causal relationship between the two. Dr. Hotchkiss, of the United States Public Health Service, states that in the Cripple Creek district one man died of edema of the lungs, probably the result of exposure to powder smoke, and that in the same district 20 similar cases had been reported within 10 years, of which 18 proved fatal. Dr. Dale Logan tells me of two men who returned to a particular working in a coal mine three and one-half minutes after having exploded 1 pound of gunpowder. Shortly afterwards both complained of the foulness of the air and of their work becoming more difficult; they also had headache, giddiness, and vomiting. They made their way home, staggering all the way. In the case of one of the men speech was so thick that his wife could not understand what he said. Both men seemed to be intoxicated. During the night one of the men vomited frequently. Next day, although giddy and suffering from headache, he returned to work, but on the second day he developed pneumonia and died from it on the fourth day. The pneumonia was regarded as the sequel of carbon monoxide poisoning, and compensation was awarded. Among South African miners pneumonia is extremely common. It is very fatal both to white men and to black, owing largely to the diminished vital resistance, caused by breathing mine air charged with the

products of explosives. Sudden exposure to air containing a large percentage of carbon monoxide gives rise to serious symptoms which immediately attract attention, but the effects produced upon men by the combined influence of fatigue and of breathing for several hours daily small percentages of carbon monoxide in the high temperature of the mine are not so well known. Although the symptoms observed in miners after the use of explosives are for the most part due to CO, it is not maintained that nitrous fumes can be inhaled with impunity. On the contrary, owing to their irritating properties, they set up congestion of the lungs with edema. In an ordinary way the symptoms appear much earlier than those caused by carbon monoxide. Shortly after exposure to nitrous fumes, a burning sensation in the nostrils and throat is complained of, followed by a dry, hacking cough, and by expectoration frequently tinged with blood. Should the miner die, the mucous membrane of the trachea and bronchi is found to be acutely congested, and there are signs of acute bronchopneumonia and hemorrhagic edema of the lungs.

What becomes of the dust when it is inhaled? It is a natural supposition that, while some of it reaches the lungs, the major part of it is retained in the nares. Saito, working in Prof. K. B. Lehmann's laboratory in the Institute of Hygiene in Wurzburg, has tried to determine experimentally the fate of dust breathed by workmen in factories. In his preliminary experiments dogs and rabbits inhaled air charged with white-lead dust from 1 to 33 hours. He found that the greater part of the dust was subsequently recovered not from the lungs, as might have been expected, but from the alimentary canal. In five out of six experiments 4 to 24 per cent of the total amount of lead dust breathed in was located in the respiratory organs and the remainder in the digestive. In an ordinary way the dust caught in the nasal mucous membranes mixes with the mucus which is secreted and is unknowingly swallowed. Experiments were also carried out on man with white-lead dust, the mouth and nares being previously carefully washed. The experiments were conducted from 10 to 15 minutes on 20 occasions, care being taken by the men not to swallow the saliva. Inspiration and expiration took place through the mouth and nose, singly and combined, with the result that, provided sneezing did not take place, 95 per cent of the dust inhaled remained behind in the body, 50 per cent of which was primarily retained in the nares. By processes of exclusion 12 per cent probably finally found its way into the lungs, for the bulk of the lead dust, 60 to 80 per cent, was recovered from the alimentary canal. Saito's experiments demonstrate that the principal portal of entrance of soluble dust into the body when inhaled is the alimentary canal and not the lungs. Where two such channels of entrance as the respiratory and alimentary are so close to each other, it is not always easy to say upon which the dust has exerted its baneful influence. In Laborde's experiments with guinea pigs exposed to air laden with fine white-lead dust, the animals died within two hours. In the lungs were found intense congestion and ecchymoses. When the exposure was less intense and the animals lived longer, similar but equally profound vascular changes were found in the lungs, pointing, therefore, to direct irritation by dust.

In my early cases of gold miners' phthisis the physical signs showed that the disease was located for the most part toward the base of one

or other of the lungs. The men, although bronzed and healthy looking, were yet the subjects of a difficulty of breathing on the slightest exertion, a difficulty of breathing far in excess of what the physical signs on examination of the chest suggested. In its inception pneumoconiosis is a nontuberculous disease; it is the direct result of dust irritation. The course of the malady is hastened by the recurrence of bronchial and pulmonary catarrh. The changes set up in the lungs by previous catarrh prepare the soil for infection by tubercle; but in some of my patients the disease ran its course from commencement to finish without becoming tuberculous. Within recent years a change has apparently been taking place in the mines on the Rand. Ten years ago, when I first drew attention to gold miners' phthisis, there was a much smaller percentage of tuberculous disease amongst the men than in recent years. In making this statement I am supported by the medical experts of the recent commission, who report that it was the opinion of the medical men on the Rand who examined patients in 1902–1904, that at that period miners' phthisis terminated fatally without any clinical or bacteriological evidence of tubercle and that men continued at work until a week or two of their death, which often came by heart failure, with cyanosis and urgent dyspnea. Death, indeed, sometimes came to men quite suddenly from heart failure when they were working in the mine. As it is not always easy to find the bacilli of Koch in the sputum even of ordinary cases of pulmonary tuberculosis, so their absence for months from the expectoration of a gold miner is no proof that the disease in him is not tuberculous. When, however, tubercle bacilli are absent all through the illness and the lungs after death do not give evidence either macroscopically or microscopically of tubercle, then gold miners' phthisis in its typical form is nontuberculous. Sooner or later, as the malady progresses, tubercle becomes grafted upon the pulmonary lesions, and with the invasion of the microorganisms the character of the illness becomes almost immediately changed. While the hard and fibrotic portion of the lung of a gold miner is not a suitable soil for microorganisms the concurrent catarrhal conditions in other parts of the lungs offer little resistance both to the bacillus of Koch and the pneumococcus of Friedländer, and yet I have seen a Rand miner with silicosis in the early stage develop an acute inflammatory affection of the lungs, with high temperature and with physical signs indicating extensive consolidation, make an excellent recovery. In the case I refer to the microorganism found in the expectoration was the bacillus catarrhalis. In the Transvaal the high mortality rate of miners from pneumonia led the mining authorities of South Africa a few months ago, with the view of treating the disease by a vaccine, to call to their assistance the service of Sir Almroth Wright. The high death rate from pneumonia and the increasing number of cases of gold miners' phthisis, which in later years have been assuming a tuberculous type, raises the question as to whether the mines themselves or the lodgings of the men may not be partly responsible for this fact.

Since dust is the foe of workmen means ought to be employed for its removal from factory and workshop. General ventilation is all very good, so long as the question is simply one of a vitiated atmosphere due to the air having been rendered impure by the respiratory

products of the workpeople, and by artificial heating and lighting, but where the dust is generated by machinery or is evolved during the ordinary course of production general ventilation only disseminates the dust, so that recourse must be had to local ventilation such as is afforded by an exhaust apparatus. Exhausts are superior to water spraying. The wearing of respirators is no doubt in many instances a necessity, but the men complain of the heat engendered by them and of the restraint imposed upon their breathing. Still it remains a fact that men working in color grinding, when they have taken to wearing respirators, have recovered the weight they had lost and regained their health.

OBSERVATIONS ON THE AIR IN MINES.

In this connection the further observations by Sir Thomas Oliver on fumes more or less contaminated by dust are also of exceptional practical importance. The extract is from an address on "The metallic poisons, lead and arsenic, as met with in our industries," contributed to the Transactions of the Sanitary Institute of Great Britain (Vol. XIV, 1893, pp. 157–161):

Carbonic acid is one of the great dangers to the men, and there is a tendency for it always to be present in excess, as it is given off from the lungs of the miners in respiration, and the combustion of the candles, as well as from the strata in which the men are working. Add to these facts the deterioration of the air of the mine by the use of dynamite and from the explosions of gunpowder, and you have an atmospheric condition in the mine which frequently obliges the men to retire to the mouth of the pit in order that the needs of respiration may be satisfied. What with the impure air and the inhalation of the dust and grit from the limestone rock, the lead miner is exposed to risks that are in constant operation during the whole period he is at work. When to these are added the fact that the mines are warm and the men on leaving are overheated, owing to the exertion required in scaling the ladders, and are obliged to trudge home 2 or 3 miles across a bleak moor exposed to biting winds and in all kinds of weather, we can readily understand how it is that many of them succumb to such acute illnesses as pneumonia, or how the neglected cold or pleurisy, acting in conjunction with a family predisposition, too frequently throws the miner into consumption.

When we come to consider the manufacture of white lead, we observe that at certain stages of the process a good deal of dust is evolved. It is the inhalation of this fine penetrable dust, and the fact that women are largely employed in the trade, that have gained for this industry a bad name. We believe that women are much more susceptible to the influence of lead than men. This statement, for which I am largely responsible, has been disputed, but an increasing acquaintance with the subject, an extensive hospital experience of plumbism, and renewed experimental investigation upon animals, lend weight to the opinion that women are not only more susceptible than men but they are so at an earlier age. In addition, there is a greater tendency for lead poisoning to assume its most serious form in which headache followed by convulsions and coma are the most

PRINCIPLES OF TUBERCULOSIS PREVENTION.

The conveyance of tuberculosis infection through the medium of industrial dust has been referred to with brevity in an address of exceptional importance on "The prevention of tubercular disease," by Sir James Crichton-Browne, contributed to the Transactions of the Sanitary Institute of Great Britain (Vol. XV, 1894, pp. 445, 446, 448), as follows:

The presence of tubercle bacilli and their spores in the air breathed by consumptive patients, floating independently or buoyed up by particles of dust, is now indisputable. Dr. Williams hung up glass slides smeared with glycerin in the ventilating shafts of the Brompton Hospital and shortly found tubercle bacilli adhering to the glycerin; and Dr. Cornet, by elaborate experiments, conducted in the rooms of private consumptive patients and in hospitals, has shown that tubercle bacilli are expired by consumptive patients in small numbers, and that they and their spores, which, remember, are very indestructible and will retain their vitality even when dried, are given off in clouds from the handkerchiefs and bed linen of consumptive patients and from the floors or walls of the rooms they inhabit, if they are not scrupulously cleanly in their ways—from any place or thing, in short, with which their expectoration has come in contact. Cornet has further shown that tubercle bacilli may be caught in open spaces and in the air of streets and squares where tubercular persons are present, and in all these cases he has shown that the dust collected when inoculated into animals sets up tubercular disease. Klein has shown that guinea pigs become tubercular when finely divided tubercular matter is diffused by a spray producer in the air of their hutches, and he has succeeded in communicating tubercle to those animals by keeping them for a time in cages in the ventilation-extraction shaft at the Brompton Hospital, through which the foul air from the wards passes. And quite recently M. Straus has communicated to the Académie de Médécine in Paris a very instructive observation. By means of little plugs of cotton wool the dust and mucus from the nasal orifices of 29 healthy nurses and medical students serving in the wards of hospitals containing consumptive patients were collected, and solutions prepared from these were injected into 29 guinea pigs, of which 9 manifested tubercular disease within a month. There can no longer be any doubt that the air of apartments occupied by consumptive patients is loaded with virulent dust; that the germs of tubercle exist in the atmosphere of all populous districts; and that the inhalation of the dried virus floating in the air is one of the commonest ways of the propagation of the disease.

Then ventilation is not less necessary for the prevention of tubercular diseases in mines, factories, and workshops than it is in public institutions. The loading of their atmosphere with particular kinds of dust appertaining to the trades carried on in them is a prolific cause of tubercle in the lungs, and we have come to speak of miners' and knife-grinders' and potters' consumption. The dust in such cases penetrates the lungs and by its hardness and angularity wounds the mucous membrane, setting up irritation and catarrh and

creating that raw surface on which the tubercle bacillus loves to fasten and batten.

VENTILATION AND DUST REMOVAL.

Dr. D. D. Kimball, in a paper on "Ventilation and public health," contributed to the Annals of the American Academy of Political and Social Science (Vol. XXXVII, No. 2, March, 1911, p. 212), directs attention to the fact that "Many ventilating systems are worse than useless because the air is taken in at or below the street level or from other dust-contaminated sources, and is passed into the building without filtration, the result being that the last state of the building is worse than the first." The problem of effective ventilation and dust control[1] does not, however, fall within the scope of the present discussion, but it is necessarily of the first importance in any and all efforts to mitigate the lamentable consequences which arise out of a needlessly dust-contaminated atmosphere, under which so large a number of industrial processes are carried on at the present time.

DUST IN RELATION TO OCCUPATIONAL DISEASES.

The importance of dust as a factor in occupational mortality has attracted the attention of every authority on occupational diseases from Ramazzini to Sir Thomas Oliver. It requires no extended consideration to prove that human health is much influenced by the character of the air breathed and that its purity is a matter of very considerable sanitary and economic importance. Aside from the risk of exposure to so-called air-borne diseases, the pollution of the atmosphere by organic and inorganic dusts is unquestionably the cause of a vast amount of ill-health and premature mortality, chiefly among men and women engaged in the many indispensable trades and occupations that minister to human needs. The sanitary dangers of air contaminated by disease-breeding germs are possibly not so menacing as generally assumed, while the destructive effects of the dust-laden atmosphere of factories and workshops are a decidedly

[1] In a more recent address by Sir J. Crichton-Browne before the Sanitary Inspectors' Association of London (Modern Hospital, November, 1913), he observes that "town dust is most to be feared as a carrier of pathogenic germs and microbes of many kinds which can resist drying and may be wafted about with the particles. So catarrh, influenza, hay fever, etc., may be disseminated. Tuberculosis, too, is similarly spread in the dust of the dried sputum. In all dust the danger of implantation of germs, fresh or dried, is enhanced if associated with corrosive, chemical, or mechanically wounding elements. Sharp particles of mineral matter may plow a way in the tissues through which pathogenic germs may enter. Even tetanus might be caused by road dust carrying it to some superficial wound, for the organism lives in the alimentary canal of the horse, and so is found in the manure of street refuse as well as in the soil of gardens and other places. The tetanus antitoxin is efficacious if used immediately, and in these days of dust-scattering motors the president suggested that a tube of antitoxin might well form a part of the furniture of a car, so that in case of accident it might instantly be administered if any wound comes in contact with the dust."

serious menace to health and life. While the investigations of Dr. McFadden and Mr. Lunt seem to prove the paucity of bacteria in very dusty air, the evidence otherwise available is entirely conclusive that the risk to disease infection is much greater indoors than out in the open, where sunlight, rain, and wind in combination go far to purify the atmosphere by destroying the bacterial life contained in minute particles of suspended matter. Apart, however, from the transmission of disease through a dust-contaminated atmosphere, dust in any form, when inhaled continuously and in considerable quantities, is prejudicial to health because of its inherent mechanical properties, which are destructive to the delicate membrane of the respiratory passages and the lungs. It has long been known that those who live most of their time out of doors have a decided advantage over those who, because of their employment, are compelled to spend their working hours inside the home, the office, the factory, or the workshop, and it is an accepted axiom of modern sanitary science that measures and methods for the prevention of dust are an essential preliminary consideration in rational methods of sanitary reform. All that sanitary science can suggest or that sanitary legislation can regulate and change should be done for humane reasons and as a matter of governmental concern, to mitigate the needless hardships of those who suffer in health and life as the result of conditions over which they themselves have but a very limited control.

The importance of dust as a factor in occupational diseases has been emphasized by all who have written on the subject, but by no one more precisely and clearly than by Sir James Crichton-Browne, in his address on "The dust problem," read at the Sanitary Congress held at Manchester, England, in 1902, from which the following profoundly suggestive extract is taken:

> The mortality of the principal dust-producing occupations, compared with that of agriculturists, who live and work in what is practically dustless atmosphere, *is excessive to a startling degree.* It is not suggested that this excess is to be ascribed to dust alone, no doubt various factors contribute to it, but the facts that it is due mainly to respiratory diseases, that it is distributed amongst the several occupations pretty much in proportion to their dustiness, and that it has diminished in some instances where dust has been effectually dealt with, justify the conclusion that it is largely dust begotten.

THE DUST PROBLEM IN INDUSTRY.

Sir Crichton-Browne in continuation of his remarks pointed out that a detailed examination of the conditions of work in each of the 22 principal dusty trades brought out clearly the fact that the unhealthiness was born of or was primarily due to the dust inhaled by the workmen, and that there was always a well-defined relation

between the death rate and the quantity and quality of dust present in the atmosphere. There is apparently no very material difference in the manner in which the different varieties of dust act upon the human organism, except where, in addition to mechanically injurious properties, the dust is of a poisonous character, which leads to diseases such as lead poisoning, phosphorus poisoning, anthrax poisoning, etc. Industrial mineral dust apparently acts with greater rapidity upon the lungs than organic dust, which is slower and more insidious in its operations, but in a general way follows similar lines. All varieties of dust that are the immediate result of occupation are therefore comprehended under the term of "industrial dust," which is specifically limited by Sir Crichton-Browne as follows:

I select this dust for my further remarks, because it is readily recognized and defined, because its pernicious effects are well marked and indisputable, because it is to a large extent, if not entirely, preventable or removable, and because the efforts already made to prevent or remove it have been rewarded with conspicuous benefit. And I still further simplify and abbreviate what I have to say by restricting my observations to those varieties of it which are dust and nothing more, which are injurious by their physical properties and mechanical operations, and not as poisons to the systems, chemical destructives of the tissues, or bearers of bacterial invaders.

A similar but even more restricted limitation has been adopted for the present purpose, and only such occupations will be considered in detail in the following discussion as expose to the continuous and considerable inhalation of metallic and mineral, or other inorganic fiber dust, and in which the evidence is at least fairly conclusive that the resulting disease liability and mortality from tuberculosis and other respiratory diseases is above the average for occupied males generally.

SCIENTIFIC TERMINOLOGY OF INDUSTRIAL DUSTS.

Preliminary to a discussion in detail of the mortality from tuberculosis in dusty trades it may prove of some advantage to those who do not have access to the original sources of information to present a brief summary of qualified medical opinion regarding dust as a factor in occupation diseases and mortality. In a course of lectures on "Unhealthy trades," delivered before the Society of Arts, London, in 1876, Dr. B. W. Richardson[1] placed injuries from the inhalation into the lungs of fine particles of solid matter, usually defined as dust, at the head of the causes responsible for industrial diseases, and from his discussion the following is quoted:

The term "dusts," as I would here apply it, includes all those fine, solid particles which are thrown off from various substances in the processes of manufacture or treatment of articles in common use in

[1] Scientific American Supplements, Nos. 9, 10, 18, 19, and 22, dated, respectively, Feb. 26, Mar. 4, Apr. 29, May 6, and May 27, 1876.

daily life, such as earthenware utensils, knives, needles, or mechanical instruments, like files or saws; or ornamental things, such as ornaments of pearl, ivory, and turned wood; or articles that are worn, of silk, cotton, hemp, fur; or things that are used for food, such as flour; or for creating warmth, such as coal; or for using as a supposed luxury, such as tobacco and snuff. These are only a few illustrations; many others will naturally occur to those who think on the subject.

The dusts which inflict injury are of varied quality, as will be seen from the brief sketch just given. They are also of varied effect in regard to the specific injuries which they produce. We may profitably study them divided into different groups, according to their physical characters, as follows:

(*a*) Cutting dusts, formed of minute hard, crystallized particles which have sharp, cutting, and pointed edges. These dusts are composed of iron or steel, of stone, of sand or glass, of dried silicates in earthenware, of lime, of pearl.

(*b*) Irritant dusts, derived from woods, from ivory, from textile fabrics, fluffs of wool, of silk, of cotton, of flax, and of hemp, from hair, from clay.

(*c*) Inorganic poisonous dusts, derived from some poisonous chemical compounds used for coloring artistic products, or for preserving organic substances, such as furs. These dusts are charged with arsenical salts.

(*d*) Soluble saline dusts, derived from soluble crystalline substances used for dyeing purposes. The sulphate of iron, copperas, yields a dust of this class.

(*e*) Organic poisonous dusts, which are thrown off during the making up of tobacco into cigars and snuff. These dusts carry with them particles of the dried tobacco plant.

(*f*) Obstructive and irritating dusts composed of carbon, of fine particles of coal dust, of scrapings of carbon or of soot, of dust of rouge, and of flour.

Whatever may be the kind of dust to which the workman is subjected, to whichever of the above named he may be exposed, the primary cause of danger lies in the circumstance that the fine particles are borne by the air into the lungs. They pass, wafted by the air, through the mouth and nostrils into the windpipe; they pass along the bronchial tubes; in some instances they reach and traverse the bronchial passages which lie between the larger bronchial tubes and the minute air vesicles, or they even reach the air vesicles themselves.[1]

DISEASES RESULTING FROM DUST INHALATION.

An American authority on occupational diseases has referred to the subject at some length in an article contributed to Buck's Hygiene

[1] One of the most important contributions to the scientific study of industrial dusts is the second and enlarged edition of a treatise issued by the Museum of Industrial Hygiene of Vienna in 1895. The title of the publication is "In den gewerblichen Betrieben vorkommende Staubarten in Wort und Bild." The publication includes 14 pages of 56 micro-photographic illustrations of typical industrial dusts and an extended explanatory text by Dr. F. Migerka, with the divisions of: (1) metallic dust, (2) mineral dust, (3) dust in polishing and turning, (4) wood dust, (5) textile dust, (6) miscellaneous dust. It is regrettable that this valuable treatise should not have been translated into

and Public Health, printed in 1879. This writer, Dr. Roger S. Tracy, for many years registrar of vital statistics of New York City and sanitary inspector of the board of health, makes the following statement, with particular reference to the special form or type of disease resulting from the inhalation of metallic and mineral dusts:

The disease comes on very gradually, like the more slowly developed forms of phthisis pulmonalis, and its duration may be extended over four or five years. It begins with the cough of irritation, dry and hacking at first, with very scanty expectoration, whitish and stringy in character; there is no hæmoptysis, but sometimes nausea and vomiting in the morning. Auscultation at this time reveals puerile respiration, with occasional slight râles. The expectoration gradually increases in amount and becomes reddish, and soon after this tinge appears there may be hæmoptysis. There is dyspnea on slight exertion, and dullness over the whole chest, with weak respiration and mucous râles. There is no fever, and the appetite and strength are still good. If work is abandoned at this time, recovery is not only possible, but in most cases probable. If work is continued, the lung tissue begins to break down, and cavities form near the apices. Expectoration is very profuse, and there may be severe hemorrhages. There is general dullness on percussion, and the last traces of vesicular respiration give way to sibilant, large mucous and cavernous râles. Fever is continuous, with evening exacerbations, night sweats, emaciation, insomnia, and great dyspnea, soon followed by death.

Very suggestive also are the observations and conclusions of Dr. John Syer Bristowe, F. R. S., who, in an address on industrial diseases, read at the conference on sanitary subjects held in connection with the International Health Convention of 1884, discussed the effects of nonpoisonous irritants on the lungs, in part as follows:

Occupations which habitually expose the workmen to the inhalation of abundant solid particles that are incapable of solution or removal by the animal tissues or secretions, in many cases induce chronic diseases of the lungs, which are known as the asthmas or consumptions of the several occupations referred to, and tend very materially to shorten life among those engaged in them. Workers in coal mines and in copper mines, grinders, millstone makers, and flax dressers are perhaps especially liable to suffer from such causes. It is marvelous how tolerant the bronchial tubes and lungs are of foreign particles which are drawn into them with the breath. Wherever smoke impregnates the atmosphere, as in London and other manufacturing towns, its particles are conveyed in greater or less abundance into the lungs; whence some are expelled with the expectoration, which presents, consequently, a slaty or black appearance, while some get absorbed, and becoming deposited in the tissue of the lungs, produce in them that black mottling which increases with advancing years, and is well known to pathologists. Yet, as a general rule, the soot-studded organs remain practically healthy, and no clinical evidences of pulmonary disease manifest themselves. The same remarks doubtless apply to the inhalation of the siliceous particles of ordinary dust. The effects are different, however, when such matters are inhaled in large excess. * * * The symptoms under which the sufferers labor have some resemblance to those of chronic phthisis, some to those of chronic bronchitis and emphysema, for either of which they may well be mistaken. They consist in gradually increasing shortness of breath, lividity of surface, feebleness of circulation, and cough, with more or less abundant expectoration; to which, at a later period, general dropsy and hæmoptysis may be superadded. There is generally a total, or almost total, absence of fever. The only methods, so far as I know, by which the irritative diseases of the lungs just considered can be lessened or prevented, are by providing good ventilation, and (when possible) by adopting methods to prevent the diffusion of particles of dust in the atmosphere which the workmen have to breathe. It is obvious, too, that since the diseases are insidious in their progress, and increase in proportion as the inhaled particles accumulate, it would be well for persons who present early traces of them to seek at once some other kind of employment.

HARMFUL CONSEQUENCES OF INDUSTRIAL DUST EXPOSURE.

The most qualified and extended discussion of the entire subject of the inhalation of dust, its pathology and symptomatology, with special reference to dusty trades, is by Dr. J. T. Arlidge, who, in 1892, published a treatise on The Hygiene, Diseases, and Mortality of Occupations. "Few, indeed," he argued, "are the occupations in which dust is not given off," and "in none can it be absolutely harmless, for the lung tissue must be just so much the worse, and less efficient for its purpose, in proportion to its embarrassment by dust." And in continuation—

What occurs to the ordinary citizens becomes magnified ten or a hundred fold to those engaged in dusty occupations, and more especially where the dust itself possesses noxious properties. But unless dust has this latter quality, it is remarkable with what indifference its inhalation is treated by the majority of workmen. In one sense, indeed, it is unfortunate that it does not, for the most part, awaken attention by any immediate tangible consequences. Its disabling action is very slow, but it is ever progressive, and until it has already worked its baneful results upon the smaller bronchial tubes and air cells and caused difficulty of breathing, with cough and spitting, it is let pass as a matter of indifference—an inconvenience of the trade.

OBSERVATIONS ON NONTUBERCULOUS RESPIRATORY DISEASES.

Arlidge called attention to the fact that bronchitis, asthma, and pulmonary fibrosis and tuberculosis were foremost in the causes of British mortality, holding that without doubt these maladies were largely attributable to the inhalation of dust operating *per se*, or in conjunction with constitutional proclivities and insanitary surroundings. In further continuation he observes—

Pathologists tell us of the presence of bacilli in tubercular disease, and favor the belief that these minute bodies are the cause of it.

This notion may represent a whole truth or only a partial one; in my opinion, the latter. For I doubt if these bacilli actually develop phthisis unless there be some antecedent change in the vitality of the affected tissue; a change wrought by depressing causes connected with the mode of life, or with constitutional debility and inherited taint, or with the occupation followed; of which contributory factors two or more may cooperate. And assuredly the breathing of dust may be reckoned as one such of no light energy. In other words, I look upon a phthisical lung as one prepared for the germination and multiplication of bacilli, and not a primary product of those microscopic organisms, nor of the products of their organic existence.

The conclusions of Arlidge are summarized in the statement that "One practical lesson is to be gained by these considerations—namely, that *persons predisposed to respiratory diseases and phthisis ought not to engage in dusty occupations.*"

BRITISH GOVERNMENTAL INVESTIGATIONS.

More recently the subject of occupational diseases in their relation to workmen's compensation has been considered at length and in much detail by a British departmental committee appointed to consider the pressing and important question of workmen's compensation for industrial diseases. In its observations upon respiratory diseases, and in particular bronchitis, pneumonia, and phthisis, and their relation to occupation exposure, the committee concluded that—

Pulmonary disease manifests itself in three kinds or forms—as ordinary tuberculous phthisis, acute or chronic; as "fibroid phthisis," and as a mixed form when a tuberculous process is ingrafted sooner or later upon the fibroid. Fibroid phthisis is always a slow disease. It consists in a chronic reactive inflammation around the many minute foci of dust inhalation, which by coalescence gradually invades large areas, impairing and strangling the proper lung tissues in corresponding measure. Again, a lung so impaired is very apt to harbor bacilli, especially the bacillus of tubercle, by the influence of which it may be still further destroyed. Thus both fibroid phthisis uncomplicated and fibroid phthisis with the supervention of tubercle are in their nature occupational diseases.[1]

TYPICAL FORMS OF FIBROID PHTHISIS.

The committee, in its final report, describes the typical forms of fibroid phthisis as induced by the inhalation of industrial dust, holding that—

The first symptom is a cough which insidiously, and for a while almost imperceptibly, becomes habitual. At first in the morning only, it gradually becomes more frequent during the day, and expectoration, nominal at the beginning, becomes more marked, though

[1] Report of the Departmental Committee on Compensation for Industrial Diseases, London, 1907, p. 13.

not profuse until the latter stages of the disease. Leaving out of account the more rapid progress of the disease in tin and gold miners, these symptoms of a negative phase of purely local damage may last for years—10 or 15 or even more—without advancing to such a degree as to throw the workman out of employment or even to cause him serious inconvenience. At some period, however, rarely less than 10 years and frequently more than 20, of continuous employment, in a like imperceptible manner the breathing gets shorter and the patient finds himself less and less capable of exertion. Yet, even when the cough and dyspnea have reached a considerable degree, there are no signs of fever, as is the case of pulmonary tuberculosis; the flesh does not fall and the muscles retain their strength and volume. Thus even at a period when the malady is fully established the general health may be but little impaired, and the patient may not be compelled to cease work. Herein fibroid phthisis presents a well-marked difference from pulmonary tuberculosis: a[n] even if, as we have said, the disease becomes complicated with tu[ber]cle, yet the rate of progress may be determined rather by the cha[rac]ter of the primary than of the secondary disease, though usually the supervention of tubercle hastens the sufferer into a more rapid consumption.[1]

The results of all these researches into an almost neglected field of preventive medicine prove that occupation diseases, properly so called, demand the most thoroughly qualified medical supervision of factories and workshops and the periodical medical examination and inspection of persons employed in recognized unhealthy trades. For, as the committee referred to points out, "If in the early stage of fibroid phthisis the workman leaves the dusty employment for work in agriculture or in other occupation in air free from irritating particles, the disease may be practically arrested; that is, although the part affected may proceed to obliteration, the disease would not extend to other parts of the lung, and the portion destroyed would be negligible as a factor of health and capacity."[2]

FIBROID PHTHISIS AND OCCUPATIONAL DISEASE.

The conclusion of this investigation, the most important official inquiry ever made into the subject of industrial diseases, fully warrants the view that while ordinary tuberculous phthisis can not be regarded as a disease peculiar to any occupation, fibroid phthisis in its latter stage, and when the history of the case is known, can be clearly distinguished from tuberculous phthisis; so that it may be regarded as an established fact that fibroid phthisis is a disease peculiar to employment in certain trades, of which the committee mentions the following: Grinders continuously using either grindstones or emery for the abrasion of metals, especially steel; potters engaged in certain

[1] Report of the Departmental Committee on Compensation for Industrial Diseases, 1907, p. 13.
[2] Idem, p. 14.

processes; stone workers employed on certain kinds of stone, especially if not working in the open air; tin miners, in particular such as have previously been exposed to the exceedingly unhealthy conditions of the gold mines of the Transvaal; and ganister miners, including men employed in certain processes of ganister brickmaking. The committee did not arrive at final conclusions regarding persons employed in the slate industry, or employees in the working of asbestos and many other recognized unhealthy trades, partly, no doubt, because of the limited scope of the inquiry and the paucity of conclusive statistical data. It is pointed out by the committee that it was not possible to separate the English death rates for fibroid phthisis from those for other diseases of the respiratory system, since medical men do not, as a rule, distinguish that disease when certifying the causes of death. It is clearly established by the results of the investigation that such a distinction should be made and that medical practitioners should qualify the death returns from tuberculosis in all cases where the death was the result of fibroid phthisis.

The committee, having arrived at the opinion that fibroid phthisis is a specific and distinguishable trade disease, concluded that employers might properly be required to pay compensation to their workpeople who contract it; but it did *not*, however, recommend the extension of the workmen's compensation act to the disease for two reasons. The first was that, owing to the long period of its development, it would not be right to lay the whole burden on the employer under whom the workman had been serving during the 12 months prior to the incapacity. The other and even more important reason was that for several years before the nature of the disease can be definitely diagnosed the patient may suffer from symptoms that, while not distinctive, are sufficient to prevent him from securing employment.

In the brief descriptive account of 118 industries and occupations considered in detail in this discussion only the most general facts have been included in order to emphasize, as far as possible, the industrial processes productive of conditions more or less injurious to health in general, and conducive to the development of tuberculosis in particular. Authorities are referred to only so far as this has seemed necessary to establish clearly, in the case of each trade or occupation considered, the facts of a more or less excessive degree of frequency of pulmonary tuberculosis, aside from the statistical sources of information which form the basis of the subsequent conclusions, except in the case of a few employments for which neither general vital statistics nor insurance mortality experience are as yet available. The term "tuberculosis" is used in a very general sense, but as a rule limited to phthisis pulmonalis, or pulmonary tuberculosis, unless otherwise stated. All of the references to insurance mortality experience are

limited to the mortality from phthisis pulmonalis and do *not* include that from other forms of tuberculosis or other forms of respiratory diseases unless specifically stated in the text.

SOURCES OF STATISTICAL INFORMATION.

The principal statistical data utilized in the present discussion are the following: First, the occupation returns according to age and sex as published in 1914 by the Thirteenth United States Census for the year 1910; second, the occupation mortality statistics of the Twelfth Census, published in 1904; third, the occupation mortality data published in the annual reports on the mortality of the United States registration area for the years 1908 and 1909; fourth, the occupation mortality statistics published decennially as a supplement to the Report of the Registrar-General of Births, Marriages, and Deaths for England and Wales for the two periods, 1890–1892 and 1900–1902 (no later data have as yet been published); fifth, the corresponding decennial mortality statistics of Scotland; sixth, the industrial mortality statistics of the Prudential Insurance Co. of America for the period 1897 to 1914, published in connection with the company's exhibits at the British Congress on Tuberculosis, 1901, the Louisiana Purchase Exposition, 1904, the International Congress on Tuberculosis, 1908, the International Congress on Hygiene and Demography, 1912, and the Panama-Pacific International Exposition, 1915; seventh, the industrial mortality statistics of the Metropolitan Life Insurance Co., presented at the annual meeting of the American Public Health Association, 1915; and eighth, miscellaneous occupation mortality statistics derived from special sources or made public in connection with local investigations, including, among others, medico-actuarial experience data, the mortality returns for the textile industry of Blackburn, England, the cutlery industry in Sheffield, England, the quarry industry of Derbyshire, England, the stone industry of Aberdeen, Scotland, the mining industry of Cornwall, South Africa, Montana, southwest Missouri, etc.

PRINCIPLES OF STATISTICAL ANALYSIS.

At least four different statistical methods are available for the purpose of determining with approximate accuracy the degree of tuberculosis frequency in different trades or specified occupations. Absolute accuracy is not obtainable in investigations of this kind, nor is this absolutely essential for the practical ends in view.

The first method is to determine the proportion of persons in specified occupations living at ages 65 and over, and to compare the same with the corresponding proportion for occupied males generally. This method is never conclusive by itself, but is occasionally useful in connection with the use of other statistical data. It is

self-evident that other factors besides mortality determine the proportion of persons in different occupations at ages 65 and over. It has been shown, for illustration, by the census of 1910, that of the male population, ages 14 to 44, the proportion employed in gainful occupations is 89.3 per cent, in contrast with only 28.6 per cent for the female population. The proportion employed in the general population varies materially according to sex and age, there being a gradual increase from ages 14 to about 45, subsequent to which the proportion either unemployed for physical or retired for economic reasons gradually increases. At ages 21 to 44, for illustration, in the American population 96.7 per cent of the males but only 26.3 per cent of the females are employed in gainful occupations. The maximum proportion of employed among women occurs at ages 16 to 20, when 39.9 per cent are engaged in gainful occupations.

In the general population, ages 10 years and over, according to the census of 1910, 81.3 per cent of males and 23.4 per cent of females were engaged in gainful occupations. The corresponding percentages in 1900, according to the census, were 80 for males and 18.8 for females. The proportions for the aggregate employees in the principal occupations with exposure to dust, according to the census of 1910, are shown in Table 3.

TABLE 3.—AGE DISTRIBUTION OF PERSONS IN GAINFUL OCCUPATIONS WITH EXPOSURE TO INDUSTRIAL DUSTS.

[Compiled from Report of Bureau of the Census on Occupation Statistics, 1910. For occupations included, see pp. 46 to 50.]

Age group.	Males.		Females.	
	Number.	Per cent.	Number.	Per cent.
10 to 13 years	11,817	0.4	8,211	1.2
14 to 15 years	64,110	2.0	55,671	8.3
16 to 20 years	435,105	13.3	251,477	37.3
21 to 44 years	2,094,694	64.2	308,130	45.8
45 years and over	658,774	20.1	49,989	7.4
Total, 10 years and over	3,264,500	100.0	673,478	100.0

By way of further illustration attention may be directed to the fact that of 5,606,789 farmers 2,457,572, or 43.8 per cent, were 45 years and over. In contrast, out of 210,566 males employed in cotton mills only 34,476, or 16.4 per cent, were 45 years and over. It, of course, would be quite erroneous to conclude that the differences in percentages measure the full effect of an excessive mortality, since for obvious reasons the age distribution is primarily determined by occupational requirements and conditions. The illustration is sufficient for the purpose of emphasizing the practical limitations of the method of ascertaining occupational mortality by means of the proportion of persons living at advanced ages in specified employments.

The second method is to ascertain the average age at death in particular occupations from all and specified causes. This method was quite extensively employed in the earlier registration reports for certain New England States, and while occasionally useful in connection with other data the method by itself is frequently seriously misleading. According to the combined statistics for the State of Rhode Island (1852–1910), the average age at death of farmers was 67.4 years, against 55.86 years for florists. There are no reasons for believing that on the average florists experience a higher death rate than farmers and certainly not to the extent indicated by the difference of 11.5 years in the average age at death. Another interesting illustration is the high average age at death of clergymen, given according to the Rhode Island experience[1] as 63.78 years, and the very low average age at death of electricians, given as 36.14 years. These illustrations are sufficient for the purpose of emphasizing the uselessness and misleading character of a method still occasionally employed in determining the relative mortality in different occupations from all causes or special causes by means of the average age at death.

The third method is to determine the exact mathematical rate of mortality from all causes or specific causes, such as tuberculosis or industrial accidents, by the ascertainment of the number of deaths occurring among every 1,000 persons of any particular trade or occupation exposed to risk of death for a given period of time, usually a single year. This method is probably the most satisfactory; but it is often quite impossible to secure strictly accurate information regarding the number of persons employed in particular trades or occupations and the corresponding number of deaths in precisely the same group of employments. *Estimates* of the numbers exposed to risk in particular occupations are quite likely to be seriously misleading, and the chance of error is materially increased by differences in the prevailing methods of occupation classification. It is rarely the case that both the census enumeration and the occupation mortality returns are ascertained in *exactly* the same manner by the census and the health authorities or registration officials throughout the country.

The fourth method is to determine the exact proportion of deaths from a specific cause, such as pulmonary tuberculosis, occurring in the mortality from all causes, without reference to ages at death. When this method is used with the required caution, the proportions thus determined are often sufficiently suggestive of abnormal conditions and occasionally conclusive.

A fifth method is a modification of the fourth and is generally known as the proportionate mortality figure, by means of which the propor-

[1] Fifty-eighth Registration Report, Rhode Island, 1910, p. 631 et seq.

tion of deaths from any particular disease, such as pulmonary tuberculosis, is calculated as a percentage of the deaths from all causes occurring during specified periods of life. This method has been extensively employed in the present discussion, since otherwise the available industrial insurance mortality statistics could not have been fully utilized. This method, in a measure, is, however, the most satisfactory and practically conclusive, since it presents with approximate accuracy the true proportionate incidence of pulmonary tuberculosis or the degree of its frequency at specified periods of life.

INDUSTRIAL INSURANCE MORTALITY STATISTICS.

The industrial insurance mortality statistics utilized in the present discussion are derived largely from the experience of two thoroughly representative companies which have from time to time given publicity to the facts of their experience. The resulting proportionate mortality returns, however, indicate a specific mortality from pulmonary tuberculosis somewhat below the actual, since the experience is, to a certain extent, modified by medical selection; in other words, the proportionate mortality from pulmonary tuberculosis, or the true, actual loss from the disease at specified age periods would have been somewhat higher if medical selection had not been made use of. In comparing this experience with the corresponding standard for the registration area of the United States the comparison is, therefore, somewhat more favorable to the various trades and occupations considered than would have been the case if the returns could have been derived from the registration records of the different States and cities comprehending the experience of the companies referred to.

Of the aggregate number (34,997,474) of industrial policies in force with all American industrial companies on December 31, 1916, the proportion in force with the Prudential and Metropolitan companies was 84 per cent. The experience utilized, therefore, may be considered as thoroughly representative for the industrial population of the country at large.

THE PROPORTIONATE MORTALITY FROM PULMONARY TUBERCULOSIS.

The proportionate mortality figures may briefly be explained as follows: At ages 25 to 34, out of every 100 deaths from all causes in the registration area of the United States during the 14 years ending in 1913, 30.5 deaths were from pulmonary tuberculosis. The corresponding proportion of deaths in the industrial insurance mortality experience of the Prudential Co. was 67.9 per cent for grinders, 55.9 per cent for printers and compositors, 53 per cent for

upholsterers, 45.3 per cent for potters, etc. The difference between the average mortality from pulmonary tuberculosis for the registration area as a whole and the corresponding proportionate mortality from pulmonary tuberculosis in the occupations considered in some detail, measures approximately the health-injurious circumstances for different employments. It, however, does not follow that all of the difference is necessarily or specifically attributable to the employment as such, or to the health-injurious conditions under which the industry may be carried on.

DESCRIPTIVE DEFINITIONS OF INDUSTRIAL DUSTS.

Preliminary to the analysis of the mortality data and the observations having reference to the specific occupations or employments considered, the following descriptive definitions of industrial dusts, by Charles Baskerville, Ph. D., are included in explanation of the statistical data and groupings of occupations with exposure to industrial dust. The extract is from an exceptionally useful and trustworthy dissertation on "Air impurities: dust, fumes, and gases," in the New York Medical Journal, November 23 and 30, 1912.

First, as regards *insoluble inorganic dusts*, it is said that "this class includes metals (antimony, arsenic, type metal, brass, bronze, copper, aluminum, iron, steel, lead, manganese, vanadium and ferrovanadium, silver, tin, zinc, and solder) in a state of fine division (dusts, atomized metals, metallic powders); flue dusts; various ore dusts (iron ore, etc.); silica, sand, emery, flint, glass powders; carbon graphite, diamond, coal, soot; brick dust, marble, granite, cement, terra cotta; lime, gypsum, plaster, meerschaum; phosphates, guano, etc." The continuous and considerable exposure to the inhalation of insoluble inorganic dusts, according to Baskerville (who is sustained by numerous other authorities) may result in fibrosis of the lungs, chiefly because of the inhalation of siliceous or metallic particles, as, for example, is the case in the so-called potters' asthma and grinders' phthisis. Pneumonia has been reported as frequent among workmen in blast furnaces, owing, in part, directly or indirectly, to the inhalation of slag dust. The disease known as siderosis is commonly met with among metal polishers, knife grinders, and others engaged in metal working.

Second, soluble inorganic dusts.—This class, according to Baskerville, includes such substances as are likely to be swallowed and absorbed, as, for illustration, metal particles, including lead, brass, copper, zinc, arsenic, mercury, and silver, as well as soluble inorganic salts. Many dusts of this class, it is pointed out, "are dangerous not only because of their irritating or poisonous properties, but also because of their inflammability, e. g., potassium chlorate."

Third, organic dusts.—This class is defined as comprising such widely varying materials as "sawdust, fur, skins, feathers, broom and straw, grains and flours, jute, flax, hemp, cotton, wool, carpet dust, street sweepings, tobacco-box dust, hides and leather, felts, rags, paper, horsehair, etc." Typical of the diseases caused by organic dusts are: "Flax dressers' disease, a kind of pneumonia due to the inhalation of particles of flax; pneumoconiosis due to the inhalation of dust by ganister workers; alkaloidal poisoning from African boxwood by workmen engaged in shuttle making; and malignant pustule and a febrile disease among rag sorters."

THE CLASSIFICATION OF DUSTY TRADES.

The occupational grouping adopted for the purposes of the present discussion is necessarily a more or less arbitrary one, since all employments involve exposure to more than one particular kind of dust. It is, however, safe to assume that the predominating characteristic of a particular kind of dust exposure primarily determines the resulting departure of the mortality from pulmonary tuberculosis from the normal for the general population. All the groupings of dusty trades which have been adopted by Benoiston de Chateauneuf, in Oesterlen's Medical Statistics,[1] by Hirt, Sommerfeld, Merkel, Arlidge, Oliver, and others have this limitation in common, since no entirely conclusive scientific investigation has been made to afford the material for a final and strictly scientific classification of dusty trades. The present classification, however, will at least serve the purpose of a convenient arrangement, with a strict regard to the facts as they are known and understood at the present time.

The occupational grouping as given below has been adopted to emphasize in a rather general way the principal dust hazards in 118 occupations or groups of employments, and to facilitate the convenient reference to the particular industries considered in more or less detail in the subsequent discussion.

INDUSTRIAL AND OCCUPATIONAL CLASSIFICATION ACCORDING TO THE KIND OF UNAVOIDABLE DUST EXPOSURE, WITH SPECIAL REFERENCE TO THE MORTALITY FROM PULMONARY TUBERCULOSIS.

SECTION A.—INORGANIC DUSTS.

Group 1.—Metallic dust.

- Artificial-flower makers.
- Brass workers.
- Chippers, at blast furnaces and steel rolling mills.
- Compositors and typesetters.
- Cutlery makers.
- Die setters and sinkers.
- Electrotypers and stereotypers.
- Engravers.
- Filers.
- Gold beaters.
- Grinders.

[1] Handbuch der medicinischen Statistik. by Dr. Fr. Oesterlen, Tübingen, 1874, p. 389.

- Grinders, card (cotton mills).
- Jewelers, manufacturing.
- Polishers, buffers, and finishers.
- Pressmen and press feeders.
- Sand blasters.
- Saw filers.
- Solderers.
- Toolmakers.

Group 2.—Mineral dust.

- Asbestos workers.
- Brick, tile, and terra-cotta factories.
- Core makers.
- Color mixers.
- Glass blowers.
- Glass factories (other than blowers).
- Lacquerers, japanners, enamelers.
- Lime, cement, and gypsum factories.
- Lithographers.
- Marble and stone workers.
- Mica workers.
- Mirror makers.
- Molders.
- Paint factories.
- Paper hangers and helpers.
- Plasterers.
- Potteries.
- Whitewashers.

Group 3.—Mineral industries.

- Asphalt miners.
- Bauxite miners.
- Coal miners.
- Copper miners.
- Gold and silver miners.
- Graphite miners.
- Iron miners.
- Lead and zinc miners.
- Mica miners.
- Phosphate miners.
- Quarries.
- Quicksilver miners.
- Spar miners.
- Sulphur miners.
- Other and not specified miners.

SECTION B.—ORGANIC AND MISCELLANEOUS DUSTS.

Group 4.—Vegetable fiber dust.

- Broom and brush factories.
- Corn shellers, grain thrashers, wood sawyers, etc., in agriculture.
- Cotton ginners.
- Cotton spinners.
- Cotton weavers.
- Other cotton mill employees.
- Hay and straw balers.
- Hemp and jute mills.
- Knitting mills.
- Lace and embroidery.
- Linen mills.
- Paper and pulp mills.
- Paper-box makers.
- Rag dealers.
- Rag pickers, sorters, and cleaners.
- Rope and cordage factories.
- Sail, awning, and tent factories.
- Straw factories.
- Textile mills—dyeing, finishing, printing.
- Textile mills (not specified).
- Wood—cabinetmakers.
- Wood—box makers.
- Wood carvers.
- Wood—furniture factories, except polishers and finishers.
- Wood—piano and organ factories, except polishers and finishers.
- Wood polishers and finishers.
- Wrappers and packers.

Group 5.—Animal and mixed fiber dust.

- Carpet mills.
- Furriers.
- Hair workers.
- Hat factories.
- Mattress makers.
- Upholsterers.
- Silk mills.
- Woolen and worsted spinners.
- Woolen and worsted weavers.
- Woolen and worsted mills.

Group 6.—Organic dust.

Bakeries.
Bone and ivory workers.
Button factories.
Candy factories.
Celluloid workers.
Charcoal and coke works.
Cigar and tobacco factories.
Fertilizer factories.
Glove factories.
Grain and flour mills.
Grain-elevator employees.
Harness and saddle factories.
Pocketbook and belt makers.
Rubber factories.
Shoe factories.
Shoemakers (not in factories).
Tanneries.
Trunk factories.

Group 7.—Mixed organic and inorganic (public) dusts.

Carriage and hack drivers.
Chauffeurs.
Coachmen.
Drivers and teamsters.
Garbagemen and scavengers.
Street car conductors.
Street car motormen.
Street cleaners.
Sweepers, car.
Waste products (junk).

AGE IN RELATION TO OCCUPATION AND DUST EXPOSURE.

For convenience and ready reference the so-called dusty industries, trades, and occupations have been arranged in seven large groups, which include specific subgroupings and an aggregate of 3,264,500 males and 673,478 females, as returned by the occupation census of 1910. The grouping in matters of detail is unquestionably open to criticism, but in the absence of a thoroughly worked out descriptive account of the industries, trades, and occupations referred to it is exceedingly difficult to adopt a more satisfactory arrangement. Since each subgrouping will be discussed in detail, the errors inherent in the main groupings are not, as a matter of practical certainty, of sufficient importance to invalidate the final conclusions concerning the specific injuriousness of particular forms of dust. Since the age distribution of wage earners in particular occupations varies widely, the details according to sex and for all the seven subdivisions are given in Table 6 (pp. 46 to 50), included in which is a column showing for each and every industry, trade, or occupation the proportion living at ages 45 and over. The wide differences in age distribution disclosed by this analysis are of special importance in the scientific consideration of the mortality data and the descriptive observations concerning the conditions under which the various dusty trades are carried on. The same conclusion applies to differences in the sex distribution of employees; for, as elsewhere shown, the specific death rates from tuberculosis vary considerably, according to age and sex. For illustration, at ages 15 to 24 the mortality from tuberculosis of the lungs is 12.15 per 10,000 for males, against 14.15 per 10,000 for females; in other words, the normal tuberculosis mortality of females

is excessive at this period of life. If, therefore, an industry, trade, or occupation includes a disproportionately large number of young women wage earners, the general mortality from tuberculosis might be higher without necessarily implying a very definite relation to the more or less considerable degree of dust exposure.

Conceding the general untrustworthiness of morbidity and mortality conclusions based exclusively upon the age distribution of persons employed in different industrial groups according to the kind of dust exposure, some value may safely be attached to this method of analysis when made use of with exceptional caution on account of the large variety of special conditions and circumstances which have an important bearing upon the age distribution of men and women in different industrial pursuits. Some employments are obviously only for the young, while others are chiefly for the old. In some no special trade ability is required, with the result that there are frequent occupation changes, while in other groups the required degree of specialized skill is such that the employment becomes practically the pursuit of a lifetime. Furthermore, in certain occupations there is a constant elimination of employees with advancing age on account of unsuitability for the special industrial pursuits carried on, which, of course, tends materially to disturb the proportion of aged persons under the conditions stated.

AGE DISTRIBUTION OF EMPLOYEES IN DUSTY TRADES.

Table 4 shows the proportionate distribution of males in the seven groups of dusty trades according to three subdivisions of age—under 16, from 16 to 44, and 45 and over. It is most regrettable that the census age grouping by occupation should not have been extended to the age period 65 and over, which, of course, for certain morbidity and mortality purposes is distinctly more useful and conclusive than the age period of 45 and over:

TABLE 4.—PROPORTIONATE AGE DISTRIBUTION OF MALES IN DUSTY TRADES.

[Compiled from Report of Bureau of the Census on Occupation Statistics, 1910. For occupations included, see pp. 45 to 50.]

Trade groups.	Per cent in age group—		
	Under 16.	16 to 44.	45 and over.
1. Metallic dust	0.54	82.52	16.94
2. Mineral dust	1.86	78.43	19.71
3. Mineral industries	1.74	79.65	18.61
4. Vegetable fiber dust	7.73	75.01	17.26
5. Animal and mixed fiber dust	4.06	75.49	20.45
6. Organic dust	2.28	72.53	25.19
7. Mixed organic and inorganic (public) dusts	.77	77.91	21.32
Total	2.33	77.49	20.18

According to this table, the proportion of young persons is largest in the group of occupations with exposure to vegetable fiber dusts, which, of course, is inclusive of the entire cotton-textile industry. The proportion is least in the group of occupations with exposure to metallic dusts, largely because of the practical absence of an apprentice system and the highly specialized skill required of a large number of employees in the cutlery, tool, jewelry, printing, and related trades. In the entire group of dusty trades the proportion of men aged 45 and over is 20.18 per cent, being lowest among the workers with exposure to metallic dusts, or 16.94 per cent, and highest among workers with exposure to organic dusts, or 25.19 per cent. This result is of special significance in the case of men employed with exposure to metallic dusts, on account of the small proportion employed at ages under 16, which ordinarily, of course, would tend to raise the proportion at ages 45 and over. The abnormal age distribution in the case of this group of employees, therefore, confirms the mortality data suggestive of an excessive death rate among men employed in this group of occupations, particularly or largely in consequence of considerable and continuous exposure to metallic dusts. In the case of men employed in occupations with exposure to vegetable fiber dusts the proportion aged 45 and over is 17.26 per cent, but this low proportion is in part due to the very high proportion of persons employed at ages under 16. Here, however, also to a limited extent the high figure is fairly conclusive and indicative of a relatively high mortality in middle adult life. The group of occupations following, in the order of the proportion of persons aged 45 and over, is composed of men employed in mineral industries, followed by men employed in occupations with exposure to mineral dusts, which two groups, of course, have much in common, and for which the age distribution is almost the same. A more favorable proportion is shown for persons employed in occupations with exposure to animal and mixed fiber dusts, or 20.45 per cent, and these are followed by persons with exposure to public or street dusts (21.32 per cent), and, finally, by persons in the group of occupations with exposure to organic dusts, or 25.19 per cent. As shown elsewhere, in this group of occupations the result of dust exposure is apparently least harmful where the proportion of workers 45 years and over is correspondingly the largest. In a general way, therefore, the age distribution fairly conforms to the conclusion based upon mortality statistics.

Table 5 exhibits the corresponding information for females, but the data must be considered distinctly less conclusive and, in the case of certain groups, practically valueless, on account of the small number of employees concerned.

TABLE 5.—PROPORTIONATE AGE DISTRIBUTION OF FEMALES IN DUSTY TRADES.

[Compiled from Report of Bureau of the Census on Occupation Statistics, 1910. For occupations included, see pp. 46 to 50.]

Trade group.	Per cent in age group—		
	Under 16.	16 to 44.	45 and over.
1. Metallic dust	4.27	90.50	5.23
2. Mineral dust	7.99	85.26	6.75
3. Mineral industries	7.27	80.91	11.82
4. Vegetable fiber dust	11.94	81.75	6.31
5. Animal and mixed fiber dust	8.44	82.20	9.36
6. Organic dust	7.45	84.55	8.00
7. Mixed organic and inorganic (public) dusts	1.00	78.20	20.80
Total	9.50	83.10	7.40

No safe deductions can be based upon this table, which is merely included here for the purpose of completeness. The chief factor of uncertainty inherent in this table is the constant elimination of women from industry on account of marriage and for other reasons, naturally tending toward a decidedly lower proportion of women ages 45 and over in industrial pursuits, regardless of the fact that in the population at large the proportion of women at this period of life exceeds the corresponding proportion of men. Even subject to these qualifications it is suggestive that the proportion of women aged 45 and over employed in occupations with exposure to metallic dusts should be the lowest of the seven groups, 5.23 per cent, against 7.40 per cent for the aggregate number of female employees in occupations with exposure to industrial dusts. There are practically no women employed in mineral industries, but as shown by the introductory tables most of the occupied females are employed in the occupations with exposure to vegetable fiber dusts, animal and mixed fiber dusts, and organic dusts, which are, of course, inclusive of all the different subdivisions of the textile industry. It is suggestive in this connection that no definite conclusions can be drawn from the table further than as stated.

The analysis could have been extended to the 118 individual occupations, employments, or industries, but the table following makes this unnecessary. The details, however, in the case of many occupations are distinctly indicative of unfavorable health conditions, and especially is this true for grinders, polishers, and buffers, toolmakers, and sand blasters in the iron and steel industries. An analysis in detail, however, is much more subject to the qualification of extreme care in the use of the data for the purpose of emphasizing the possibly injurious results of any particular occupation, industry, or trade on the basis of the proportion of men or women employed at ages 45 and over. The data are included primarily for the purpose of making the statistics conveniently available, and to bring the facts of age distribution into intelligent correlation to the general discussion of

the circumstances and conditions more or less accountable for health-injurious results of certain occupations, trades, and industries by reason of the approximately ascertainable exposure to different kinds of industrial dust.

TABLE 6.—AGE DISTRIBUTION OF EMPLOYEES IN DUSTY TRADES, BY SEX AND OCCUPATION GROUPS.

Compiled from Report of Bureau of the Census on Occupation Statistics, 1910.]

GROUP 1.—METALLIC DUST.

Sex and occupation group.	Total employees.	Number in age group— 10 to 13.	14 to 15.	16 to 20.	21 to 44.	45 and over.	Per cent 45 years and over.
MALE.							
Artificial-flower makers	1,238	7	57	267	672	235	19.0
Brass workers	15,912	.....	82	1,665	11,166	2,999	18.8
Chippers (blast furnace and steel rolling mill)	968	.....	3	62	722	181	18.7
Compositors and typesetters	111,489	4	23	21,902	70,726	18,834	16.9
Cutlery makers	4,840	5	107	889	2,894	945	19.5
Die setters and sinkers	2,744	.....	4	290	1,996	454	16.5
Electrotypers and stereotypers	4,268	.....	1	510	3,097	660	15.5
Engravers	11,315	.....	27	1,850	7,574	1,864	16.5
Filers	3,016	1	31	329	1,769	895	29.7
Gold beaters	697	.....	12	103	327	165	27.2
Grinders	8,214	.....	93	1,070	5,346	1,705	20.8
Grinders, card	1,037	.....	1	66	726	294	27.0
Jewelers, manufacturing	6,943	.....	11	1,243	4,257	1,432	20.6
Polishers, buffers, and finishers	31,772	4	401	4,241	21,759	5,367	16.9
Pressmen and press feeders	25,951	15	437	6,851	16,677	1,971	7.6
Sand blasters, iron and steel	99	.....	.....	20	65	14	14.1
Saw filers	7,345	.....	2	387	4,910	2,046	27.9
Solderers	434	.....	3	97	278	56	12.9
Toolmakers	20,212	.....	75	2,282	14,186	3,669	18.2
Total	258,454	36	1,370	44,115	169,147	43,786	.....
Per cent in each age group	100.00	0.01	0.53	17.07	65.45	16.94	.....
FEMALE.							
Artificial-flower makers	8,616	50	919	3,791	3,297	559	6.5
Brass workers	187	.....	4	82	83	13	7.0
Compositors and typesetters	13,681	.....	7	4,567	8,411	696	5.1
Cutlery makers	543	.....	39	263	218	23	4.2
Die setters and sinkers	4	.....	.....	2	2	.....	.....
Electrotypers and stereotypers	100	.....	1	27	62	10	10.0
Engravers	451	.....	2	158	268	23	5.1
Filers	227	.....	4	100	111	12	5.3
Gold beaters	76	.....	2	32	35	7	9.2
Grinders	364	.....	11	189	157	7	1.9
Grinders, card	4	.....	.....	1	3	.....	.....
Jewelers, manufacturing	1,435	.....	23	550	789	68	4.7
Polishers, buffers, and finishers	3,204	1	176	1,269	1,577	181	5.6
Pressmen and press feeders	4,133	.....	174	1,863	1,962	134	3.2
Sand blasters, iron and steel	2	.....	.....	2	.....	.....	.....
Saw filers	2	.....	.....	.....	2	.....	.....
Solderers	161	.....	2	73	85	1	.6
Toolmakers	65	.....	.....	16	44	5	7.7
Total	33,255	51	1,369	12,985	17,111	1,739	.....
Per cent in each age group	100.00	0.15	4.12	39.05	51.45	5.23	.....

GROUP 2.—MINERAL DUST.

MALE.							
Asbestos workers	1,197	2	15	121	891	168	14.0
Brick, tile, and terra-cotta factories	92,823	566	2,112	14,663	59,862	15,620	16.8
Core makers	16,479	4	411	4,049	10,638	1,377	8.3
Color mixers (not paint)	858	.....	15	114	512	217	25.3
Glass blowers	15,474	.....	17	957	11,885	2,615	16.9
Glass factories (excluding blowers)	61,299	395	4,104	14,416	34,135	8,249	13.5
Lacquerers, japanners, enamelers	1,225	.....	23	174	811	217	17.7
Lime, cement, and gypsum factories	46,898	78	414	5,573	33,340	7,493	16.0
Lithographers	7,661	.....	11	1,299	5,001	1,350	17.6
Marble and stone yards	52,813	23	278	4,138	33,731	14,643	27.7
Mica workers	27	.....	1	10	14	2	7.4
Mirror makers	687	1	8	100	482	96	14.0

TABLE 6.—AGE DISTRIBUTION OF EMPLOYEES IN DUSTY TRADES, BY SEX AND OCCUPATION GROUPS—Continued.

GROUP 2.—MINERAL DUST—Concluded.

Sex and occupation group.	Total employees.	Number in age group— 10 to 13.	14 to 15.	16 to 20.	21 to 44.	45 and over.	Per cent 45 years and over.
MALE—concluded.							
Molders	113,617	.....	37	8,165	84,070	21,345	18.8
Paint factories	4,727	4	91	730	3,010	892	18.9
Paper hangers, apprentices, and helpers	25,561	14	255	2,362	16,636	6,294	24.6
Plasterers	50,525	18	147	3,452	30,564	16,344	32.3
Potteries	21,159	44	488	3,578	13,397	3,652	17.3
Whitewashers	1,663	1	4	65	696	897	53.9
Total	514,693	1,150	8,431	63,966	339,675	101,471	.....
Per cent in each age group	100.00	0.22	1.64	12.43	66.00	19.71	.....
FEMALE.							
Asbestos workers	129	.....	21	55	47	6	4.7
Brick, tile, and terra-cotta factories	1,581	8	135	613	711	114	7.2
Core makers	1,836	.....	90	1,016	708	22	1.2
Color mixers (not paint)	37	.....	3	23	10	1	2.7
Glass blowers	90	.....	2	39	45	4	4.4
Glass factories (excluding blowers)	3,874	33	451	1,957	1,338	95	2.5
Lacquerers, japanners, enamelers	289	1	17	140	120	11	3.8
Lime, cement, and gypsum factories	281	.....	9	87	146	39	13.9
Lithographers	477	.....	1	222	238	16	3.4
Marble and stone yards	221	1	22	85	96	20	8.9
Mica workers	164	.....	6	119	36	3	1.8
Mirror makers	33	.....	2	10	19	2	6.1
Molders	66	.....	2	20	35	9	13.6
Paint factories	213	3	21	109	70	10	4.7
Paper hangers, apprentices, and helpers	823	.....	4	18	466	335	40.7
Plasterers	8	.....	.....	.....	4	4	50.0
Potteries	5,202	16	377	2,030	2,138	341	6.6
Whitewashers	5	.....	.....	.....	2	3	60.0
Total	15,332	62	1,163	6,543	6,529	1,035	.....
Per cent in each age group	100.00	0.40	7.59	42.68	42.58	6.75	.....

GROUP 3.—MINERAL INDUSTRIES.

MALE.							
Asphalt miners and laborers	132	2	1	14	106	9	6.8
Bauxite miners and laborers	200	.....	2	36	128	34	17.0
Coal miners	591,024	1,292	11,319	73,514	402,631	102,268	17.3
Copper miners	35,117	16	86	2,632	27,034	5,349	15.2
Gold and silver miners	53,869	5	43	2,154	32,915	18,752	34.8
Graphite miners and laborers	178	1	2	19	131	22	12.4
Iron miners	45,917	152	427	5,681	34,189	5,468	11.9
Lead and zinc miners	18,526	4	100	2,093	13,363	2,966	16.0
Mica miners and laborers	277	3	8	45	169	52	18.8
Phosphate miners and laborers	4,582	80	131	665	3,201	505	11.0
Quarries	73,954	118	815	9,029	49,097	14,895	20.1
Quicksilver miners and laborers	126	.....	.....	3	88	35	27.8
Spar miners and laborers	501	10	14	68	330	79	15.8
Sulphur miners and laborers	485	1	1	78	338	67	13.8
Mines not specified	19,117	15	55	973	11,561	6,513	34.1
Other miners and laborers	892	4	16	119	549	201	22.9
Total	844,897	1,703	13,020	97,123	575,833	157,218	.....
Per cent in each age group	100.00	0.20	1.54	11.50	68.15	18.61	.....
FEMALE.							
Bauxite miners and laborers	1	.....	.....	.....	1	.....	.....
Coal miners	368	2	27	91	214	31	8.4
Copper miners	15	.....	.....	.....	12	3	20.0
Gold and silver miners	39	.....	.....	.....	19	20	51.3
Iron miners	32	.....	3	8	17	4	12.5
Lead and zinc miners	14	.....	1	5	8	.....	.....
Mica miners and laborers	29	1	3	13	10	2	6.9
Phosphate miners and laborers	11	.....	.....	1	9	1	9.1
Quarries	28	.....	.....	8	18	2	7.1
Spar miners and laborers	1	.....	.....	.....	1	.....	.....
Other miners and laborers	12	2	1	1	6	2	16.7
Total	550	5	35	130	315	65	.....
Per cent in each age group	100.00	0.91	6.36	23.64	57.27	11.82	.....

TABLE 6.—AGE DISTRIBUTION OF EMPLOYEES IN DUSTY TRADES, BY SEX AND OCCUPATION GROUPS—Continued.

GROUP 4.—VEGETABLE FIBER DUST.

Sex and occupation group.	Total employees.	Number in age group— 10 to 13.	14 to 15.	16 to 20.	21 to 44.	45 and over.	Per cent 45 years and over.
MALE.							
Broom and brush factories	10,563	39	370	1,825	6,096	2,233	21.1
Corn shellers, grain thrashers, wood sawyers etc., agriculture	3,919	.....	4	107	2,701	1,107	28.2
Cotton ginners, other miscellaneous industries	1,342	7	9	81	854	391	29.1
Cotton spinners	15,874	996	1,810	4,387	6,848	1,833	11.5
Cotton weavers	48,929	244	1,383	9,758	31,779	5,765	11.8
Other cotton-mill employees	80,778	4,295	8,985	18,379	38,077	11,042	13.7
Hay and straw balers	1,698	9	32	197	1,128	332	19.6
Hemp and jute mills	3,438	7	144	722	2,092	473	13.8
Knitting mills	27,236	622	2,421	7,816	13,510	2,867	10.5
Lace and embroidery	5,199	7	325	1,305	2,872	690	13.3
Linen mills	1,248	1	97	280	603	267	21.4
Paper and pulp mills	6,933	.....	72	1,037	4,635	1,189	17.1
Paper-box makers	5,688	22	381	1,600	3,002	683	12.0
Rag dealers	1,805	2	9	79	952	763	42.3
Rag pickers, sorters, and cleaners	1,220	5	18	135	702	360	29.5
Rope and cordage factories	6,372	22	304	1,327	3,555	1,164	18.3
Sail, awning, and tent factories	2,604	1	34	288	1,444	837	32.1
Straw factories	205	.....	9	54	115	27	13.2
Textile mills—dyeing, finishing, printing	30,382	22	692	4,459	17,949	7,260	23.9
Textile mills, (not specified)	23,800	78	1,266	4,468	12,983	5,005	21.0
Wood—cabinetmakers	7,142	.....	3	405	4,069	2,665	37.3
Wood—box makers	6,382	147	432	1,690	3,143	970	15.2
Wood carvers	12,054	1	66	1,101	7,397	3,489	28.9
Wood—furniture factories, except polishers and finishers	4,146	.....	120	756	2,381	889	21.4
Wood—piano and organ factories, except polishers and finishers	635	1	4	87	385	158	24.9
Wood polishers and finishers	20,271	3	224	2,324	13,360	4,360	21.5
Wrappers and packers	6,460	10	273	1,212	3,746	1,219	18.9
Total	336,323	6,541	19,487	65,879	186,378	58,038	.....
Per cent in each age group	100.00	1.94	5.79	19.59	55.42	17.26	.....
FEMALE.							
Broom and brush factories	2,359	4	199	1,018	1,018	120	5.1
Cotton ginners, other miscellaneous industries	39	.....	.....	1	29	9	23.1
Cotton spinners	32,151	3,520	5,906	13,564	8,706	455	1.4
Cotton weavers	43,911	330	2,047	11,867	25,379	4,288	9.8
Other cotton-mill employees	59,372	1,242	5,664	21,030	27,820	3,616	6.1
Hemp and jute mills	2,781	2	163	1,361	1,142	113	4.1
Knitting mills	69,414	918	7,237	28,682	28,962	3,615	5.2
Lace and embroidery	15,820	75	1,266	5,747	7,201	1,531	9.7
Linen mills	1,540	3	135	584	678	140	9.1
Paper and pulp mills	2,744	4	138	1,076	1,278	248	9.0
Paper-box makers	14,226	56	1,865	7,014	4,875	416	2.9
Rag dealers	170	.....	4	32	71	63	37.1
Rag pickers, sorters, and cleaners	1,806	2	56	393	971	384	21.3
Rope and cordage factories	4,162	26	410	1,991	1,542	193	4.6
Sail, awning, and tent factories	1,074	1	44	281	590	158	14.7
Straw factories	2,378	1	77	589	1,300	411	17.3
Textile mills—dyeing, finishing, printing	4,083	10	200	1,446	2,154	273	6.7
Textile mills (not specified)	28,908	253	2,572	10,455	13,297	2,331	8.1
Wood—box makers	778	16	91	369	279	23	3.0
Wood carvers	145	.....	6	45	66	28	19.3
Wood—furniture factories, except polishers and finishers	144	.....	6	66	65	7	4.9
Wood—piano and organ factories, except polishers and finishers	3	.....	.....	2	1	.....	.....
Wood polishers and finishers	346	2	22	117	167	38	11.0
Wrappers and packers	7,781	25	755	4,058	2,717	226	2.9
Total	296,135	6,490	28,863	111,788	130,308	18,686	.....
Per cent in each age group	100.00	2.19	9.75	37.75	44.00	6.31	.....

TABLE 6.—AGE DISTRIBUTION OF EMPLOYEES IN DUSTY TRADES, BY SEX AND OCCUPATION GROUPS—Continued.

GROUP 5.—ANIMAL AND MIXED FIBER DUST.

Sex and occupation group.	Total employees.	Number in age group— 10 to 13.	14 to 15.	16 to 20.	21 to 44.	45 and over.	Per cent 45 years and over.
MALE.							
Carpet mills	19,534	22	656	3,680	11,485	3,691	18.9
Furriers	8,127	3	58	1,168	5,303	1,595	19.6
Hair workers	1,636	17	61	467	829	262	16.0
Hat factories	25,500	8	458	4,162	15,575	5,297	20.8
Mattress makers	3,202	8	65	524	2,150	455	14.2
Upholsterers	18,808	4	104	1,971	11,084	5,645	30.0
Silk mills	35,165	146	2,456	7,503	19,887	5,173	14.7
Weavers (carpets, blankets, etc., not in factories)	2,151	2	11	89	608	1,441	67.0
Woolen and worsted spinners	6,997	23	447	1,671	3,887	969	13.8
Woolen and worsted weavers	17,197	10	157	2,060	11,718	3,252	18.9
Woolen and worsted mills	45,620	106	2,650	8,502	24,534	9,828	21.5
Total	183,937	349	7,123	31,797	107,060	37,608	.....
Per cent in each age group	100.00	0.19	3.87	17.29	58.20	20.45	.....
FEMALE.							
Carpet mills	14,163	8	662	5,063	7,180	1,250	8.8
Furriers	2,734	.....	64	921	1,458	291	10.6
Hair workers	1,894	5	187	773	624	305	16.1
Hat factories	10,735	17	563	3,631	5,425	1,099	10.2
Mattress makers	924	4	29	307	477	107	11.6
Upholsterers	1,291	.....	13	318	706	254	19.7
Silk mills	52,504	283	6,098	23,027	21,495	1,601	3.0
Weavers (carpets, blankets, etc., not in factories)	10,781	57	122	976	4,098	5,528	51.3
Woolen and worsted spinners	6,390	16	806	3,550	1,883	135	2.1
Woolen and worsted weavers	14,660	14	350	3,728	9,902	1,566	10.7
Woolen and worsted mills	33,186	98	3,203	12,465	15,534	1,836	5.5
Total	149,262	502	12,097	54,759	67,932	13,972	.....
Per cent in each age group	100.00	0.34	8.10	36.69	45.51	9.36	.....

GROUP 6.—ORGANIC DUST.

Sex and occupation group.	Total employees.	Number in age group— 10 to 13.	14 to 15.	16 to 20.	21 to 44.	45 and over.	Per cent 45 years and over.
MALE.							
Bakeries	95,026	155	1,702	14,079	61,425	17,665	18.6
Bone and ivory workers	520	1	15	98	291	115	22.1
Button factories	8,101	30	379	1,853	4,822	1,017	12.6
Candy factories	15,438	40	630	3,772	8,994	2,002	13.0
Celluloid workers	538	.....	13	93	329	103	19.1
Charcoal and coke works	9,928	36	103	1,036	7,016	1,737	17.5
Cigar and tobacco factories	95,060	948	2,996	14,644	54,878	21,594	22.7
Fertilizer factories, mixers	118	.....	1	12	90	15	12.7
Glove factories	5,681	5	191	1,036	3,355	1,094	19.3
Grain and flour mills	36,065	49	193	2,506	20,508	12,809	35.5
Grain elevator employees	6,484	9	35	540	4,382	1,518	23.4
Harness and saddle factories	20,271	1	103	1,736	11,027	7,404	36.5
Pocketbook and belt makers	4,842	1	119	894	3,012	816	16.9
Rubber factories	13,422	6	334	2,405	8,405	2,272	16.9
Shoe factories	104,430	97	3,051	19,141	64,097	18,044	17.3
Shoemakers (not in factories)	68,788	18	228	2,384	30,821	35,337	51.4
Tanneries	46,142	37	514	5,540	29,787	10,264	22.2
Trunk factories	1,057	5	82	255	538	177	16.7
Total	531,911	1,438	10,689	72,024	313,777	133,983	.....
Per cent in each group	100.00	0.27	2.01	13.54	58.99	25.19	.....
FEMALE.							
Bakeries	11,333	43	821	4,069	4,613	1,787	15.8
Bone and ivory workers	121	.....	14	55	41	11	9.1
Button factories	4,707	23	468	2,269	1,805	142	3.0
Candy factories	12,553	72	1,656	6,311	4,254	260	2.1
Celluloid workers	249	.....	28	124	94	3	1.2
Charcoal and coke works	12	.....	.....	4	3	5	41.7

TABLE 6.—AGE DISTRIBUTION OF EMPLOYEES IN DUSTY TRADES, BY SEX AND OCCUPATION GROUPS—Concluded.

GROUP 6.—ORGANIC DUST—Concluded.

Sex and occupation group.	Total employees.	Number in age group—					Per cent 45 years and over.
		10 to 13.	14 to 15.	16 to 20.	21 to 44.	45 and over.	
FEMALES—concluded.							
Cigar and tobacco factories	77,468	880	5,463	28,968	36,719	5,438	7.0
Glove factories	14,172	13	704	4,199	7,278	1,978	14.0
Grain and flour mills	396	3	20	130	188	55	13.9
Grain elevator employees	11	.....	.....	5	6	.....	.....
Harness and saddle factories	290	.....	6	88	147	49	16.9
Pocketbook and belt makers	1,128	4	128	545	415	36	3.2
Rubber factories	7,955	11	488	2,853	4,257	346	4.3
Shoe factories	44,485	45	2,181	14,423	24,060	3,776	8.5
Shoemakers (not in factories)	782	.....	6	148	396	232	29.7
Tanneries	1,614	4	121	749	666	74	4.6
Trunk factories	269	1	28	145	86	9	3.3
Total	177,545	1,099	12,132	65,085	85,028	14,201	.....
Per cent in each age group	100.00	0.62	6.83	36.66	47.89	8.00	.....

GROUP 7. MIXED ORGANIC AND INORGANIC (PUBLIC) DUSTS.

MALE.							
Carriage and hack drivers	57,844	166	722	6,113	36,183	14,660	25.3
Chauffeurs	44,973	5	116	8,208	34,775	1,869	4.2
Coachmen	25,171	34	159	1,534	16,379	7,065	28.1
Drivers	332,141	380	2,907	38,461	209,103	81,290	24.5
Garbagemen and scavengers	4,227	8	33	310	2,653	1,223	28.9
Street car conductors	56,932	.....	4	3,573	48,174	5,181	9.1
Street car motormen	56,218	.....	.....	1,057	46,432	8,729	15.5
Street cleaners	9,946	2	22	270	4,571	5,081	51.1
Sweepers, car (street and steam railroad)	6,833	5	27	675	4,554	1,572	23.0
Total	594,285	600	3,990	60,201	402,824	126,670	.....
Per cent in each age group	100.00	0.10	0.67	10.13	67.78	21.32	.....
FEMALE.							
Carriage and hack drivers	36	.....	.....	6	20	10	27.8
Chauffeurs	32	1	.....	3	25	3	9.4
Drivers	67	.....	.....	15	35	17	25.4
Sweepers, car (street and steam railroad)	1,264	1	12	163	827	261	20.6
Total	1,399	2	12	187	907	291	.....
Per cent in each age group	100.00	0.14	0.86	13.37	64.83	20.80	.....

CHAPTER II.—OCCUPATIONS WITH EXPOSURE TO METALLIC DUST.

THE OCCUPATIONAL MENACE OF METALLIC DUST.

The continuous and considerable exposure of workmen to the inhalation of metallic dust in its various forms is generally recognized by medical and other authorities on occupational diseases as probably the most serious health hazard with particular reference to a material increase in liability to pulmonary tuberculosis and nontuberculous respiratory diseases. The term "metallic dust" for practical reasons is for the present purpose limited to finely comminuted particles of iron, steel, brass, gold, silver, bronze, lead, arsenic, and other metallic substances. Some of these are exceedingly common in connection with industrial processes, while others are rarely met with. Occasionally the pathological aspects of the problem are complicated by chemical considerations, aside from the physical or mechanical properties of the several varieties of metallic dust referred to. In the vast majority of mechanical operations in which metallic dust is generated there is more or less intermixture with particles of mineral dust, which quantitatively may exceed in importance the ascertainable presence of metallic dust. On account of the heavier weight of metallic particles the relative degree of air pollution in factories, workshops, mines, etc., where metallic dust is generated is considerably less than the corresponding amount of air impurities resulting from atmospheric pollution by mineral dust. The injurious consequences of industrial dust exposure are, broadly speaking, proportionate to the amount of dust inhaled into the lungs, but important exceptions to this conclusion are brought out by the consideration in detail of the several kinds of metallic dust, of which, perhaps, lead and arsenic are the most harmful, on account of the additional liability to industrial poisoning. Quantitatively the most important kind of metallic dust as met with under typical industrial conditions is the dust of iron and steel, which, however, is generally more or less intermixed with dust of other metallic or mineral substances. Pure iron and steel dust is rarely met with except under laboratory and other conditions which are not within the plan and scope of the present discussion. Typical employments with metallic dust exposure are file

MORTALITY OF JEWELERS—INDUSTRIAL INSURANCE EXPERIENCE.

The mortality of jewelers in the industrial insurance experience of the Prudential Insurance Co. of America includes 812 deaths from all causes, of which 238, or 29.3 per cent, were from pulmonary tuberculosis. Of the mortality of jewelers from other respiratory diseases, 61 were from pneumonia, 5 from asthma, 10 from bronchitis, and 7 from other respiratory diseases. The deaths from pulmonary tuberculosis and nontuberculous respiratory diseases combined show that 39.5 per cent of the mortality of jewelers was from diseases of the lungs and air passages. The excess in the mortality from pulmonary tuberculosis among jewelers is very clearly brought out in Table 40, which shows the proportionate mortality from this disease by divisional periods of life.

TABLE 40.—PROPORTIONATE MORTALITY FROM PULMONARY TUBERCULOSIS AMONG JEWELERS, INDUSTRIAL EXPERIENCE OF PRUDENTIAL CO., 1897 TO 1914, COMPARED WITH THAT OF ALL MALES IN UNITED STATES REGISTRATION AREA, 1900 TO 1913, BY AGE GROUPS.

Age at death.	Deaths of jewelers, 1897 to 1914, from—		Per cent of deaths from pulmonary tuberculosis among—	
	All causes.	Pulmonary tuberculosis.	Jewelers.	Males in registration area, 1900 to 1913.
15 to 24 years	110	56	50.9	27.0
25 to 34 years	144	84	58.3	30.5
35 to 44 years	106	48	45.3	23.4
45 to 54 years	132	28	21.2	14.7
55 to 64 years	144	16	11.1	7.9
65 years and over	176	6	3.4	2.6
Total, 15 years and over	812	238	29.3	13.9

GENERAL CONCLUSIONS.

The preceding observations and statistical data confirm the conclusion that jewelers as a class are subject to a decidedly excessive mortality from pulmonary tuberculosis at ages under 45, but particularly so at ages 15 to 34, inclusive. There can be no reasonable question of doubt but that this excess is, in a large measure, the direct result of health-injurious circumstances connected with the employment.

THE PRINTING TRADES.

The printing and allied trades give employment to a large number of men and women, including a considerable proportion of young persons. The printing trades have undergone material changes in methods of composition, use of machinery, etc. To an increasing extent composition is done by machines, which are, strictly speaking, type-casting machines, operated in quite a different manner from the old-time process of setting type by hand. The best known of these typesetting machines are the Mergenthaler linotype and the Lanston monotype, both of which are extensively used throughout the country.

LINOTYPE AND MONOTYPE OPERATION.

As observed by Mr. Charles C. Dominge, insurance engineer, in an article on the "Processes and hazards of printing," including stereotyping, electrotyping, etc., in the Weekly Underwriter, August 5, 1911—

In the case of small job work, small newspapers, pamphlets, and certain books the printing is done direct from the type, which is locked tightly in metal chases and securely fastened in the proper place in the press.

Most of the modern newspaper composition, however, is done by means of linotype and monotype machines, the former of which is described by Mr. Dominge in part as follows:

These machines derive their name from the fact that they set up one continuous line of type. The machine is operated by means of a keyboard and resembles somewhat a huge typewriter. When the operator strikes a letter on the keyboard the matrices (brass slugs on which is an impression of the desired character) fall down through a channel until a line is made up. Metal followers push the line across until it is dropped in front of a pot of hot type metal, where a chamber is formed around it, of which the brass matrix or type impression makes up one side. A plunger connected with the metal pot ejects a charge of metal into the chamber under pressure, and this metal, coming into contact with matrices, causes a line to be cast. This "line of type" is then pushed off to one side, to be followed by other "lines of type," and the matrices are automatically conveyed and distributed to their respective tubes ready to be called upon again.

The same writer points out as regards the monotype machines that—

The monotype is perhaps more marvelous in its operations than the linotype. The operator takes the copy and proceeds to write it out on a machine somewhat like a typewriter, except that the result is a long strip of paper with innumerable perforations thereon. There are two perforations for each character, arranged in a series of combinations, the purpose of which will be explained later on. When the operator has written out the "story" upon the strip this paper is placed in position on the casting machine. As the strip moves automatically through the machine two perforations are always brought into position simultaneously over a pair of "lugs," which are forced through the perforations at once by means of compressed air. These lugs govern the lateral direction of a matrix containing 226 characters, which moves laterally in two directions

until stopped by the lugs. Hence the necessity for the different "combinations" in the perforations mentioned above. Molten type metal is then forced against the matrix and a type is cast—not a line, as is the case with the linotype, but a single type. This whole process of casting takes about as long as it takes the average typewriter to strike the keys of her instrument, so rapid is the action of the monotype.

OCCUPATIONAL HAZARDS OF THE PRINTING TRADE.

The occupational hazards of printing are chiefly in connection with the inhalation of a more or less badly contaminated atmosphere. The dust factor, while frequently serious, is, as a rule, of secondary importance to other unhygienic circumstances of the trade. As regards the operation of the linotype and monotype machines it is stated by Dominge that—

> The only hazard in connection with these machines is the lead pot, holding about 1 quart of molten lead, which is usually heated by gas. If the gas connection is made of rigid iron pipe instead of rubber tube, as formerly, the hazard is only moderate. In large shops these lead pots are now heated by electricity, and if approved by the underwriters this is the best arrangement.

There is no reference here to the dust factor which, of course, as a fire hazard is of distinctly secondary, if any, importance.

SANITARY AND MEDICAL CONSIDERATIONS.

The employment of printers differs in many essentials from most of the other occupations considered in this discussion, since it is homogeneous and well defined and common throughout the country. While in many of the modern printing establishments the conditions favoring health and life, with special reference to ventilation and light, are probably satisfactory, in the smaller workshops the sanitary conditions, as a rule, are decidedly to the contrary, and predispose to tuberculosis. Thackrah in 1832 called attention to the diseases of printers, and in his opinion "few appear to enjoy full health." Pulmonary tuberculosis, according to this writer, was frequent, but was apparently caused rather by the confinement or indoor employment than by direct injury to the respiratory organs. The trade is one which has received a considerable amount of attention because of its recognized unhygienic features, and, in addition to the general data upon this subject, the mortality experience of various typographic associations has been carefully investigated. It is suggested by Oliver that "Printing houses should be so constructed that free currents of air can get to them, and not, as is so frequently the case, shut in by other buildings."

But such construction is even to-day the exception rather than the rule. Considering that, as a class, printers probably rank above the average mechanics in intelligence and earnings, it is difficult to understand why they should so persistently in the past have neglected the important problem of workshop hygiene. The successful effort to secure to the members of the craft in illness or old age a home in the mountain region of the West emphasizes what could be done by concentrated effort in other and even more important directions. In the historical sketch of the Union Printers' Home, at Colorado Springs, it is, in fact, pointed out that the place was selected for the location of the home primarily because of the special liability of printers to all forms of lung and throat diseases, and in explanation of the subsequent necessity for a hospital annex the statement is repeated that "consumption is one of the diseases to which the printer is especially liable."

ENGLISH AND AMERICAN MORTALITY STATISTICS.

Tatham, in commenting upon the excessive mortality of printers, as disclosed by an analysis of the English mortality data, remarks that "like bookbinders, printers die very rapidly from phthisis, and probably for a similar reason, namely, because of the excessively unhealthful conditions under which their work is carried on."[1] Tatham calls attention, however, to the decline in the mortality of printers, due among other causes to the decrease in the deaths from lead poisoning, which had fallen to one-half of the earlier figure. The frequency of phthisis among English printers had decreased during the decade by one-sixth of the former rate.

In the occupation mortality statistics of the Twelfth Census, printers are grouped with compositors and pressmen, which is to be regretted since there are certain important differences in the disease liability of these allied employments which are sufficiently distinct to warrant separate consideration, at least in the case of pressmen, although the number of the latter is comparatively small. The total number of persons included in this group in the registration States, aged 15 or over, according to the census, was 54,374, but of this number only 818, or 1.5 per cent, had attained to the age of 65 or over.[2] This rather surprising result is confirmed by the statistics of the New Jersey Bureau of Labor for 1891, according to which out of 462 printers only 2 had attained to the age of 60 or over. The census mortality statistics of this group of printers, or as stated, compositors, printers, and pressmen, are of some value though not entirely conclusive on account of probable defects in the census enumeration.

[1] Dangerous Trades, by Thomas Oliver, London, 1902, p. 151.

[2] Report of the Bureau of the Census on Vital Statistics, 1900, p. cclxxxii. There has been no subsequent census report giving comparable data.

TABLE 41.—MORTALITY FROM ALL CAUSES AMONG COMPOSITORS, PRINTERS, AND PRESSMEN, COMPARED WITH THAT OF THE MANUFACTURING AND MECHANICAL CLASS AND THE MERCANTILE AND TRADING CLASS, IN THE REGISTRATION STATES, 1900, BY AGE GROUPS.

[Source: Report of the Bureau of the Census on Vital Statistics, 1900.]

Age at death.	Death rate per 1,000 among—		
	Compositors, printers, and pressmen.	The manufacturing and mechanical class.	The mercantile and trading class.
15 to 24 years	5.05	4.43	2.60
25 to 44 years	12.29	8.35	6.72
45 to 64 years	20.01	20.16	19.91
65 years and over	108.80	105.43	93.79

According to Table 41 the death rate of printers at ages 15 to 24 is 5.05 per 1,000, compared with 4.43 for men in the mechanical and manufacturing class, and only 2.60 for the mercantile and trading class. At ages 25 to 44 the rate is 12.29 for printers, but only 8.35 and 6.72, respectively, for the other two selected groups of occupations. At ages 45 and over the differences in the mortality of printers compared with that in other occupations are very slight, due in all probability to the fact that on the one hand most of those at all liable to tuberculosis had died and that on the other many of the impaired in health had left the trade. In addition there is also the factor of a possible defect in the census enumeration.

EXPERIENCE OF THE INTERNATIONAL TYPOGRAPHICAL UNION.

At the forty-sixth session of the International Typographical Union, held at Milwaukee, Wis., in 1900, a statistical summary was submitted showing that out of 419 deaths of printers during the preceding year, 192, or 45.8 per cent, had been deaths from diseases of the lungs or air passages, including under this term bronchitis, asthma, pulmonary tuberculosis, pneumonia, and all other respiratory diseases. Of the 411 printers whose ages at death were known, 44, or 10.7 per cent, died at the age of 65 or over, while the average age at death was only 41.25 years, compared with 52.2 years for all males aged 15 or over in the registration area of the United States in 1900.

Kober, in his article on "Industrial hygiene," in Bulletin No. 75 of the Bureau of Labor Statistics, refers briefly to printers, type founders, and typesetters, quoting Sommerfeld to the effect "that among 38 occupations tabulated by him printers occupied the fifth rank in the number of deaths from tuberculosis." It is to be assumed, of course, that this has reference to the death rate and not merely to the number of deaths without reference to the exposed risk. Kober also quotes Albrecht in the statement that "the statistics of the Berlin Sick

Benefit Insurance Fund, covering a period of 33 years, show that 48.13 per cent of the deaths among printers are caused by consumption." He observes in this connection that—

This may be due in part to the fact that many weaklings engage in this occupation, but the work itself is often performed in most unfavorable environments and in an impure and dusty atmosphere, which has been found to contain traces of lead, arsenic, and antimony. Special attention should be paid to proper ventilation, and particularly to the collection and removal of dust from the type cases. One gram of this dust has been found to contain 57.7 mg. of lead, 186.8 mg. of antimony, and traces of arsenic.[1] Strasser has suggested a type case with perforated tin bottom, which is placed within another case, so as to facilitate the collection and proper disposition of this injurious form of dust.

The results of an extended investigation into the sanitary conditions of the printing trade, as prepared by Mr. George A. Stevens, were published in the report of the New York State Bureau of Labor Statistics for 1906. This investigation included the entire mortality of the International Typographical Union for the five years ending with 1905, or 2,498 deaths, representing a mean death rate of 12.63 per 1,000. The rate was highest among the printers of New York City, or 16.32 per 1,000, and lowest in Chicago, or 10.12 per 1,000. The average age at death for all printers was not quite 45 years. The disease most frequent and severe among compositors was found to be tuberculosis of the lungs. The average age at death of compositors dying from tuberculosis was only 36.33 years. Out of 2,498 deaths from all causes, 660, or 26.4 per cent, were from tuberculosis, equivalent to an annual mean death rate of 3.34 per 1,000. Pneumonia caused 258 deaths, or 10.3 per cent of the deaths from all causes, equivalent to an annual mean death rate of 1.3 per 1,000. In commenting upon the high degree of frequency of pulmonary tuberculosis the report points out that "scarcely any other occupation furnishes so large a quota of victims from consumption. The domestic life of printers is parallel to that of other artisans in equal financial circumstances. They are fairly compensated for their labor, thus enabling them to have homes as healthful as those procured by the best-paid workmen in any community. Neither can it be said that compositors are ill-nourished and, therefore, rendered more susceptible to the tubercle bacilli. The determining cause of their susceptibility to the harmful process of the great white plague lies in a different direction—neglect of sanitary precautions in composing rooms."[2]

Of the mortality at known ages, from all causes, 18.9 per cent were deaths at 60 years of age and over. Of the 464 deaths in this group,

[1] Rozsahegyi, Archiv. für Hygiene, Munich and Leipzig, vol. 3, p. 522.
[2] Report of the New York State Bureau of Labor Statistics, 1906, pp. cxxi and cxxii.

321 occurred between the ages of 60 and 69, 122 between 70 and 79, 19 between 80 and 89, 1 at age 90, and 1 at age 96.[1]

COMPARATIVE VITAL STATISTICS OF COMPOSITORS IN THE STATE OF NEW YORK.

The statistics by Stevens indicate a rather wide variation in the incidence of pulmonary and respiratory diseases among printers according to localities, as shown by Table 42.

TABLE 42.—ANNUAL DEATH RATE PER 1,000 FROM PRINCIPAL CAUSES AND ALL CAUSES, AMONG COMPOSITORS IN CERTAIN LOCALITIES, FOR THE FIVE YEARS, 1901 TO 1905.

[Source: Twenty-fourth Annual Report of the New York State Bureau of Labor Statistics, 1906.]

Locality.	Death rate per 1,000.							
	Tuberculosis of lungs and other respiratory organs.	Pneumonia.	Diseases of nervous system.	Diseases of genito-urinary system.	Diseases of the heart.	Diseases of digestive system.	Accidents and injuries.	All causes.
New York City	3.82	2.42	1.91	1.63	1.37	0.99	0.89	16.32
Other New York State	2.54	.97	1.49	.70	1.67	.97	.61	11.14
Total New York State	3.48	2.03	1.80	1.38	1.45	.98	.82	14.94
Chicago, Ill	2.42	1.57	1.04	.98	1.44	.45	.72	10.12
Philadelphia, Pa	3.65	.70	2.26	.70	1.39	.52	.....	12.35
All other United States	3.38	1.07	1.33	1.02	1.37	.74	.60	12.20
Total United States	3.34	1.30	1.44	1.08	1.39	.76	.64	12.63
London, England	3.69	.67	1.16	.51	1.97	.51	.19	12.19

EXCESSIVE FREQUENCY OF PULMONARY TUBERCULOSIS.

The corresponding proportionate mortality from pulmonary tuberculosis and other respiratory diseases among compositors varied from 30.2 per cent for London, England, to 26.4 per cent for printers in large cities of the United States, in contrast to a normal average of approximately 15 per cent for adult men and women in the territory under consideration.

As subsequently to be shown, there are reasons for believing that printers are physically below the average of men employed in other gainful occupations and that occupational selection has some bearing

[1] A most important investigation of the health of printers is a recent bulletin (No. 209) of the U. S. Bureau of Labor Statistics (1917), by Dr. Alice Hamilton and Mr. Charles H. Verrill. This investigation includes a concise description of printing plants, observations on the effects of lead fumes and other poisons, descriptive accounts of modern methods of printing by means of linotype and monotype machines, extended observations on the health of printers in the United States and foreign countries, observations on the health conditions of men entering the industry and the health campaign of the International Typographical Union. Appendixes describe a proposed scheme for the inspection of composing rooms in the District of Columbia, precautions for printers published by the Massachusetts General Hospital, and hygienic regulations for printing and typecasting establishments published by the Department of Labor of the State of New York. The report is a model of impartiality and scientific conclusiveness, subject, of course, to the limitations of scientific research inherent in all investigations of this kind.

upon the excessive mortality from tuberculosis in the printing and allied trades, aside from the special hazard of dust and fume exposure.

The statistical data of the mortality rate among printers for the United States are fully confirmed by the corresponding statistics for German printers which were published in a small treatise on the hygiene of the printing trade by Dr. Lewitt, of Berlin, in 1899. According to this authority, out of 1,390 recorded deaths of printers, 798, or nearly 61 per cent, were from diseases of the lungs and air passages, including 630 deaths from pulmonary tuberculosis. Of the total number, 243, or 17.5 per cent of the mortality at known ages, had attained to the age of 60 or over. The suggestions made by this writer regarding the prevention of tuberculosis and other diseases in the printing trade are eminently practical and feasible in most of the workshops in which printers are employed.

SANITARY CONTROL OF THE PRINTING INDUSTRY IN GERMANY.

The regulations of the Federal Council of the German Empire with reference to the control of sanitary conditions in the printing industry, put into effect July 31, 1897, are reprinted in Bulletin No. 75 of the United States Bureau of Labor Statistics, and these regulations as amended in 1907 and in 1908 are reprinted in Bulletin No. 209. The corresponding regulations issued by the Austrian Department of Commerce have been reprinted in a special bulletin (No. 76) on European Regulations for Prevention of Occupational Diseases, published by the New York State Department of Labor, Albany, March, 1916.

DUST HAZARDS IN THE PRINTING INDUSTRY IN OHIO.

The investigations by Hayhurst with special reference to the State of Ohio for the year 1915 include 26 establishments, in 12 of which, however, printing was a more or less auxiliary feature. One of the practical difficulties of separating specific processes in the printing trade is that they are usually all carried on more or less in common. According to Hayhurst—

Dust was a fair hazard in 10 places, bad in 1, and negligible in the remaining. Quarters were kept clean in 14, fairly so in 9, and not so in 3. Dry sweeping and dusting of fonts with an air blast are pernicious. Cold and dampness, due to inefficient heating, were found to exist in 4 places. Light was good in 17 places, fair in 4, and poor in the remaining 5. General room ventilation was only fair in 10 places and bad in 7 more. Fatigue seemed a negligible factor in 8 places, fair in 10, and bad in the remaining 8, due, principally, to hurrying piecework, monotony, constant standing, strain, chairs and stools without backs, faulty postures, and in some cases jarring

processes and loud noises. Eyestrain and myopia are special hazards of the printers, and every such worker should be assured of the condition of his eyes for such work.

The chief complaints of the employees were with reference to poor ventilation, fumes, typesetting dust, risk of lead poisoning, and working with fellow workers infected with tuberculosis.

Regarding typesetting machines and the special hazard in connection with linotyping, monotyping, stereotyping, etc., Hayhurst, on the basis of personal investigation, writes as follows:

This class of procedure includes all processes in which type metal is melted and used, such as linotyping, monotyping, and stereotyping. (Electrotyping is practically identical with electroplating.) These are here reported upon as the result of our investigation in 15 plants. The total wage earners so employed was 361, of whom 348 were males and 13 were females. Seven of the places were union shops. The general attitude toward employees was good in 12 places, and at least fair in the remaining. The workers were of intelligent type in all places, except here and there a few non-English speaking laborers. Retention of workers was good in 12 places, fair in 1, and not so in 2. Health appliances, such as hoods and stacks over metal pots, furnaces, and burners, were good in 5 places, fair in 2, and absent in the balance.

The dust factor in connection with these occupations was considered of relatively small importance; the chief conditions detrimental to health were the escape of gases and fumes from the hot processes, and the absence of air agitators and means of effective ventilation. Fatigue was not found to be a particular hazard in any one of the working places examined. Industrial poisoning was found to be a considerable hazard in 7 of the work places examined and a fair hazard in 4 others, due chiefly to the absence of hoods and vent pipes over metal pots, especially over gas burners and furnaces.[1]

The actual printing process or pressroom work was investigated by Hayhurst in 13 plants employing 392 wage earners, including 32 females. Health appliances, consisting of hoods and flues for drawing off escaping gas fumes in drying freshly printed work, were present in only 2 places. A slight amount of dust was observed in the air in the majority of places, but no strictly scientific investigations were made with reference to the exact degree of atmospheric pollution.

OCCUPATIONAL DISEASES OF PRINTERS.

Occupational diseases among employees of printing plants have not been made the subject of a thoroughly qualified and strictly scientific investigation.[1] Exact information, however, is gradually increasing, and among other recent investigations is one by Strumpf and Zabel, with reference to the physical condition of a large number of typesetters employed in Strassburg, Germany. According to the Journal of the American Medical Association of December 3, 1910—

One thing which impressed them was the rarity of typical cases of lead poisoning. They observed, however, with great frequency, a clinical syndrome characterized by a fatigued expression, nervousness, irritability, insomnia, exhaustion especially in the morning hours, vertigo, headache, particularly in the frontal and occipital regions, general or local muscular pains, neuralgic pains in the extremities, nausea and vomiting, and constipation. Mild, moderately severe, and severe cases were encountered. The authors find evidence in the literature that this symptom-complex has been looked on as a manifestation of chronic lead poisoning. The patients showed no elevation of blood pressure, which, as Krehl has shown, is so common in plumbism from spasm of the arterial walls; the erythrocytes had no basophilic granules; and leucocytosis was lacking. Nor did the urine show traces of albumin or bile. On the contrary, the red count was almost or quite normal even in the severe cases with an absence of basophilic granules and there was leucopenia with eosinophilia between 10 and 25 per cent. (Typesetters without symptoms possessed as high as 9 per cent eosinophiles.[2]) The urine was normal and likewise the blood pressure.

Since the facts observed suggested no connection with lead poisoning, further research led to the conclusion that the employees affected had been suffering from chronic antimony poisoning, subsequently confirmed by further investigations. As pointed out in the editorial of the Journal of the American Medical Association—

Thus a new danger to typesetters working with antimonial compounds is brought to light and a distinct contribution added to the growing subject of occupational diseases.

CAUSES OF EXCESSIVE FREQUENCY OF PULMONARY TUBERCULOSIS.

Among American printers, using the term in a broad and comprehensive sense, the health conditions have been reported upon by Dr. James Alexander Miller, of New York, in a paper read before

[1] See in this connection Special Bulletin No. 82 of the New York State Department of Labor on "Hoods for Removing Dust, Fumes, and Gases," prepared by the division of industrial hygiene, Albany, May, 1917. See also Public Health Bulletin No. 81, Washington, 1917, on "The Effect of Gas-heated Appliances Upon the Air of Work Shops," by Charles Weissman.

[1] A fairly extensive analysis of the available mortality data of printers is included in the bulletin (No. 209) of the U. S. Bureau of Labor Statistics (1917) on the Hygiene of the Printing Trades, by Hamilton and Verrill. To be entirely conclusive, however, a much more specialized technical analysis of the statistical material is required, with a due regard to the strictly medical aspects of a problem of exceptional technical complexity. A really conclusive investigation should include a sufficient number of physical examinations of printers with a due regard to the length of trade life and the various special occupations followed in the printing trade from the beginning of the apprenticeship to the attainment of permanency in the branch of the industry selected as a permanent means of gaining a livelihood.

[2] Eosinophile: In bacteriology and histology, applied to microbes or histologic elements showing a peculiar affinity for eosin stain.

the Sixth International Congress on Tuberculosis in 1908. A summary of his more important findings follows:[1]

The main point in the investigation was not only to determine the extent of pulmonary tuberculosis but all other diseases were considered both in the history and the physical examination. It was found that almost all the men were young, native-born Americans, earning good wages, and living under good conditions; the majority of them used alcohol and tobacco; 20 per cent of all used them in excess, and about 20 per cent were total abstainers. One hundred and twenty-four complained of unfavorable conditions in the shop designated as follows: Poor ventilation, 49; metal fumes from unpiped machines, 27; insanitary water-closets, 19; insufficient number or absence of cuspidors, 14; dirty walls and ceilings, 8; metal dust, 5; overcrowded rooms, 7; poor light, 5. The medical history and examination showed that catarrh of the upper air passages was frequent, also dry pleurisy, bronchitis, and pulmonary tuberculosis. Pulmonary tuberculosis was present in 34 cases or 17 per cent of the whole number. Dr. Miller concluded that pulmonary tuberculosis is prevalent among printers and is largely due (1) to unfavorable shop conditions, especially poor ventilation, overcrowding, dust and dirt, promiscuous spitting, and poor lighting; (2) to the irregular habits of the printers, especially alcoholism, careless habits of eating, needless exposure to drafts, and insufficient outdoor exercise.[1]

SANITARY CONDITIONS IN GOVERNMENT PRINTING AND ENGRAVING.

A somewhat similar investigation concerning 4,000 persons employed in connection with Government printing and engraving was reported upon by Dr. B. S. Warren, of the United States Public Health Service, at the ninth annual meeting of the National Association for the Study and Prevention of Tuberculosis, Washington, 1913. In part, Dr. Warren states that—

My purpose in writing of this unusual condition is to submit the facts that here are 4,000 employees, working under very bad sanitary conditions, and the death rate is surprisingly low. The force consists of engravers, printers, printers' assistants, examiners, counters, mechanics, and all the help required in such an establishment. All the buildings of this establishment are very badly overcrowded. There are 1,731 employees working with less than 500 cubic feet of air space and 30 square feet of floor space per person. Ventilation is very poor, especially in the pressrooms, where from 150 to 300 printers and printers' assistants are at work. The poor ventilation is made still worse by the small gas stoves required by each printer to heat his plates. Ink fumes and often carbon monoxide rise from these stoves.

The printing is done on piecework basis, and all are working at top speed continuously. In the ink-making rooms the employees are exposed to the dust rising from the dry, powdered colors. In the steel-plate hardening room, cyanide of potash fumes were in the air

[1] For paper in full, see Transactions of the International Congress on Tuberculosis, Washington, 1908, Vol. III, pp. 209–217.

all the time; in fact, every insanitary condition that surrounds any printing shop was noted.

AVERAGE WEIGHT AND HEIGHT OF PRINTERS.

Further and more strictly scientific investigations would be necessary to produce the required evidence regarding the precise effect on health (if at all ascertainable) of the obviously numerous factors and conditions inimical to health in the printing and allied industries. Since the problem is quite complicated, particularly in view of the probably inferior physique of printing employees at entrance to the trade, Table 43, derived from the ordinary mortality experience (males only) of the Prudential Insurance Co. of America, 1886 to 1914, will prove of interest and value.

TABLE 43.—AVERAGE WEIGHT AND HEIGHT OF PRINTING EMPLOYEES COMPARED WITH THOSE OF ALL OCCUPIED MALES, ACCORDING TO MALE ORDINARY MORTALITY EXPERIENCE OF THE PRUDENTIAL INSURANCE CO. OF AMERICA, 1886 TO 1914, BY AGE GROUPS.

Age at entry.	Male printers.			All occupied males.		Average height (inches).	
	Number.	Average weight (pounds).	Relative weight (pounds per inch).	Average weight (pounds).	Relative weight (pounds per inch).	Male printers.	All occupied males.
15 to 24 years	126	140	2.05	145	2.12	68.2	68.1
25 to 34 years	230	149	2.20	155	2.26	67.6	68.3
35 to 44 years	150	154	2.28	160	2.35	67.7	68.1
45 to 54 years	51	159	2.37	163	2.40	67.0	67.9
55 to 64 years	31	154	2.29	163	2.40	67.4	67.8
65 years and over	1	195	2.91	162	2.38	67.0	67.9
Total, 15 years and over	589	149	2.21	157	2.30	67.7	68.1

According to this table, at every period of life the average weight of persons employed in the printing trade, with one exception, is below the average for all occupied males, to the extent of 8 pounds for all ages combined. The one exception at ages 65 and over is, of course, due to the fact that only a single case was under observation. Since there is invariably an important correlation between height and weight, the last two columns of the table are included for the purpose of emphasizing the fact that printers, on examination, were not only below the average in weight, but also in stature. The differences here are not quite so marked as shown by the weight, but they are, nevertheless, of importance.

Correlating the height and weight, the table shows the relative weight at entry in pounds of weight to each inch of stature, proving conclusively a sufficient difference in the physique of printers to require consideration in the correct interpretation of the subsequent mortality tables. The average relative weight of printers, according to this table, was 2.21 pounds per inch of stature

occupied males. It may be said in this connection that the proportion of deaths from pulmonary tuberculosis among the 589 printers under observation was 29.2 per cent for all ages, against 18.6 per cent for all occupied males in the company's ordinary experience.

ENGLISH MORTALITY STATISTICS OF PRINTERS.

The most recent English mortality statistics of printers are for the three years ending with 1902, referred to in the Supplement to the Sixty-fifth Annual Report of the Registrar-General of Births, Deaths, and Marriages in England and Wales, in part as follows:

The death rates of printers were above the standard for occupied and retired males at all ages up to 35 years, but above that age they were below the standard. Within the main working period of life the comparative mortality figure of printers is 994, which practically corresponds to the standard; they show a slightly excessive mortality from influenza, nervous diseases, and Bright's disease; and their mortality from phthisis exceeds the standard by 60 per cent. On the other hand, their mortality from circulatory and respiratory diseases is considerably below the average, and they appear to be subject to small risk from fatal accident, and to be but little addicted to alcoholism and suicide.

Since 1880–1882 there has been a continuous decline in mortality from phthisis, liver disease, and accident. It is also worthy of notice that the mortality from lead poisoning is now only one-fifth part as high as it was 20 years ago. From the other causes shown in the table the mortality in this occupation has fluctuated considerably.

The English occupation mortality statistics for printers are quite conclusive of the unfavorable effects of this occupation on health. In Table 44, which follows, the mortality from all causes among men in this employment is compared with that of occupied males generally, and the result is decidedly suggestive of conditions in this trade more or less unfavorable to life and health, but in particular at the early ages, or 15 to 34, when the excess in mortality is from 0.45 to 1.62 per 1,000. This table is deserving of particular consideration in that it emphasizes the health-destructive circumstances of this employment at a very early period of life. Among those who survive to age 35 or over there is not apparently a decidedly unfavorable mortality in comparison with other occupations, and in this respect the English statistics are confirmed by the United States census statistics previously quoted. While the actual excess in the mortality of printers at ages 20 to 24 is only 1.62 per 1,000, this excess is equivalent to nearly 40 per cent of the normal mortality at this period of life.

TABLE 44.—MORTALITY FROM ALL CAUSES AMONG PRINTERS, COMPARED WITH THAT OF ALL OCCUPIED MALES, IN ENGLAND AND WALES, 1900 TO 1902, BY AGE GROUPS.

[Source: Part II, Supplement to the Sixty-fifth Annual Report of the Registrar-General of Births, Deaths, and Marriages in England and Wales.]

Age at death.	Death rate per 1,000 for all occupied males.	Death rate for printers.		
		Rate per 1,000.	Greater (+) or less (−) than rate for all occupied males.	Per cent of rate for all occupied males.
15 to 19 years	2.44	3.19	+0.75	131
20 to 24 years	4.41	6.03	+1.62	137
25 to 34 years	6.01	6.46	+ .45	107
35 to 44 years	10.22	10.19	− .03	100
45 to 54 years	17.73	17.76	+ .03	100
55 to 64 years	31.01	30.76	− .25	99
65 years and over	88.39	87.61	− .78	99

The preceding table requires no further comment. A more extended comparison, however, is made in Table 45, in which the mortality of printers from pulmonary tuberculosis and other diseases of the respiratory system is compared with the normal mortality of occupied males from these diseases, by divisional periods of life.[1] The comparison shows that at all ages the mortality of printers from pulmonary tuberculosis is excessive by from 0.49 to 2.11 per 1,000. The excess is most marked at ages 35 to 44, but the difference is a material one at all ages, 20 to 64, inclusive. The corresponding mortality from other respiratory diseases among printers was slightly excessive at ages under 20 and comparatively high at ages 65 or over, but below the average at ages 20 to 64, inclusive. Apparently the employment does not predispose seriously to respiratory diseases except such as assume the pulmonary form of true tuberculosis of a rapidly developing type most destructive to young printers at ages under 45. The table which follows is self-explanatory.

[1] For additional data on the health of printers see table included in the footnote on page 55 for the year 1914 for the city of New York. According to this table, at ages 25 to 34 the proportionate mortality from pulmonary tuberculosis was 66.6 per cent for compositors and printers against 33.5 per cent for all occupations. Every statistical investigation of this kind confirms previous conclusions that the health of printers is unquestionably seriously impaired in consequence of occupational hazards at the present time more or less ill defined and largely a matter of conjecture.

TABLE 45.—MORTALITY FROM PULMONARY TUBERCULOSIS AND FROM OTHER DISEASES OF THE RESPIRATORY SYSTEM AMONG PRINTERS, COMPARED WITH THAT OF ALL OCCUPIED MALES, IN ENGLAND AND WALES, 1900 TO 1902, BY AGE GROUPS.

[Source: Part II, Supplement to the Sixty-fifth Annual Report of the Registrar-General of Births, Deaths, and Marriages in England and Wales.]

Age at death.	Mortality from pulmonary tuberculosis.				Mortality from other diseases of the respiratory system.			
	Death rate per 1,000 for all occupied males.	Death rate for printers.			Death rate per 1,000 for all occupied males.	Death rate for printers.		
		Rate per 1,000.	Greater (+) or less (−) than rate for all occupied males.	Per cent of rate for all occupied males.		Rate per 1,000.	Greater (+) or less (−) than rate for all occupied males.	Per cent of rate for all occupied males.
15 to 19 years.....	0.54	1.03	+0.49	191	0.24	0.36	+0.12	150
20 to 24 years.....	1.55	3.41	+1.86	220	.48	.37	− .11	77
25 to 34 years.....	2.03	3.65	+1.62	180	.77	.55	− .22	71
35 to 44 years.....	2.74	4.85	+2.11	177	1.66	1.24	− .42	75
45 to 54 years.....	3.04	4.27	+1.23	140	3.32	2.17	−1.15	65
55 to 64 years.....	2.16	3.42	+1.26	158	6.54	5.16	−1.38	79
65 years and over.	1.11	1.60	+ .49	144	17.77	20.76	+2.99	117

FACTS DISCLOSED BY THE NEW YORK STATE FACTORY INVESTIGATING COMMISSION.

There are no other recent mortality statistics for American printers obtainable through census investigations or the annual reports of State and local boards of health than those subsequently to be referred to. The most recent investigation of the existing labor conditions in the printing trade was made in connection with the work of the New York State Factory Investigating Commission. According to this investigation 2,245 workers were employed in 25 establishments, including 60 per cent male employees, 39 per cent females, and 1 per cent children under 16; 14 per cent of the employees were found to be working in dirty shops, and 86 per cent were at work in fairly clean or clean quarters. The statement is made that "Printers have improved in health and have suffered less from lead poisoning since the handling of type and inhaling of dust from the cases have been so largely superseded by the newer processes." But it is added that there are still evils to be remedied, and special reference is made to air contaminated by fumes from linotype machines not provided with adequate ventilating devices. Some of the shops investigated were found to require better ventilation with special reference to gas or lead fumes. A large number of pressmen and paper handlers were found to be subject to a high degree of heat and humidity, owing to the need for quick drying and smooth flow of the ink. The dust factor is obviously less important than gas and fumes and unsuitable atmospheric conditions, but, as said in the report of the same commission for the year 1913, "There is a total lack of adequate provision for ventilating printing establishments. The abundant dust from the type, the fumes from the molten lead, the particles of graphite from the stereotyping processes, the heat from the artificial illumination and from the gas-heated lead pots in the linotype, all these cause extreme vitiation of the air in such establishments." The investigations of the commission ascertained that mechanical ventilation was made use of in only 6 per cent of the shops. The statistical data of the commission are amplified by an extended review of the health of the workers, including many interesting and useful observations derived from foreign sources.

SPECIAL OCCUPATIONAL HAZARDS IN THE PRINTING TRADES.

In reply to the question, "What are the dangers in the trade or conditions injurious to the workers?" it is said that—

As has been stated, the chief dangers are lead poisoning and tuberculosis. Lead poisoning is caused by the lead dust which is so common in printing shops, and also by the fumes arising from the lead in the various processes of machine composition. The dust in the shops, especially that in the type boxes, contains a large amount of lead and some antimony. Prof. Steingraber analyzed the dust from a type box in Cracow and found it contained 16.43 per cent of lead. Dust from the top of stove in a composing room contained 0.24 per cent of lead, while that from the floor of a gallery 16.4 feet high in the composing room contained 0.37 per cent of lead. Much of the lead dust is undoubtedly inhaled by the workers. A great deal of dust is raised by the foolish and highly insanitary method so prevalent in old printeries of cleaning the dust out of the type boxes with bellows. Much lead dust is also deposited on the fingers and hands of the workers as well as upon their clothes, and remains there from lack of proper washing facilities. The dust is very often ingested with their food, which is commonly eaten at the workstand in the printing shop.[1]

These observations are in strict conformity to the facts and are suggestive of health-injurious conditions which have not heretofore received the required consideration. As observed by the New York State Factory Investigating Commission in their second report—

Grave as are the dangers to the life and health of male workers in the printing industry, these are still greater in the case of women. It is well known that women are more subject to lead poisoning than men, and their general constitution is apt to fall a prey to the dangers of the trade sooner than that of the more robust male workers.

Attention is also directed to the prevalence of tuberculosis among young persons employed in printing trades, and it is pointed out that—

[1] New York State Factory Investigating Commission, Second Report, 1915, Vol. II, p. 525.

Not only has legislation been introduced to limit the work of minors in this trade, but in England as well as Germany stringent medical examination is made of all minors entering this industry, and a large number of applicants rejected. The opinion is prevalent that no minors under 18 should be allowed to work in printing establishments, and then only after a thorough physical examination. Hahn as well as Teleky advocate a thorough medical examination of all workers in lead every three months, especially minors.

MORTALITY OF PRINTERS—UNITED STATES REGISTRATION AREA.

Printers, lithographers, and pressmen, considered as a group, have been reported upon for the years 1908 and 1909 by the Division of Vital Statistics of the United States Census Bureau, but no subsequent information has been made public, and the data are therefore restricted to the two years referred to; in fact, the mortality of lithographers included in the group is for 1909 only. The data are of rather limited value, but on account of the large number of deaths included the conclusions may be accepted as representative for the printing trade. According to the census report, out of 2,847 deaths of printers, lithographers, and pressmen from all causes, 840 or 29.5 per cent were from pulmonary tuberculosis. The details of the mortality by divisional periods of life are shown in Table 46.

TABLE 46.—PROPORTIONATE MORTALITY OF PRINTERS, LITHOGRAPHERS, AND PRESSMEN FROM PULMONARY TUBERCULOSIS, UNITED STATES REGISTRATION AREA, 1908 AND 1909, BY AGE GROUPS.

Age at death.	Deaths from all causes.	Deaths from pulmonary tuberculosis.	
		Number.	Per cent of total deaths.
15 to 24 years	427	186	43.6
25 to 34 years	551	278	50.5
35 to 44 years	614	223	36.3
45 to 54 years	522	112	21.5
55 to 64 years	350	27	7.7
65 years and over	381	14	3.7
Unknown	2	.....	.....
Total, 15 years and over	2,847	840	29.5

TABLE 47.—PROPORTIONATE MORTALITY OF PRINTERS, LITHOGRAPHERS, AND PRESSMEN FROM NONTUBERCULOUS RESPIRATORY DISEASES, UNITED STATES REGISTRATION AREA, 1908 AND 1909.

Cause of death.	Nontuberculous respiratory diseases.	
	Number.	Per cent of total deaths.
Asthma	2	0.1
Bronchitis	14	.5
Pneumonia	193	6.8
Other nontuberculous respiratory diseases	41	1.4
Total	250	8.8

Table 46 indicates conclusively an exceptionally high degree of frequency of pulmonary tuberculosis among men employed in the printing trade, and particularly so during the early years of life. At ages 25 to 34, for illustration, the proportionate mortality from pulmonary tuberculosis was 50.5 per cent, which is exceeded by the corresponding figure for few other trades or occupations with continuous and considerable exposure to inorganic dust. The table in a general way confirms the data derived from other sources and quite clearly suggests the relative unhealthfulness of employment in the printing trade, subject, of course, to the qualification that adverse physical occupational selection, as elsewhere pointed out, may materially affect the mortality returns. It may be said in this connection, however, that the mortality from nontuberculous respiratory diseases, as shown in Table 47, was 8.8 per cent of the mortality from all causes, which compares, for illustration, with 12.2 per cent for marble and stone cutters and 12.5 per cent for potters, according to mortality returns derived from the same official American sources.

MORTALITY OF PRINTERS—INDUSTRIAL INSURANCE EXPERIENCE.

The observations and conclusions of the New York State Factory Investigating Commission are in conformity with the results of other investigations, and are sustained by the insurance mortality statistics. Table 48 shows the results of the mortality experience of the industrial department of the Metropolitan Life Insurance Co. for the three years 1911 to 1913. The experience is limited to white males.

TABLE 48.—PROPORTIONATE MORTALITY FROM PULMONARY TUBERCULOSIS AND PNEUMONIA AMONG COMPOSITORS AND PRINTERS, METROPOLITAN LIFE INSURANCE CO., INDUSTRIAL EXPERIENCE, 1911 TO 1913, BY AGE GROUPS.

[Compiled from Bul. 207, U. S. Bureau of Labor Statistics, pp. 33, 34.]

Age at death.	Deaths of printers and compositors, 1911 to 1913, from—		Per cent of deaths from pulmonary tuberculosis among—		Deaths of printers and compositors, 1911 to 1913, from pneumonia.	
	All causes.	Pulmonary tuberculosis.	Printers and compositors.	Males in registration area, 1900–1913.	Number.	Per cent.
15 to 24 years	217	98	45.2	27.0	10	4.6
25 to 34 years	221	110	49.8	30.5	16	7.2
35 to 44 years	225	88	39.1	23.4	6	2.7
45 to 54 years	176	42	23.9	14.7	9	5.1
55 to 64 years	120	19	15.8	7.9	7	5.8
65 years and over	97	3	3.1	2.6	4	4.1
Total, 15 years and over	1,056	360	34.1	13.9	52	4.9
Average age at death	40.2	33.5	.....	.....	39.7	.....

According to this table, out of 1,056 compositors and printers, 360, or 34.1 per cent, died of tuberculosis of the lungs, at an average age of 33.5 years. In addition there are 52 deaths from lobar and un-

defined pneumonia, accounting for 4.9 per cent of the mortality from all causes, at an average age at death of 39.7 years.

The investigation of the Metropolitan Co. includes also an extended study of the mortality of printers from other diseases than pulmonary tuberculosis. The details of the analysis are given in an abbreviated form in the table below, which has been derived from Bulletin 207 of the United States Bureau of Labor Statistics, on "Causes of Death by Occupation."

TABLE 49.—NUMBER AND PER CENT OF DEATHS FROM SPECIFIED CAUSES AMONG COMPOSITORS AND PRINTERS, BY AGE PERIODS, 15 YEARS AND OVER—WHITE MALES.

[Metropolitan Life Insurance Co.—Industrial department—Mortality experience, 1911 to 1913.]

Cause of death.	Ages 15 years and over.		Per cent of deaths during age period (years)—					
	Number.	Per cent.	15–24	25–34	35–44	45–54	55–64	65 and over.
Number of deaths	1,056	.....	217	221	225	176	120	97
Typhoid fever	22	2.1	3.2	4.5	1.8	0.6	.....	.....
Tuberculosis of the lungs	360	34.1	45.2	49.8	39.1	23.9	15.8	3.1
Cancer (all forms)	28	2.7	.9	.5	1.3	5.1	5.0	7.2
Cerebral hemorrhage, apoplexy, and paralysis	38	3.6	.....	.9	2.2	6.8	5.8	12.4
Organic diseases of the heart	118	11.2	6.0	5.9	10.2	13.1	19.2	23.7
Pneumonia (lobar and undefined)	52	4.9	4.6	7.2	2.7	5.1	5.8	4.1
Cirrhosis of the liver	19	1.8	.5	.5	1.3	2.3	6.7	2.1
Bright's disease	94	8.9	1.4	3.6	10.7	18.2	11.7	13.4
Suicide (all forms)	19	1.8	3.2	3.2	1.3	.6	.....	1.0
Accidental violence	62	5.9	10.1	5.4	4.8	7.4	1.7	2.1
All other causes	244	23.1	21.9	18.8	24.4	17.1	28.3	30.9
Total	1,056	100.0	100.0	100.0	100.0	100.0	100.0	100.0

In connection with the table it is said in the text by Dr. Louis I. Dublin, the author of the report, that—

In the age period 15 to 24 the relative index of tuberculosis of the lungs is high (133.7); this cause accounts for 45.2 per cent of all deaths, as against 33.8 per cent in the general group. Accidental violence has a low index (52.6). In the period 25 to 34 tuberculosis of the lungs is somewhat lower than in the previous age period, though still high (121.8). Bright's disease is low (80.0) and accidental violence is still lower (43.2). In the age period 35 to 44 tuberculosis of the lungs (118.8) and organic diseases of the heart (132.5) are both high. Bright's disease is high (137.2). Pneumonia is very low (33.3). Both suicide (44.8) and accidental violence (48.5) exhibit low relative indices. In the age division 45 to 54 the high relative index for tuberculosis of the lungs is maintained (129.2). Cerebral hemorrhage, apoplexy, and paralysis loom up as important in this age period; the relative index is 130.8. The index for pneumonia remains low (62.2); Bright's disease is even higher than in the previous age period (164.0). Suicide remains low as before (23.1), and accidental violence shows an increase over the previous age period (87.1). In the age period 55 to 64 tuberculosis of the lungs shows a very high relative index (183.7). Organic diseases of the heart (120.8) are somewhat higher than the average and pneumonia is lower (77.3). Accidental violence is very low (26.2). There are no cases of suicide in this age group. In the age period 65 and over

the cases in which variations from all occupations are noted are too few to warrant discussion.

With special reference to tuberculosis it is said that confirmatory data are provided by the returns of the United States Census, the reports of the Registrar-General, and the experience of the Prudential. All of the index figures derived from these sources are higher than those of the Metropolitan experience. The high proportionate mortality definitely marks this occupation as one in which the environment favors the development of pulmonary tuberculosis. All investigators are agreed as to this, yet there is a diversity of opinion as to the exact causative factor.

As regards the possible effect of lead dust, it is said that in the Metropolitan experience, out of 1,056 deaths of printers and compositors from all causes only 4 were from lead poisoning. It, however, is explained that "It must not be inferred that the exposure to lead is not a serious factor in the causation of tuberculosis. A similar relation has been suggested between lead poisoning and Bright's disease, which also shows a high proportionate mortality in the age periods 35 to 44 and 45 to 54, the relative indices being 137.2 and 164.0, respectively."

The experience of the Metropolitan Co. is fully confirmed by the more extended data derived from the industrial experience of the Prudential Insurance Co. of America for the period from 1897 to 1914, inclusive:

TABLE 50.—PROPORTIONATE MORTALITY FROM PULMONARY TUBERCULOSIS AMONG PRINTERS AND COMPOSITORS, INDUSTRIAL EXPERIENCE OF PRUDENTIAL CO., 1897 TO 1914, COMPARED WITH THAT OF ALL MALES IN THE REGISTRATION AREA, 1900 TO 1913, BY AGE GROUPS.

Age at death.	Deaths of printers and compositors, 1897 to 1914, from—		Per cent of deaths from pulmonary tuberculosis among—	
	All causes.	Pulmonary tuberculosis.	Printers and compositors.	Males in registration area, 1900 to 1913.
15 to 24 years	795	368	46.3	27.0
25 to 34 years	904	505	55.9	30.5
35 to 44 years	851	350	41.1	23.4
45 to 54 years	567	141	24.9	14.7
55 to 64 years	427	42	9.8	7.9
65 years and over	318	14	4.4	2.6
Age unknown	1	.....	.....	.....
Total, 15 years and over	3,863	1,420	36.8	13.9

The mortality of printers in the industrial-insurance experience of the Prudential Co. includes 3,863 deaths from all causes, of which 1,420, or 36.8 per cent, were from pulmonary tuberculosis. Of the mortality of printers from other respiratory diseases, 343 were from pneumonia, 19 from asthma, 35 from bronchitis, and 55 were from

less frequent respiratory diseases. If the deaths from pulmonary tuberculosis and nontuberculous respiratory diseases are combined, 48.5 per cent of the mortality of printers was from diseases of the lungs and air passages. The excess in the mortality from tuberculosis among printers is decidedly suggestive of a typical indoor employment where the exposure to the inhalation of metallic dust, complicated by more or less injurious gases and fumes, is continuous and, in a measure, unavoidable. While, as shown by Table 50, the mortality from pulmonary tuberculosis among printers is excessive at all ages, the excess is most pronounced at ages 25 to 34, when out of every 100 deaths from all causes 55.9 are from pulmonary tuberculosis, against a normal expected proportion of 30.5 per cent. The preceding observations and statistical data derived from American and foreign sources, including extensive industrial-insurance experience data, fully confirm the conclusion that the printing trade is unquestionably subject to decidedly unfavorable health conditions more or less predisposing to a high degree of tuberculosis frequency. The data suggest the necessity for an improvement in shop conditions in conformity with the Austrian and Swiss regulations covering sanitation in the printing trade.[1]

MORTALITY OF PRINTERS—MEDICO-ACTUARIAL EXPERIENCE.

The data as to height and weight prove that a large proportion of printers are physically below the general average, and by implication they suggest the great practical importance of a physical examination on entrance and of a physical reexamination from time to time for the purpose of ascertaining the earliest indications of physical impairment. Life insurance companies have never discriminated against journeymen printers and compositors, and a large number have been insured on the ordinary plan or with fraternal insurance organizations. Since applicants for ordinary or fraternal insurance are, however, subjected to a fairly rigid medical examination, this class of risks would not be strictly representative of the general average. The results of the medico-actuarial investigation with regard to journeymen printers and compositors can not, therefore, be considered entirely conclusive. The results, however, are shown in Table 51.

[1] See in this connection the proportionate mortality data for New York City printers by divisional periods of life and comparative data for selected occupations as given in footnote to page 55.

TABLE 51.—MORTALITY FROM ALL CAUSES AMONG JOURNEYMEN COMPOSITORS, BY AGE GROUPS—MEDICO-ACTUARIAL INVESTIGATION.

Age at death.	Number exposed to risk one year.	Actual deaths.	Expected deaths.	Per cent actual are of expected deaths.
15 to 29 years	6,428	35	29.64	118
30 to 39 years	3,706	20	21.23	9[illegible]
40 to 49 years	962	7	9.58	73
50 to 59 years	261	6	4.95	121
60 years and over	21	.....	1.04	.....
Total, 15 years and over	11,378	68	66.44	102

According to this table the actual mortality of the risks under consideration is 102 per cent, being highest at the two extremes, or 118 per cent at ages 15 to 29, and 121 per cent at ages 50 to 59. The table would seem to prove that the health-injurious effects of the printing trade are most pronounced in youth and after middle age.

It would make a valuable contribution to the scientific study of the subject if the statistics of the International Typographical Union could be subjected to a critical analysis. The same conclusion applies to the experience which has been had with sanatorium treatment at the home for sick and aged printers in Colorado.

SPECIAL CONSIDERATION OF THE MORTALITY AND DISEASE LIABILITY OF COMPOSITORS.

Compositors, considered as a distinct occupation (for many printers are also compositors), are exposed to practically the same health-injurious conditions as are persons engaged in the other occupations of the printing business, and in addition they suffer from eyestrain, which may, under given conditions, affect very seriously the disease-resisting capacity of the system. Stereotyping might have been included here, and its enormous development as a separate branch of the printing trade would warrant special consideration if any really authenticated observations had been made a matter of record useful for the present purpose. In stereotyping, the liability to lead poisoning is a serious factor, affecting especially the men employed in melting the alloy and ladling it into the forms.[1] The same observation applies to operatives on linotype machines, but our present information regarding these employments is too indefinite to warrant the conclusion that the exposure to the risk of plumbism increases materially the mortality from tuberculous and respiratory diseases.

[1] Stereotyping is fully described in the report by Hamilton and Verrill on the "Hygiene of the Printing Trades" (Bulletin of the United States Bureau of Labor Statistics No. 209), including references to the findings of the Illinois Commission on Occupational Diseases as regards the occurrence of cases of lead poisoning. Stereotypers were apparently most liable, proportionately to the numbers exposed to risk. According to Hayhurst the proportion of lead poisoning among linotypers was 3½ per cent against 7.6 per cent among stereotypers.

There are no general vital statistics of compositors separate from those of printers and pressmen, since in both American and foreign statistics these employments are considered as a group.

There is included here a brief extract from a letter by Mr. J. W. Sullivan, a New York City printer, in the Typographical Journal for November, 1903, and reprinted in the annual report of the New York State Bureau of Labor Statistics for 1906, reading in part as follows:

Typesetting is exhaustive work. Standing hour by hour brings on backache, and in some men varicose veins and swollen feet. Sitting on the high printing-office stools doubles the typesetter up, constraining his arm motions and interfering with his digestion. The linotype operator's stool is too low, as it throws his legs into cramped positions. From the pot of molten type-metal under his machine comes a trying heat and offensive gases. He must watch the delicate machinery lest it go wrong. The electric light thrown on his copy often sharply conflicts with the daylight. His keyboard work with wrist and fingers and his handling of hot slugs sometimes results in numbness that threatens scrivener's palsy. Whether typesetter or linotype operator, the compositor's brain is active every moment during the workday. Composition can never be wholly mechanical. Attention must be given to deciphering the copy, to spelling, to capitalizing, punctuating, office style, and correcting the lines as composed. Each of these distinct mental acts, on the whole tedious and monotonous, helps to drain the bodily forces. As the brain becomes fatigued its cells shrink. With every type a man sets there is a touch of wear on the cerebral tissue itself, only to be repaired by the restorative operations of nature—through food, rest, and sleep.

SPECIAL CONSIDERATION OF THE MORTALITY AND DISEASE LIABILITY OF PRESSMEN.

Pressmen in printing plants may also be separately considered, although the information regarding this occupation is rather fragmentary and inconclusive. Arlidge comments on the hygienic aspects of the employment in part as follows:

Their old mode of working has been superseded by the wonderful development of the modern printing machine, whereby the pressman has become little else than an attendant upon it; and we see the marvelous machine in newspaper offices strike off, fold, and count the sheets by thousands in an hour. Bodily strength is consequently at a discount, and the disadvantages of the occupation limited to the heat of the pressroom—caused principally by the heated cylinders of the press, and to a greater or smaller extent, where coal gas and not electricity is used for lighting, by the gas jets. Add to these the noise of the machines, the standing posture, and confinement in the pressroom and sustained attention to their work, and there remains nothing else calculated to injure the pressman's health, barring circumstances within his own control.

The occupation of pressmen does not appear to have attracted the special attention of American writers on occupation mortality, but it is safe to assume that the disease liability of this class, and in particular the degree of frequency of pulmonary tuberculosis, do not materially differ from the observed mortality of men employed in the printing trade generally. More definite data, however, would supply a much to be desired addition to our at present very limited knowledge regarding the specific occupation mortality of this employment.

MORTALITY OF PRESSMEN—MEDICO-ACTUARIAL EXPERIENCE.

The only available mortality data regarding pressmen as differentiated from compositors are the medico-actuarial statistics, which, of course, are inclusive of deaths from all causes and not with special reference to tuberculosis. The number exposed to risk, especially at the younger ages, was relatively fairly large, and the experience shows that the actual mortality was 117 per cent of the expected, in contrast to 102 per cent for journeymen compositors. The data in detail are given in Table 52.

TABLE 52.—MORTALITY FROM ALL CAUSES AMONG JOURNEYMEN PRESSMEN, BY AGE GROUPS—MEDICO-ACTUARIAL INVESTIGATION.

Age at death.	Number exposed to risk one year.	Actual deaths.	Expected deaths.	Per cent actual are of expected deaths.
15 to 29 years	5,674	32	25.99	123
30 to 39 years	3,012	15	17.02	88
40 to 49 years	976	10	9.29	108
50 to 59 years	310	11	6.93	159
60 years and over	15	2	.51	392
Total, 15 years and over	9,987	70	59.74	117

This table is exceptionally interesting, in that it confirms the results of the previous analysis of the mortality of journeymen compositors, showing an excessive death rate from all causes at ages under 30 and at ages over 50. It suggests the practical value of further and more specialized inquiries in connection with the different branches of the printing trade. It is of interest in this connection to draw attention to the industrial mortality experience of the Prudential Co., which, in a general way, confirms the results of other investigations.

TABLE 53.—PROPORTIONATE MORTALITY FROM PULMONARY TUBERCULOSIS AMONG PRESSMEN, INDUSTRIAL EXPERIENCE OF PRUDENTIAL CO., 1897 TO 1914, COMPARED WITH THAT OF ALL MALES IN THE REGISTRATION AREA, 1900 TO 1913, BY AGE GROUPS.

Age at death.	Deaths of pressmen, 1897 to 1914, from—		Per cent of deaths from pulmonary tuberculosis among—	
	All causes.	Pulmonary tuberculosis.	Pressmen.	Males in registration area, 1900 to 1913.
15 to 24 years	168	72	42.9	27.0
25 to 34 years	151	72	47.7	30.5
35 to 44 years	116	51	44.0	23.4
45 to 54 years	45	9	20.0	14.7
55 to 64 years	27	3	11.1	7.9
65 years and over	16	.....	.....	2.6
Total, 15 years and over	523	207	39.6	13.9

GENERAL CONCLUSIONS.

The mortality of pressmen from pulmonary tuberculosis is shown to be somewhat more favorable at the earlier ages than the corresponding mortality of printers and compositors, but for the later age groups the numbers are insufficient for a safe conclusion. In a general way the differences are not sufficiently pronounced to suggest material variations in the occupational hazards of the more important occupational groups of the printing trade. At all ages it is shown in Table 53 that out of 523 deaths from all causes among pressmen, 207, or 39.6 per cent, are from pulmonary tuberculosis, against a normal proportion of 13.9 per cent among males in the United States registration area. The statistical evidence is therefore decidedly suggestive of more or less health-injurious conditions common to this particular occupational group, which are elsewhere shown to prevail in the printing trades generally.

In this connection attention may be directed to an exceptionally carefully considered set of precautions for printers published by the New York City Department of Health, through its division of industrial hygiene, and published in the Monthly Review of the United States Bureau of Labor Statistics, for December, 1915. The suggestion made in these rules regarding the necessity of avoiding lead dust should, however, be amplified to apply to the avoidance of all forms of metallic or mineral dust common to the printing trades generally.

ENGRAVERS.

Engravers are a fairly numerous and widely distributed class of workmen, whose occupation is sufficiently well defined to warrant separate consideration. According to the census of 1910 there were 11,766 engravers in the United States. Engravers upon copper, steel,

or other metals are subject to much the same conditions injuriously affecting health and life, and the differentiation of the employment according to the kind of metal worked upon is not practicable.

The employment decidedly predisposes to tuberculosis, and all the available data indicate an excessive proportion of deaths from this disease among engravers, at least during the active working period of life. Aside from health-injurious factors directly resulting from operations and processes inseparable from the employment, there is also the unfavorable effect of a sedentary occupation demanding a fixed and stooping position. Arlidge has called attention to the fact that there are other accessory conditions unfavorable to health in this employment, such as the frequent use of strong light, severe taxing of the eyes,[1] and the employment of strong acids.

Some fairly conclusive data are available regarding the mortality of engravers, with particular reference to pulmonary tuberculosis, but as an interesting case of extreme longevity mention may be made of a Mr. Charles Harris, who died at the age of 93, and who for more than half a century had been an engraver of the American Bank Note Co. A somewhat similar case was that of a Mr. James P. Mayer, who, at the time of his death at the age of 83, was reputed to be the oldest steel engraver in America.

RELATIVE FREQUENCY OF PULMONARY TUBERCULOSIS.

These, however, are but illustrations of exceptions and rather mark the rule of the comparative infrequency of extreme longevity among men in this employment. Thackrah held that "engravers and copper plate printers present few examples of old age," and he may have included printers and lithographers and similar employments under this term. Tracy, writing with reference to more recent and American conditions, holds that engravers, in common with lapidaries and watchmakers, are very liable to phthisis. It is probably quite true, as pointed out by Sommerfeld, that the amount of metallic or mineral dust generated in this occupation is comparatively small in quantity, but it is practically certain to be injurious in its effects just because of the minuteness of the particles. According to Sommerfeld's data, 23.6 per cent of all cases of sickness of engravers were diseases of the lungs and air passages. He suggests, among other things, as a precaution, extreme care in the physical selection of engravers' apprentices to eliminate those already predisposed to pulmonary tuberculosis. He further advises the proper ventilation of the workshops, which in most cases is almost entirely neglected.

[1] For an extended discussion of the cause of eyestrain, see Biographic Clinics, Vol. IV, by George M. Gould, M. D., Philadelphia, 1906, p. 61 et seq.; also Popular Science Monthly for December, 1905.

preliminary report of the commission for 1912. In none of these investigations was definite evidence produced tending to prove an exceptional liability to pulmonary tuberculosis in consequence of exposure to the inhalation of metallic and mineral dusts, but more extended investigations would be required for the purpose of scientific conclusiveness.

An admirable discussion of the life and labor of artificial-flower workers by Miss Mary Van Kleeck was published by the Russell Sage Foundation in behalf of the Committee on Women's Work (New York, 1913). The investigation is of special importance in view of the fact that it was made in the city of New York where three-quarters of all the artificial flowers produced in the United States are made. All of the shops in the Borough of Manhattan known to make artificial flowers, employing 5,240 workers, were visited. The proportions in various age groups of 371 home workers in 110 families were as follows: Children under 8 years of age, 10.2 per cent; children 8 to 14 years of age, 27.2 per cent; children 14 to 16 years of age, 11.3 per cent; and adults 16 years of age and over, 51.3 per cent. The proportions in various age groups of women shop workers employed in artificial-flower making were: Ages 10 to 16 years, 14 per cent; ages 16 to 25 years, 63 per cent; and ages 25 and over, 23 per cent. This compares with all women workers in manufacturing industries as follows: Ages 10 to 16 years, 9 per cent; ages 16 to 25, 53 per cent; and ages 25 years and over, 38 per cent. The artificial-flower making industry is, therefore, typically representative of female workers at the younger or immature ages. An analysis of the wages earned proves conclusively that the employments are decidedly underpaid. An inquiry into the hours with special reference to fatigue seemed to justify the conclusion that, regardless of the fact that the work was light, the elements of fatigue were by no means lacking; that many of the workrooms were poorly ventilated, and that the air was vitiated because of the use of gas stoves for heating the tools and sometimes by gas used in illumination. Complaint was also made that certain dyes used were poisonous, and, according to the author, "this opinion was expressed so frequently by the workers that it seems credible, although no medical examinations have been made to support it. The girls say that they inhale the dust from cheap flowers and that the color frequently stains their hands and may inadvertently be rubbed on the mouth or eyes." It is, therefore, suggested that "a special investigation of the physical effects of these dyes ought to be made, but in the broader sense the health aspects of the entire industry should be subjected to critical and qualified consideration."

GENERAL CONCLUSIONS.

Since in this industry women are almost exclusively employed, the industrial insurance experience data are inconclusive. There have been only 13 deaths of male artificial-flower makers in the experience of the Prudential Insurance Co. during the period 1907 to 1914, of which, however, 4, or 30.8 per cent, were from pulmonary tuberculosis. Three of the deaths occurred at ages under 35, of which two were from this particular disease. The corresponding data for women are not available. On account of its practical importance as an employment for young persons, chiefly girls of the period of early adolescence, it would seem a matter of some urgency that the health aspect of this group of occupations with special reference to the dust hazard and the probable liability to an excessive mortality from tuberculosis should be made the subject of a thoroughly qualified investigation.

106811°—18—Bull. 231——11.

CHAPTER III.—OCCUPATIONS WITH EXPOSURE TO MINERAL DUST.

Mineral-dust exposure is most common in the stone industry, among potters, in cement manufacture, and in mining. Mineral dust varies widely and essentially in its mechanical and chemical properties, and much more so than is the case with the different varieties of metallic dust. The quantitative degree of dust exposure is also decidedly greater in the case of mineral dust, which frequently contaminates the entire atmosphere in a finely comminuted form for prolonged periods of time. Since all dust is primarily injurious on account of its irritating effects on the respiratory organs, it is self-evident that essential variation in the mechanical properties of the dust must correspondingly affect the consequential results on lung tissue and the development of lung fibrosis and pulmonary tuberculosis. It is estimated that at every inhalation an adult person inhales about one-half liter of air, and since the normal respiration is from 16 to 18 times per minute the approximate quantity of air inhaled is from 8 to 9 liters per minute and from 480 to 540 liters per hour. Continuous exposure, therefore, to even relatively small amounts of atmospheric impurities may have proportionately serious pathological results. According to Hesse, a man working 10 hours a day inhales approximately 0.09 gram of dust per day if employed in a sawmill, 0.025 gram per day if employed in a flour mill, and 1.12 grams per day if employed in a cement mill. Regardless, however, of the fact that the quantitative exposure to dust inhalation in cement manufacture exceeds very considerably the corresponding exposure in many other occupations, it is apparently well established by reasonably trustworthy data that the inhalation of cement dust is decidedly less injurious to lung tissue, with special reference to pulmonary tuberculosis, than exposure to sandstone dust or granite dust, etc. One important factor which is frequently overlooked is the solubility or insolubility of the mineral dust inhaled, and the chemical nature of the dust may therefore be of even greater importance than its mechanically irritating qualities. The degree of comminution is also of material importance in that in almost exact proportion to the degree of fineness the dust particles will penetrate into the remote portions of the lungs. It is therefore held that the more minutely comminuted the dust, the more serious, in general terms, will be the damage to the respiratory organs.

MINERAL DUST AND PULMONARY TUBERCULOSIS.

The term "mineral dust" for practical reasons is, for the present purpose, limited to finely comminuted particles of mineral substances as generally differentiated from metallic substances obtained by mining, quarrying, or other extractive processes. No precise definition regarding mineral dust seems practicable in view of the truly enormous range of minerals, varying from potash salts and fuller's earth, phosphate rock, mica, slate, asbestos, mineral paints, graphite, cement, gypsum, borax, asphalt, lime, coke, etc., to pure silica or quartz, which for the present purpose must be considered the most injurious of all forms of mineral dust, approaching quite closely in degree of seriousness to the most irritating forms of metallic dust. The relation of mineral-dust inhalation to pulmonary tuberculosis and nontuberculous lung diseases is ascertainable only as regards the more important mineral products, such as slate, cement, lime, coal, silica, and other stones, chiefly marble, limestone, sandstone, bluestone, and granite. There are no trustworthy mortality statistics regarding dust exposure and its relation to health in connection with the mining of phosphate rock, mica, asbestos, sulphur, soapstone, graphite, borax, asphalt, and abrasive materials. Few of these industries are relatively important as regards the number of persons employed therein, but for scientific purposes it is most desirable that the health-injurious results of each and every form of mineral dust should receive the required extended and qualified consideration. The typical form of industrial-dust phthisis met with in occupations with exposure to mineral dust conforms more to the precise definition of industrial pneumoconiosis or nontuberculous lung disease in its initial development, although as a general rule there is a superinduced true pulmonary tuberculosis which is properly returned as the immediate cause of death. In occupations with exposure to mineral dust it is therefore of even greater importance than in occupations with exposure to metallic dust that the nontuberculous lung diseases, particularly asthma and chronic bronchitis, should receive some consideration, aside from the invariably more important mortality from pulmonary tuberculosis, although the latter often is not the primary but rather a contributory cause of death.

LUNG DISEASES AND MINERAL AND METALLIC DUST EXPOSURE.

This conclusion is quite fully sustained by Table 62, which is derived from the industrial insurance experience of the Prudential Insurance Co. for the period 1897 to 1914, and which may safely be considered representative for the country at large.

TABLE 62.—COMPARATIVE PROPORTIONATE MORTALITY FROM PULMONARY TUBERCULOSIS AND NONTUBERCULOUS RESPIRATORY DISEASES IN OCCUPATIONS EXPOSING TO MINERAL AND METALLIC DUST, INDUSTRIAL EXPERIENCE OF PRUDENTIAL CO., 1897 TO 1914.

Cause of death.	Deaths of workers exposed to—			
	Mineral dust.		Metallic dust.	
	Number.	Per cent.	Number.	Per cent.
Pulmonary tuberculosis	3,129	27.3	2,960	36.0
Asthma	105	.9	47	.6
Bronchitis	173	1.5	70	.9
Pneumonia	1,198	10.5	696	8.5
Other nontuberculous respiratory diseases	199	1.7	132	1.6
Total	1,675	14.6	945	11.5
All other causes	6,653	58.1	4,326	52.5
Total, all causes	11,457	100.0	8,231	100.0

According to this analysis the proportionate mortality from nontuberculous respiratory diseases in occupations with exposure to mineral dust is 14.6 per cent, against 11.5 per cent for occupations with exposure to metallic dust. Every important form of nontuberculous respiratory disease is proportionately more common among occupations with exposure to mineral dust, but the proportionate mortality from pulmonary tuberculosis is only 27.3 per cent, against 36 per cent for occupations with exposure to metallic dust.

MORTALITY FROM PULMONARY TUBERCULOSIS IN OCCUPATIONS WITH EXPOSURE TO MINERAL DUSTS—UNITED STATES REGISTRATION AREA.

The conditions of employment in the industries, trades, and occupations which are considered in detail in this chapter are often so widely at variance with one another that, as stated in the preceding chapter with regard to metallic dust, the mortality data represent averages which must be interpreted with extreme caution as regards their application to particular employments with a more or less ascertainable degree of exposure to mineral dust. Such exposure is nearly always an important predisposing cause of pulmonary tuberculosis, but particularly so in certain branches of the stone industry and among potters. Tables 63 and 64 following are, therefore, merely intended as a general statement of the essential mortality facts concerning this group of occupations, with special reference to pulmonary tuberculosis and nontuberculous respiratory diseases, as derived from the available official statistics of the Division of Vital Statistics of the United States Census Bureau. A subsequent additional table presents

the corresponding facts as derived from the extended experience of a representative industrial insurance company. The practical usefulness of this analysis is naturally rather limited for the reasons stated, but the data provide a fairly trustworthy measure of the relative frequency of pulmonary tuberculosis in the group of industries and occupations subject to a more or less ascertainable degree of health-injurious exposure to the continuous and considerable inhalation of mineral dust.

TABLE 63.—PROPORTIONATE MORTALITY FROM PULMONARY TUBERCULOSIS IN OCCUPATIONS WITH EXPOSURE TO MINERAL DUST, UNITED STATES REGISTRATION AREA, 1908 AND 1909, BY AGE GROUPS.

Age at death.	Deaths from all causes.	Deaths from pulmonary tuberculosis.	
		Number.	Per cent of deaths from all causes.
15 to 24 years	756	256	33.9
25 to 34 years	1,524	582	38.2
35 to 44 years	2,172	700	32.2
45 to 54 years	2,399	523	21.8
55 to 64 years	2,258	259	11.5
65 years and over	2,162	87	4.0
Age unknown	10	1	10.0
Total, 15 years and over	11,281	2,408	21.3

TABLE 64.—PROPORTIONATE MORTALITY FROM NONTUBERCULOUS RESPIRATORY DISEASES IN OCCUPATIONS WITH EXPOSURE TO MINERAL DUST, UNITED STATES REGISTRATION AREA, 1908 AND 1909.

Cause of death.	Number of deaths.	Per cent of deaths from all causes.
Asthma	26	0.2
Bronchitis	96	.9
Pneumonia	840	7.4
Other nontuberculous respiratory diseases	124	1.1
Total	1,086	9.6

INCONCLUSIVE OCCUPATIONAL MORTALITY STATISTICS.

The aggregate experience, according to Table 63, for the two years under observation (no subsequent official statistics have been published), indicates a proportionate mortality from pulmonary tuberculosis among men employed in occupations with exposure to mineral dust of 21.3 per cent, which compares with 21 per cent for occupations with exposure to metallic dust, as ascertained by an analysis of the corresponding data derived from the same official sources. The data can not be considered entirely conclusive on account of the fact that the industries and occupations with exposure to mineral dust include a relatively large number of persons not exposed to the risk of dust inhalation to a serious degree. If it were practicable to separate those directly exposed to the dust danger from those not exposed to any such risk whatever, the resulting proportionate mortality from pulmonary tuberculosis and nontuberculous respiratory diseases would, of course, be much more excessive. For illustration, it is noted that the pottery industry as a whole is chargeable with a serious risk of mineral-dust exposure. The particular dust hazard is experienced chiefly among flint-mill workers, mixers, scourers, and sweepers. If the mortality rate of these employments could be correctly ascertained with particular reference to pulmonary tuberculosis, there can be no question of doubt that the proportionate mortality figure would be decidedly in excess of the corresponding figure for jiggermen, jollymen, throwers, and other numerically important pottery employees. The same conclusion applies to the glass industry, where the handlers of materials and mixers are exposed to a readily ascertainable dust hazard, which to a lesser degree affects batch wheelers, carboy blowers, clay grinders, clay trampers, gatherers, pot makers, etc., and to a still lesser degree, glass blowers, finishers, lamp workers, pressers, etc. As far as possible the occupational differences in particular industries are considered in detail in the discussion following, but it has seemed advisable to consolidate the available data for the purpose of ascertaining, as far as practicable, the general effect of mineral-dust exposure, which, as previously observed, appears to be less serious with reference to pulmonary tuberculosis than continuous and considerable exposure to metallic dust.

COMPARATIVE MORTALITY BY INDUSTRIES OR OCCUPATIONS.

In addition to the mortality from pulmonary tuberculosis the comparative mortality from nontuberculous respiratory diseases, particularly asthma and bronchitis, is also distinctly excessive among occupations with exposure to mineral dust, and even more so than among the corresponding occupations with exposure to metallic dust. The details of the proportionate mortality from pulmonary tuberculosis in the principal occupations for which the information is ascertainable from the reports of the Division of Vital Statistics of the United States Census Bureau, for the two years 1908 and 1909, are, for purposes of convenience, shown in Table 65.

TABLE 65.—PROPORTIONATE MORTALITY FROM PULMONARY TUBERCULOSIS IN SPECIFIED INDUSTRIES OR OCCUPATIONS WITH EXPOSURE TO MINERAL DUST, UNITED STATES REGISTRATION AREA, 1908 AND 1909, BY AGE GROUPS.

Occupation group.	15 to 24 years.			25 to 34 years.			35 to 44 years.			45 to 54 years.		
	Deaths from all causes.	Deaths from pulmonary tuberculosis.		Deaths from all causes.	Deaths from pulmonary tuberculosis.		Deaths from all causes.	Deaths from pulmonary tuberculosis.		Deaths from all causes.	Deaths from pulmonary tuberculosis.	
		Number.	Per cent.		Number.	Per cent.		Number.	Per cent.		Number.	Per cent.
Brick and tile makers [1]	14	3	21.4	13	3	23.1	18	5	27.8	20	3	15.0
Glassworkers	176	83	47.2	202	86	42.6	169	56	33.1	117	23	19.7
Marble and stone cutters	61	16	26.2	170	74	43.5	299	132	44.1	401	167	41.6
Painters, glaziers, and varnishers	429	132	30.8	968	357	36.9	1,423	415	29.2	1,598	278	17.4
Paper hangers [1]	15	4	26.7	36	16	44.4	60	20	33.3	42	9	21.4
Plasterers	48	12	25.0	108	34	31.5	177	61	34.5	189	31	16.4
Potters [1]	13	6	46.2	27	12	44.4	26	11	42.3	32	12	37.5
Total	756	256	33.9	1,524	582	38.2	2,172	700	32.2	2,399	523	21.8

Occupation group.	55 to 64 years.			65 years and over.			Age unknown.			Total, 15 years and over.		
	Deaths from all causes.	Deaths from pulmonary tuberculosis.		Deaths from all causes.	Deaths from pulmonary tuberculosis.		Deaths from all causes.	Deaths from pulmonary tuberculosis.		Deaths from all causes.	Deaths from pulmonary tuberculosis.	
		Number.	Per cent.		Number.	Per cent.		Number.	Per cent.		Number.	Per cent.
Brick and tile makers [1]	26	2	7.7	41	.....	.....	1	.....	.....	133	16	12.0
Glassworkers	101	8	7.9	101	4	4.0	1	.....	.....	867	260	30.0
Marble and stone cutters	407	95	23.3	316	25	7.9	3	.....	.....	1,657	509	30.7
Painters, glaziers, and varnishers	1,474	132	9.0	1,398	46	3.3	4	1	25.0	7,294	1,361	18.7
Paper hangers [1]	33	1	3.0	31	2	6.5	.....	.....	.....	217	52	24.0
Plasterers	205	16	7.8	249	9	3.6	1	.....	.....	977	163	16.7
Potters [1]	12	5	41.7	26	1	3.8	.....	.....	.....	136	47	34.6
Total	2,258	259	11.5	2,162	87	4.0	10	1	10.0	11,281	2,408	21.3

[1] Data are for 1909 only.

The table emphasizes the rather wide range in the mortality from pulmonary tuberculosis in the different occupations, industries, or trades with exposure to mineral dust, a difference attributable partly at least to variations in conditions of employment, or, more precisely, to the proportion of all the employees of the industry concerned who were considerably exposed to the dust menace. A much more important influence, however, on the tuberculosis rate is the variation in the chemical and mechanical properties of the mineral dust inhaled and the quantitative degree of dust inhaled, which, as elsewhere observed, probably reaches a maximum in certain processes of cement manufacture. The statistics for the United States registration area are unfortunately limited to a comparatively small number of specified industries and trades, but there are no reasons for believing that the proportionate mortality figure would be materially modified by the inclusion of similar or allied employments or occupations for which the information is at present not ascertainable from official sources. The comparison of the different em-

ployments one with another is also subject to the further restriction, as regards practical usefulness, that while for some industries and occupations, such, for illustration, as painters, etc., the number of deaths is relatively large and sufficient for the purpose, for other occupations, such, for illustration, as brick and tile making and the pottery industry, the number of deaths is too limited for entirely safe conclusions.

MORTALITY FROM NONTUBERCULOUS RESPIRATORY DISEASES.

The limitations of the available statistics are even more serious in the case of nontuberculous respiratory diseases, but it has seemed advisable for the present purpose to include Table 66, which, however, gives data which refers only to all ages combined and not to divisional periods of life on account of the relatively small number of deaths available for analysis.

TABLE 66.—PROPORTIONATE MORTALITY FROM NONTUBERCULOUS RESPIRATORY DISEASES IN SPECIFIED INDUSTRIES OR OCCUPATIONS WITH EXPOSURE TO MINERAL DUST, UNITED STATES REGISTRATION AREA, 1908 AND 1909.

Occupation group.	Deaths caused by nontuberculous respiratory diseases.									
	Asthma.		Bronchitis.		Pneumonia.		Other.		Total.	
	Number.	Per cent.	Number.	Per cent.	Number.	Per cent.	Number.	Per cent.	Number.	Per cent.
Brick and tile makers [1]	.....	.....	.....	.....	8	6.0	2	1.5	10	7.5
Glassworkers	2	0.2	5	0.6	67	7.7	6	.7	80	9.2
Marble and stone cutters	9	.5	29	1.8	131	7.9	33	2.0	202	12.2
Painters, glaziers, and varnishers	11	.2	47	.6	533	7.3	64	.9	655	9.0
Paper hangers [1]	.....	.....	3	1.4	13	6.0	2	.9	18	8.3
Plasterers	3	.3	11	1.1	79	8.1	11	1.1	104	10.6
Potters [1]	1	.7	1	.7	9	6.7	6	4.4	17	12.5
Total	26	.2	96	.9	840	7.4	124	1.1	1,086	9.6

[1] Data are for 1909 only.

INDUSTRIAL INSURANCE MORTALITY EXPERIENCE.

In view of the limited extent of the available official occupation mortality statistics of the registration area, the industrial mortality experience of the Prudential Insurance Co. of America is somewhat more conclusive, in that the number of specific occupations is more representative of the industries and employments with exposure to mineral dust. When considered as a group and for some of the more important occupations, the actual mortality data are also more extensive. The details of the experience are set forth in Table 67.

TABLE 67.—PROPORTIONATE MORTALITY FROM PULMONARY TUBERCULOSIS IN OCCUPATIONS WITH EXPOSURE TO MINERAL DUST, INDUSTRIAL EXPERIENCE OF PRUDENTIAL CO., 1897 TO 1914.

Age at death.	Deaths from all causes.	Deaths from pulmonary tuberculosis.	
		Number.	Per cent of deaths from all causes.
15 to 24 years	1,141	365	32.0
25 to 34 years	1,920	875	45.6
35 to 44 years	2,280	823	36.1
45 to 54 years	2,303	602	26.1
55 to 64 years	2,127	355	16.7
65 years and over	1,684	109	6.5
Age unknown	2	.....	.....
Total, 15 years and over	11,457	3,129	27.3

TABLE 68.—PROPORTIONATE MORTALITY FROM NONTUBERCULOUS RESPIRATORY DISEASES IN OCCUPATIONS WITH EXPOSURE TO MINERAL DUST, INDUSTRIAL EXPERIENCE OF PRUDENTIAL CO., 1897 to 1914.

Cause of death.	Number of deaths.	Per cent of deaths from all causes.
Asthma	105	0.9
Bronchitis	173	1.5
Pneumonia	1,198	10.5
Other nontuberculous respiratory diseases	199	1.7
Total	1,675	14.6

As observed in connection with the corresponding discussion of the occupations with exposure to metallic dust, the insurance experience is not strictly comparable with the general mortality for the country at large, for the principle of adverse selection must be considered, and the fact that only a small proportion of the risks accepted for industrial insurance are at entry subjected to a thorough medical examination. A much more important factor, however, is that the occupation analysis in the Prudential Co. experience is more strictly limited to specific occupations with mineral-dust exposure as separate and distinct from industries or groups of closely allied employments, which it is safe to assume are more representative of the census mortality returns; in other words, in the Prudential mortality experience the reference is rather to potters than to men employed in the pottery industry; to glassworkers rather than to men employed in the glass industry; more so than is the case in the returns made available through the Division of Vital Statistics of the United States Census Bureau for the two years 1908 and 1909.

EXCESSIVE FREQUENCY OF PULMONARY TUBERCULOSIS.

According to Table 67, the proportionate mortality from pulmonary tuberculosis in occupations with exposure to mineral dust is 27.3 per cent for all ages, which compares with 21.3 per cent as shown by the census occupation mortality returns. The differences are quite marked, and a maximum proportion is reached at ages 25 to 34, when out of 1,920 deaths from all causes among men with exposure to mineral dust, 875, or 45.6 per cent, are deaths from pulmonary tuberculosis, in contrast to a corresponding mortality of 49.6 per cent for men employed in occupations with exposure to metallic dust. The proportionate mortality from pulmonary tuberculosis among men employed in occupations with exposure to mineral dust must therefore be considered distinctly excessive, but particularly so at ages under 45. The mortality from nontuberculous respiratory diseases affects rather the more advanced ages, and this is especially the case with pneumonia, the incidence of which is apparently increased by exposure to the continuous and considerable inhalation of mineral dust, even more so than in the case of occupations with exposure to metallic dust.[1]

PROPORTIONATE MORTALITY BY INDUSTRIES OR OCCUPATIONS.

The proportionate mortality by specific industries or occupations and by divisional periods of life is shown in Table 69 following, which will facilitate comparison with the corresponding table for the registration area, but which is subject to the same suggestion of extreme caution as regards the interpretation of the data derived, as explained, from different sources.

[1] The mortality from pneumonia in the registration area has apparently been decreasing during recent years, as shown by the following table, derived from official sources:

Mortality from pneumonia (exclusive of broncho pneumonia)—United States registration area, 1905–1915.

[Rate per 100,000 of population.]

	Males.	Females.	Total.
1905–1909	116.7	93.7	105.1
1910–1914	96.8	76.3	86.8
1915	91.5	73.8	82.9

No thoroughly qualified analysis has thus far been made of the mortality from pneumonia in the United States, particularly in its relation to the dusty trades. The subject is, however, deserving of more extended and strictly scientific consideration.

TABLE 69.—PROPORTIONATE MORTALITY FROM PULMONARY TUBERCULOSIS IN SPECIFIED INDUSTRIES OR OCCUPATIONS WITH EXPOSURE TO MINERAL DUST, INDUSTRIAL EXPERIENCE OF PRUDENTIAL CO., 1897 TO 1914, BY AGE PERIODS.

Occupation group.	15 to 24 years.			25 to 34 years.			35 to 44 years.			45 to 54 years.		
	Deaths from all causes.	Deaths from pulmonary tuberculosis.		Deaths from all causes.	Deaths from pulmonary tuberculosis.		Deaths from all causes.	Deaths from pulmonary tuberculosis.		Deaths from all causes.	Deaths from pulmonary tuberculosis.	
		Number.	Per cent.		Number.	Per cent.		Number.	Per cent.		Number.	Per cent.
Asbestos workers	3	.....	.....	3	1	33.3	3	2	66.7	1	.....	.....
Brick, tile, and terra cotta	48	11	22.9	51	18	35.3	81	16	19.8	97	18	18.6
Core makers	113	36	31.9	98	42	42.9	63	19	30.2	42	5	11.9
Glassblowers	51	23	45.1	137	73	53.3	115	36	31.3	106	30	28.3
Glass cutters	53	21	39.6	55	28	50.9	48	20	41.7	28	6	21.4
Glassworkers, other	257	81	31.5	186	95	51.1	151	52	34.4	108	25	23.1
Lime, cement, and gypsum	18	2	11.1	40	15	37.5	48	12	25.0	45	10	22.2
Lithographers	70	37	52.9	81	42	51.9	69	27	39.1	53	13	24.5
Marble and stone workers	60	23	38.3	228	121	53.1	403	179	44.4	513	200	39.0
Molders	266	63	23.7	540	218	40.4	694	213	30.7	690	149	21.6
Paint factories	10	4	40.0	26	6	23.1	25	10	40.0	33	7	21.2
Paper hangers	57	20	35.1	175	77	44.0	174	74	42.5	134	21	15.7
Plasterers	58	20	34.5	163	71	43.6	225	91	40.4	281	66	23.5
Potteries	77	24	31.2	137	68	49.6	181	72	39.8	172	52	30.2
Total	1,141	365	32.0	1,920	875	45.6	2,280	823	36.1	2,303	602	26.1

Occupation group.	55 to 64 years.			65 years and over.			Age unknown.			Total, 15 years and over.		
	Deaths from all causes.	Deaths from pulmonary tuberculosis.		Deaths from all causes.	Deaths from pulmonary tuberculosis.		Deaths from all causes.	Deaths from pulmonary tuberculosis.		Deaths from all causes.	Deaths from pulmonary tuberculosis.	
		Number.	Per cent.		Number.	Per cent.		Number.	Per cent.		Number.	Per cent.
Asbestos workers	1	.....	.....	2	.....	.....	.....	.....	.....	13	3	23.1
Brick, tile, and terra cotta	121	13	10.7	129	6	4.7	.....	.....	.....	527	82	15.6
Core makers	26	3	11.5	15	.....	.....	.....	.....	.....	357	105	29.4
Glass blowers	52	8	15.4	85	5	5.9	.....	.....	.....	546	175	32.1
Glass cutters	24	2	8.3	11	3	27.3	1	.....	.....	220	80	36.4
Glassworkers, other	103	16	15.5	92	5	5.4	.....	.....	.....	897	274	30.5
Lime, cement, and gypsum	49	6	12.2	22	1	4.5	.....	.....	.....	222	46	20.7
Lithographers	32	4	12.5	19	2	10.5	1	.....	.....	325	125	38.3
Marble and stone workers	506	135	26.7	342	32	9.4	.....	.....	.....	2,052	690	33.6
Molders	624	87	13.9	480	28	5.8	.....	.....	.....	3,294	758	23.0
Paint factories	16	.....	.....	14	.....	.....	.....	.....	.....	124	27	21.8
Paper hangers	96	11	11.5	72	3	4.2	.....	.....	.....	708	206	29.1
Plasterers	330	39	11.8	314	13	4.1	.....	.....	.....	1,371	300	21.9
Potteries	147	31	21.1	87	11	12.6	.....	.....	.....	801	258	32.2
Total	2,127	355	16.7	1,684	109	6.5	2	.....	.....	11,457	3,129	27.3

MORTALITY FROM NONTUBERCULOUS RESPIRATORY DISEASES.

On account of the importance of nontuberculous respiratory diseases,[1] Table 70 is included, showing the proportionate mortality from asthma, bronchitis, pneumonia, and other respiratory diseases among workers in occupations with exposure to mineral dust, without reference to divisional periods of life:

[1] On the nontuberculous respiratory diseases, see "Diseases of the Bronchi, Lungs, and Pleura," by Frederick T. Lord M. D., Philadelphia and New York, 1915, and "System of Medicine," edited by Sir Clifford Allbutt and Humphrey Davy Rolleston, London, 1909.

TABLE 70.—PROPORTIONATE MORTALITY FROM NONTUBERCULOUS RESPIRATORY DISEASES IN SPECIFIED INDUSTRIES OR OCCUPATIONS WITH EXPOSURE TO MINERAL DUST, INDUSTRIAL EXPERIENCE OF PRUDENTIAL CO., 1897 TO 1914.

Occupation group.	Deaths caused by nontuberculous respiratory diseases.									
	Asthma.		Bronchitis.		Pneumonia.		Other.		Total.	
	Number.	Per cent.	Number.	Per cent.	Number.	Per cent.	Number.	Per cent.	Number.	Per cent.
Asbestos workers	.....	.....	.....	.....	2	15.3	.....	.....	2	15.3
Brick, tile, and terra cotta	6	1.1	5	0.9	68	12.9	10	1.9	89	16.9
Core makers	.....	.....	1	.3	40	11.2	7	2.0	48	13.4
Glass blowers	3	.5	6	1.1	32	5.9	8	1.5	49	9.0
Glass cutters	1	.5	1	.5	21	9.5	2	.9	25	11.4
Glassworkers, other	4	.4	6	.7	71	7.9	13	1.4	94	10.5
Lime, cement, and gypsum	2	.9	3	1.4	15	6.8	5	2.3	25	11.3
Lithographers	.....	.....	3	.9	35	10.8	3	.9	41	12.7
Marble and stone workers	28	1.4	52	2.5	198	9.6	49	2.4	327	15.9
Molders	25	.8	51	1.5	463	14.1	65	2.0	604	18.3
Paint factories	1	.8	.....	.....	11	8.9	.....	.....	12	9.7
Paper hangers	1	.1	8	1.1	61	8.6	9	1.3	79	11.2
Plasterers	9	.7	23	1.7	135	9.8	9	.7	176	12.8
Potteries	25	3.1	14	1.7	46	5.7	19	2.4	104	13.0
Total	105	.9	173	1.5	1,198	10.5	199	1.7	1,675	14.6

It does not seem necessary, as observed in the discussion of occupations with exposure to metallic dust, to enlarge upon the facts disclosed by the preceding comparative statistics, which emphasize with a sufficient degree of scientific conclusiveness the obviously health-injurious consequences of considerable and continuous exposure to the inhalation of mineral dust. It is clearly recognized that the statistical data utilized for the present purpose are of rather limited intrinsic value, but they are in the main quite fully confirmed by the more extended consideration of occupations in detail where the exposure to mineral dust is sufficient to warrant their inclusion within the plan and scope of the present discussion.

ENGLISH OCCUPATIONAL MORTALITY DATA.

In conclusion, however, it has seemed advisable to add to the present observations a table obtained from English official sources which shows the combined mortality of glassworkers, potters, paper hangers, plasterers, and lithographers, and which may safely be considered sufficiently representative of the entire group of occupations with exposure to mineral dust, in the absence of more extensive information which unfortunately is not available.

TABLE 71.—MORTALITY FROM ALL CAUSES, FROM PULMONARY TUBERCULOSIS, AND FROM OTHER RESPIRATORY DISEASES IN OCCUPATIONS EXPOSED TO MINERAL DUST, COMPARED WITH THAT OF ALL OCCUPIED MALES, IN ENGLAND AND WALES, 1900 TO 1902, BY AGE GROUPS.

[Source: Part II, Supplement to the Sixty-fifth Annual Report of the Registrar-General of Births, Deaths, and Marriages in England and Wales.]

Age at death.	Death rate per 1,000 due to all causes among—		Death rate per 1,000 due to pulmonary tuberculosis among—		Death rate per 1,000 due to other diseases of the respiratory system among—	
	All occupied males.	Occupations exposed to mineral dust.	All occupied males.	Occupations exposed to mineral dust.	All occupied males.	Occupations exposed to mineral dust.
15 to 19 years	2.44	2.35	0.54	0.55	0.24	0.27
20 to 24 years	4.41	4.02	1.55	1.44	.48	.50
25 to 34 years	6.01	5.24	2.03	2.01	.77	.78
35 to 44 years	10.22	12.46	2.74	3.96	1.66	2.12
45 to 54 years	17.73	23.74	3.04	4.91	3.32	6.05
55 to 64 years	31.01	40.23	2.16	3.94	6.54	12.86
65 years and over	88.39	92.60	1.11	1.13	17.77	24.50

GENERAL CONCLUSIONS.

Table 71 brings out clearly the fact that the mortality from pulmonary tuberculosis among men in occupations with exposure to mineral dust is decidedly excessive at ages 35 to 64, but that the mortality at the other ages is not appreciably lower than for occupied males generally. Death rates are, however, not as useful and conclusive for purposes of industrial hygiene as the proportionate mortality figure which precisely emphasizes the quantitative importance of a given disease or cause of death. The proportionate mortality from pulmonary tuberculosis and nontuberculous respiratory diseases is excessive at all ages among men with exposure to mineral dust, although the relative death rate per thousand exposed to risk is not, at least according to English experience, decidedly excessive at certain periods of life. The data are not of sufficient importance to invalidate the general conclusion, and in the main the death rates sustain the proportionate mortality figure, although this is not invariably the case. The death rate from nontuberculous respiratory diseases among men employed in occupations with exposure to mineral dust, according to the English experience, is at the older ages so decidedly excessive that obviously much more extended scientific consideration should be given to this group of diseases than has heretofore been given it. At ages 55 to 64, for illustration, in the English experience there is an actual excess in the mortality from all causes among men exposed to mineral dust of 9.22 per 1,000, equivalent to 29.7 per cent, but in the mortality from pulmonary tuberculosis there is an excess of 1.78 per 1,000, equivalent to 82.4 per cent, against an excess of 6.32 per 1,000 in the mortality from nontuberculous respiratory diseases, equivalent to 96.6 per cent. The results of this analysis, therefore, reemphasize the scientific conclusiveness of the extended discussion on "Industrial pneumoconiosis with special reference to dust phthisis," by Edgar L. Collis, in the Milroy Lectures of 1915, and the corresponding observations on pneumoconiosis by Sir Thomas Oliver in Allbutt & Rolleston's System of Medicine, Volume V, Diseases of the Respiratory System.

Of interest in this connection are the observations by Dr. J. S. Haldane contained in a contribution to the Proceedings of the Institution of Mining Engineers, abstracted in a letter from London to the Journal of the American Medical Association, August 19, 1916. In the paper referred to Dr. Haldane pointed out "that while up to the age of 50 the death rate from lung disease is much lower among colliers than in the rest of the population, above 50 the opposite holds, and there is a marked excess of deaths from bronchitis." In continuation, however, he stated that "the deaths from this disease have greatly diminished since 1890, for which improved ventilation seems to be the cause. Fifty years ago miners often worked in air containing so much black damp that lamps and candles burned dimly. In such air there is usually 2 or 3 per cent of carbon dioxide, which enormously increases the breathing during muscular exertion. The breathing is exactly regulated so as to keep an average of about 5.6 per cent carbon dioxide in the alveolar air; and with 3 per cent of this gas in the air, a man breathes twice as much air, so as to keep the alveolar percentage right. A man doing moderate muscular work in pure air breathes about five or six times as much air as during rest. In air containing 3 per cent of carbon dioxide he would be breathing ten or twelve times as much air as during rest, and his breathing would be taxed to the utmost. He would thus be much more liable to contract emphysema. The better ventilation of coal mines is largely a consequence of the greater amount of fire damp and great heat encountered as mines have become deeper."

Dr. Haldane is inclined to think "that both the fire damp and the heat have indirectly caused great improvement to the health of miners. Where there is plenty of fire damp there is usually also plenty of fresh and dry air, and no harmful excess of carbon dioxide. The proportion of deaths from bronchitis among old miners was higher in Staffordshire in 1890–1892 and 1900–1902 than in any of the other coal fields; and Staffordshire mines are exceptionally subject to black damp. The excess in bronchitis among old coal miners has been attributed to the breathing of dust," and Dr. Haldane was "previously inclined to agree with this theory. But it is difficult to see why, if dust is the cause, there has been so great a diminution in

the bronchitis mortality in recent years. Coal mines have, on the whole, become drier and more dusty with increasing depth and better ventilation; and, if dust were the cause, one would have expected the bronchitis to increase, whereas it has greatly diminished. Certainly an excess in mortality from bronchitis is associated with the breathing of harmful dust. But this excess is accompanied by a far greater excess in mortality from phthisis, and begins comparatively early in life, unlike the bronchitis mortality in colliers. Experiments on animals carried out by J. M. Beattie show that both coal dust and the shale dust usually associated with it on mine roads are relatively harmless."

It is therefore quite clear that much remains to be ascertained concerning the true nature and extent of dust phthisis and that in the solution of this important industrial problem a considerable advance is necessary in the practice of medicine, which to a much larger degree should be made to rest upon knowledge concerning disease causation ascertained by means of autopsies in industrial districts subject to an excessive mortality from pulmonary tuberculosis and nontuberculous respiratory diseases.

ASBESTOS.

The number of men employed in trades and industries involving exposure to asbestos dust in the United States is unknown. Aside from the mining of asbestos, in which exposure is rather limited, there are numerous processes involving the conversion or remanufacture of the materials which are distinctly more serious in their effects on health and longevity. Asbestos weaving and spinning are described by Netolitzki on the basis of observations in Bohemia, where the conditions were found to be decidedly unfavorable. For this country our information is very limited, although the quantity of asbestos used is very large. Its fire-resisting properties have led to its extensive employment for the covering of pipes, furnaces, etc., as well as its use in the form of wall plaster, roofing material, etc. On account of its nonconducting qualities it is extensively employed by electricians and also in the construction of storage rooms of refrigerating plants.

METHODS OF MINING.

"Geologically," according to the Technical World Magazine,[1] "asbestos is a fibrous form of serpentine rock, occurring in strata of crystalline limestone. The veins run in an average thickness of one-fourth to one-half inch, but sometimes attain to as much as 6 inches.

[1] "Mining mineral wool," by Aubrey Fullerton, in Technical World Magazine, May, 1906.

The asbestos fibers are, as nearly as possible, crystals of serpentine rock." According to the same magazine—

> The ore is mined mostly in open quarries. Overlying soil, to a thickness of sometimes 20 or 30 feet, but quite often forming only a thin layer on top, has first to be removed; and as soon as the asbestos veins are thus laid bare, the actual quarrying operations may begin. The rock is cut in a series of terraces, reaching a total depth of sometimes 150 or 200 feet. Underground work has not proved successful, the open quarry having been found both more economical and more effective, despite the disadvantages of exposure to the weather. Drilling and blasting are employed much the same as in ordinary stone quarrying.
>
> When the rock is thus broken up it is rough sorted at the quarry. Two or more grades are selected, according to the length of the fiber, and are then sent on to the "cobbing sheds," where the further process of dressing goes on. This process is merely the separation of the asbestos fibers from the dead rock, and is done in some cases by hand, but to an increasing extent by machine. Hand cobbing is the very simple method of breaking the stone by small sledge hammers, throwing the fiber into one box and the waste into another. This separation is ordinarily not difficult, since the fiber lies in layers more or less loosely clinging to the rock, and can frequently be picked off with the fingers. The crude fiber, thus separated as cleanly as possible from the waste rock and looking very much like mineralized wool, is packed in 100-pound bags, in which form it goes to the market and the manufacturer.
>
> Hand dressing is not, however, an absolutely thorough method. The waste material from the cobbing tables and the fine pickings from the quarries have still some fiber in them, and the utilization of this frequently represents the largest profits of the mine. All these fine pickings are mechanically dressed. In case the asbestos contains a large percentage of water, the moisture is first dried out, by exposure to the air, by steam pipes, or by rotary driers, and the rock is then passed on to the crushers, where it is broken by successively finer-set rolls. Cylindrical fiberizers and the cyclone machine reduce it still further. The latter is the most effective apparatus yet devised for asbestos separation. It consists of two beaters, one of the screw-propeller type, driven within a cast-iron chamber at a violent speed, reducing the particles of stone almost to a powder. This is then passed over a shaking screen to remove the sand, and in some mills strong electric magnets are used to take up the particles of iron.

In all of these operations there must necessarily be a considerable degree of dust exposure, which, however, becomes exaggerated in the spinning and weaving processes in connection with the manufacture of asbestos yarn and cloth. These processes are briefly referred to in an article in the Engineering Magazine,[1] in part, as follows:

> The spinning and weaving of asbestos have offered many difficulties, as the asbestos fibers have no rough surface like wool or cotton, but

[1] "Asbestos, its mining, preparation, markets, and use," by E. Schaaf-Regelman, Engineering Magazine, Oct. 1907.

are very smooth, and thus have a tendency to slip by one another when twisted and subject to tension. An admixture of vegetable or animal fiber was therefore often necessary, but, while these facilitated the manufacturing operations, they impaired the fire resistance of the fabric, and special machinery and ingenious devices had to be invented to enable the successful spinning of a pure asbestos yarn. It is, however, now possible to make a single asbestos thread which, though weighing no more than 1 ounce per hundred yards, has a fair strength, and braided material can be made much more resistant to torsion and tension, while asbestos ropes, chiefly used by the fire department, can be strengthened either by interwoven wires or by having a wire-rope core.

HEALTH-INJURIOUS OCCUPATIONAL CONDITIONS.

On account of the rather limited extent of the asbestos industry in the United States, at least in the large centers of population, the industrial insurance mortality experience data are insufficient for definite conclusions. During the period 1907 to 1914 in the Prudential experience there were only 13 deaths, of which 3, or 23.1 per cent, were from pulmonary tuberculosis. At ages 25 to 44, there were 6 deaths, of which 3, or 50 per cent, were from this disease. Asbestos dust is not described in the extensive consideration of Dust Hazards, by Hayhurst, nor by W. Gilman Thompson in his treatise on The Occupational Diseases. In 1914 the production of asbestos in the United States was only 1,247 tons, or much less than in earlier years, indicating a very limited available source of supply. Most of the asbestos used in the United States is mined in Canada, and an excellent report on "Asbestos, its occurrence, exploitation, and use," has been published by the mines branch of the Department of the Interior of the Dominion of Canada (Ottawa, 1905), which contains a descriptive account of mining methods and of the dressing of asbestos by hand or by mechanical treatment, including the final crushing by means of rollers, fiberizers, beaters, cyclones, and pulverizers. All of these processes unquestionably involve a considerable dust hazard, but the hygienic aspects of the industry have not been reported upon. It may be said, in conclusion, that in the practice of American and Canadian life insurance companies asbestos workers are generally declined on account of the assumed health-injurious conditions of the industry.[1]

It is regrettable that there should be no further information available regarding the asbestos industry in its various branches, including the utilization of by-products of manufacture, on account of the self-evident injuriousness of asbestos dust as a predisposing cause of pulmonary tuberculosis. The subject is not referred to by Kober

[1] For a descriptive account of the Canadian asbestos district, see Engineering and Mining Journal, New York, Apr. 30, 1910.

and Hanson in their recently published treatise on Diseases of Occupation and Vocational Hygiene, nor by Sir Thomas Oliver in his recent work on Diseases of Occupation. The rapidly increasing development of industries using asbestos, as ascertained from domestic or foreign sources, suggests the urgency of more qualified medical consideration than has heretofore been given the subject. There are no references to asbestos in the Index Catalogue of the Surgeon General's Library, which, however, brings the literature of the subject down only to 1896. The discussion of asbestos in the annual reports of the United States Geological Survey on Mineral Resources is limited entirely to the technical aspects of the mining industry, which during recent years has experienced a rather retrograde movement in that the production has diminished from a maximum of 7,600 tons in 1911 to 1,247 tons in 1914. In contrast, however, there has been a gradual increase in the quantity of the unmanufactured asbestos imported, chiefly from Canada. The American production is practically limited to the States of Arizona, California, Georgia, and Vermont. Georgia has for years been one of the chief producers of asbestos in the United States, but no medical observations are on record as regards the possibly injurious results experienced in the mining and manufacturing of asbestos materials in that State. The industry itself has been described, however, in a report on the asbestos, talc, and soapstone deposits of Georgia in Bulletin No. 29 of the Georgia Geological Survey, 1914.

EVIDENCE OF DUST EXPOSURE.

The relation of asbestos dust to pulmonary tuberculosis is reported upon at some length in the Annual Report of the Chief Inspector of Factories and Workshops for England and Wales for 1910. The investigation was made by Dr. Collis, who states, in part, that—

> Following up information received from the registrar-general, it was found that five deaths of persons suffering from phthisis had occurred in five years among a staff of under 40 workers employed at a factory where asbestos is woven. The process which appeared most dangerous is the production of asbestos mattresses. These mattresses, which are composed of bags of woven asbestos filled with short asbestos fiber, are placed on a table and beaten out flat by a man with a wooden flail, from which process much dust arises. Women who sew the mattresses into sections with asbestos threads worked close to the man who beat the mattresses and of necessity inhaled the dust. The reorganization of this process with the application of localized exhaust draft was called for, and an annual medical examination of the workers by the certifying surgeon has been instituted in the hope of detecting and removing from exposure to dust those showing early signs of respiratory disease. Weaving asbestos has only become an important industry during the last 15 years. Two other large asbestos factories were visited, each of which was found to have its own specialty in the production of which dust prevention is required

There is evidently an urgent need for a more qualified and extensive investigation of the health aspects of asbestos manufacture, especially so, in view of the fact, as observed in the Scientific American (August 1, 1916), that, on account of the restrictions placed upon shipments of asbestos from Canada, the possibilities of utilizing the asbestos deposits of this country are increased, as well as because of the much larger demand for asbestos products on account of the recognized value of asbestos for protective purposes in the furtherance of the industrial safety movement. Of value in this connection is the evidence of Dr. H. M. Murray before the Departmental Committee on Industrial Diseases, limited, however, to the single case of an asbestos worker, verified as regards diagnosis by a post mortem examination. In reply to a question by the chairman of the committee as to whether, in view of the fact "that there is something characteristic in the earlier stages of dust phthisis in the predominance of shortness of breath before physical signs become very obvious," such a condition had been observed in the case of the asbestos worker under treatment by Dr. Murray, and under observation for fourteen months, the doctor said that it had been noticed in the case in question, and that, in other words, there was a definite relation between the course of phthisis and the physical incapacity resulting from the inhalation of asbestos dust. It is therefore to be anticipated that the condition of asbestos workers will attract more qualified attention in this country in the future than it has in the past.

MICA.

No special investigation has been made to ascertain the more or less health-injurious effects of mica dust. According to W. Gilman Thompson the dust is slightly irritating to the respiratory system, like dust containing any sharp solid particles, but as a general conclusion he states that the dust does not appear to be particularly injurious. Mica is extensively used in the manufacture of electrical machinery, as well as in the glazing trade, as a substitute for glass, and in the decorative trades, including the manufacture of wall paper. There are two principal varieties of mica, known as muscovite and phlogopite, but whether there is any essential difference between the physical and mechanical properties of the dust has not been determined. There are mica deposits in some 20 States of the United States, but the annual production has fluctuated considerably, reaching the lowest point in the last decade during 1914. Whether there are any special hazards in mica mining in consequence of the dust has not been ascertained. The occurrence, exploitation, and use of mica have been admirably described in a report published by the mines branch of the Department of the Interior of Canada. The report, however, includes no observations on the sanitary aspects of the various employments. It is pointed out, with special reference to the manufacture of ground mica, that the difficulties of grinding are great, owing to the tough and scaly nature of the mineral, which may be assumed to indicate that even when reduced to a fine powder the dust is apparently not of very serious importance to the employees.

Mica dust is briefly referred to by Kober and Hanson in their Diseases of Occupation and Vocational Hygiene, in which it is said that mica is "a mineral of widely varying chemical composition, but is essentially composed of silicates of aluminum and an alkali, such as potassium, sodium, or lithium." It is stated that the mineral splits easily into thin, flexible, colorless, transparent plates or scales, known as isinglass, and that in the powdered form it is employed in the manufacture of giant powder, and that it is also used for decorative purposes, chiefly in the manufacture of wall paper, illuminated designs, etc. The only medical conclusion arrived at by the authors is that "mica dust is doubtless a frequent cause of inflammatory conditions of the eyes and air passages." It is therefore suggested by inference that the dust in finely comminuted form may also have an irritating effect upon lung tissue, and to that extent predispose mica workers to pulmonary tuberculosis, although much more extended observations are required before definite conclusions can be arrived at.[1]

THE STONE INDUSTRY.

The stone industry in the United States is of vast areal extent and commercial importance. The product for 1914 was valued at nearly $80,000,000. Stone is quarried or produced in every State and Territory, and the number of persons employed in the stone industry exceeds 100,000. The principal varieties are granite, trap rock, marble, limestone, and sandstone. The industry may broadly be divided into the manufacture of crushed stone for road making and other purposes, paving stone, building stone, and monumental stone. The two latter are subdivided into rough and dressed products. The labor conditions in an industry of such vast extent and fundamental differences in the nature of the product must neces-

[1] For a valuable descriptive account of mica, see the National Museum Report, 1899, p. 283.

For a discussion of mica mining in the United States with special reference to underground conditions, see an article in the Engineering and Mining Journal, May 8, 1909. With reference to mining methods in Canada, see an article in the same publication in the issue of April 18, 1908.

See also an extended discussion by Mr. C. Hanford Henderson on "Mica and the mica mines," in the Popular Science Monthly for Sept., 1892.

According to a statement by the manager of the Crown Mica Co., of Custer City, S. D., "Mica mining is considered very healthy, as most of it is done in open cuts."