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# MORTALITY FROM RESPIRATORY DISEASES IN DUSTY TRADES

(INORGANIC DUSTS)

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## CONTENTS.

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# 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 on "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 predisposition of the damaged 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. 3, Washington, 1916.

[2] See also an article in the Scientific American Supplement, July 1, 1916, on "Modern 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 reduces 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 letterpress 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

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[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 | 150.3 |
| 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 prominent symptoms.

## 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 the English language.

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; and even if, as we have said, the disease becomes complicated with tubercle, yet the rate of progress may be determined rather by the character 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. 46 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— | | | | | Per cent 45 years and over. |
|---|---|---|---|---|---|---|---|
| | | 10 to 13. | 14 to 15. | 16 to 20. | 21 to 44. | 45 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 | 320 | 1,769 | 895 | 29.7 |
| Gold beaters | 607 | ........ | 12 | 103 | 327 | 165 | 27.2 |
| Grinders | 8,214 | ........ | 93 | 1,070 | 5,346 | 1,705 | 20.8 |
| Grinders, card | 1,087 | ........ | 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 | 88 | 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 | ........ | 28 | 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.**

| Sex and occupation group. | Total employees. | 10 to 13. | 14 to 15. | 16 to 20. | 21 to 44. | 45 and over. | Per cent 45 years and over. |
|---|---|---|---|---|---|---|---|
| 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 | 8.4 |
| 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 | 224 | 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 | 2,438 | 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.

| Sex and occupation group. | Total employees. | 10 to 13. | 14 to 15. | 16 to 20. | 21 to 44. | 45 and over. | Per cent 45 years and over. |
|---|---|---|---|---|---|---|---|
| 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 | 134 | 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 | 204 | 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 | 94 | 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 | 9,002 | 1,566 | 10.7 |
| Woolen and worsted mills | 33,186 | 98 | 3,203 | 12,465 | 15,584 | 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. | 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— 10 to 13. | 14 to 15. | 16 to 20. | 21 to 44. | 45 and over. | Per cent 45 years 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.

| Sex and occupation group. | Total employees. | 10 to 13. | 14 to 15. | 16 to 20. | 21 to 44. | 45 and over. | Per cent 45 years and over. |
|---|---|---|---|---|---|---|---|
| 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 cutters, coppersmiths, engravers, printers, lithographers, nail makers, machinists, gunsmiths, etc. Persons in all of these employments or industries are subject, as a general rule, to an exceptionally high mortality rate from all causes, and a high specific death rate from pulmonary tuberculosis. Some employments in addition are subject to an excessive incidence of nontuberculous respiratory diseases, and particularly is this the case where there is quantitatively a considerable degree of intermixture with silica and similar forms of excessively irritating kinds of mineral dust. The most common form of tuberculosis in occupations with iron and steel dust exposure is medically known as pneumoconiosis, met with in its most typical form in steel grinding and polishing processes, particularly in the manufacture of cutlery and tools and instruments.

## RELATION OF VARIATIONS IN OCCUPATIONAL CONDITIONS TO DUST EXPOSURE AND MORTALITY.

The conditions of employment in the 13 industries, trades, and occupations which are considered in detail in the following discussion are so widely at variance with each other that a grouping of the mortality data results in averages which are applicable only with extra caution to particular employments with a more or less ascertainable degree of exposure to metallic dust. Such exposure is nearly always an important predisposing cause of pulmonary tuberculosis and is met with to an exceptional degree of frequency in the grinding and polishing of small metallic objects during the final (finishing) stages of manufacture. On account of the high degree of specialized skill required in many of these occupations, the social loss represented by prolonged illness and premature death from preventable pulmonary tuberculosis is, therefore, of special economic significance.

## PROPORTIONATE MORTALITY—UNITED STATES REGISTRATION AREA.

Table 7 is merely intended as a general statement of the essential mortality facts concerning this group of occupations, with special reference to pulmonary tuberculosis, derived from the available official statistics of the Division of Vital Statistics of the United States Census. Subsequently, in addition thereto, tables are included of the more 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 occupations under review with a more or less ascertainable degree of health-injurious exposure to metallic dust.

TABLE 7.—PROPORTIONATE MORTALITY FROM PULMONARY TUBERCULOSIS AMONG WORKERS EXPOSED TO METALLIC DUST, UNITED STATES REGISTRATION AREA, 1908 AND 1909, BY AGE GROUPS.

| Age at death. | Workers exposed to metallic dust. | | | Per cent of deaths from pulmonary tuberculosis among— | |
|---|---|---|---|---|---|
| | Deaths from all causes. | Deaths from pulmonary tuberculosis. | | All occupied males. | Farmers, planters, and farm laborers. |
| | | Number. | Per cent of deaths from all causes. | | |
| 15 to 24 years | 1,230 | 412 | 33.5 | 28.1 | 23.5 |
| 25 to 34 years | 2,006 | 719 | 35.8 | 30.9 | 26.2 |
| 35 to 44 years | 2,291 | 656 | 28.6 | 24.0 | 19.1 |
| 45 to 54 years | 2,166 | 378 | 17.5 | 14.4 | 12.1 |
| 55 to 64 years | 1,738 | 150 | 8.6 | 7.6 | 6.7 |
| 65 years and over | 1,944 | 80 | 4.1 | 2.6 | 2.4 |
| Age unknown | 10 | 1 | 10.0 | 8.3 | 7.9 |
| Total, 15 years and over | 11,385 | 2,396 | 21.0 | 14.9 | 8.7 |

In Table 8 are given data relative to the proportionate mortality from nontuberculous respiratory diseases among workers exposed to metallic dust, 1908 and 1909.

TABLE 8.—PROPORTIONATE MORTALITY FROM NONTUBERCULOUS RESPIRATORY DISEASES AMONG WORKERS EXPOSED TO METALLIC DUST, UNITED STATES REGISTRATION AREA, 1908 AND 1909.

| Cause of death. | Deaths of workers exposed to metallic dust. | | Per cent of deaths from all causes among— | |
|---|---|---|---|---|
| | Number. | Per cent of deaths from all causes. | All occupied males. | Farmers, planters, and farm laborers. |
| Asthma | 23 | 0.2 | 0.3 | 0.3 |
| Bronchitis | 92 | .8 | .9 | 1.2 |
| Pneumonia | 969 | 8.5 | 7.8 | 7.0 |
| Other nontuberculous respiratory diseases | 132 | 1.2 | 1.1 | .9 |
| Total | 1,216 | 10.7 | 10.0 | 9.3 |

The aggregate experience, according to Table 7, for the two years under observation (no subsequent official statistics having been published), indicates a proportionate mortality from pulmonary tuberculosis among those employed in occupations with exposure to metallic dust of 21 per cent. As subsequently shown, this compares with 21.3 per cent for occupations with exposure to mineral dust as ascertained by an analysis of the corresponding data derived from the same official sources. The table indicates an excessive degree of frequency of pulmonary tuberculosis at every divisional period of life, but by reference to the corresponding statistics for occupations with exposure to mineral dust the latter present an even more serious tendency toward an excess in the proportionate mortality; but upon further analysis of the occupations in detail it is shown that exposure to metallic dust is unquestionably on general principles more of a menace to health with particular reference to pulmonary tuberculosis than is exposure to mineral dust. In addition to an excessive mortality from pulmonary tuberculosis the comparative mortality from nontuberculous respiratory diseases, particularly pneumonia, is higher among occupations with exposure to metallic dust than among occupations with exposure to mineral 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 for the two years, 1908 and 1909, are, for purposes of convenience, shown in Table 9.

TABLE 9.—PROPORTIONATE MORTALITY FROM PULMONARY TUBERCULOSIS IN SPECIFIED INDUSTRIES OR OCCUPATIONS WITH EXPOSURE TO METALLIC 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. |
| Brass workers | 25 | 16 | 64.0 | 42 | 21 | 50.0 | 35 | 11 | 31.4 | 48 | 8 | 16.7 |
| Engravers | 10 | 5 | 50.0 | 23 | 8 | 34.8 | 20 | 5 | 25.0 | 15 | 1 | 6.7 |
| Iron and steel workers | 460 | 91 | 19.8 | 915 | 239 | 26.1 | 1,084 | 253 | 23.3 | 992 | 166 | 16.7 |
| Iron and steel workers (listed as other) | 86 | 22 | 25.6 | 149 | 53 | 35.6 | 150 | 51 | 34.0 | 136 | 27 | 19.9 |
| Jewelers, gold and silver workers, etc | 66 | 33 | 50.0 | 78 | 31 | 39.7 | 94 | 22 | 23.4 | 128 | 18 | 14.1 |
| Metal workers, other | 52 | 18 | 34.6 | 82 | 28 | 34.1 | 93 | 21 | 22.6 | 77 | 12 | 15.6 |
| Printers, lithographers, pressmen | 427 | 186 | 43.6 | 551 | 278 | 50.5 | 614 | 223 | 36.3 | 522 | 112 | 21.5 |
| Tinplate and tinware workers | 104 | 41 | 39.4 | 166 | 61 | 36.7 | 201 | 70 | 34.8 | 248 | 34 | 13.7 |
| Total | 1,230 | 412 | 33.5 | 2,006 | 719 | 35.8 | 2,291 | 656 | 28.6 | 2,166 | 378 | 17.5 |

| 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. |
| Brass workers | 26 | 4 | 15.4 | 25 | 4 | 16.0 | ........ | ...... | ..... | 201 | 64 | 31.8 |
| Engravers | 19 | 3 | 15.8 | 25 | 1 | 4.0 | ........ | ...... | ..... | 112 | 23 | 20.5 |
| Iron and steel workers | 754 | 64 | 8.5 | 826 | 39 | 4.7 | 4 | 1 | 25.0 | 5,035 | 853 | 16.9 |
| Iron and steel workers (listed as other) | 133 | 19 | 14.3 | 145 | 7 | 4.8 | 1 | ...... | ..... | 800 | 179 | 22.4 |
| Jewelers, gold and silver workers, etc | 142 | 12 | 8.5 | 177 | 6 | 3.4 | 1 | ...... | ..... | 686 | 122 | 17.8 |
| Metal workers, other | 73 | 5 | 6.8 | 97 | 1 | 1.0 | 1 | ...... | ..... | 475 | 85 | 17.9 |
| Printers, lithographers, pressmen | 350 | 27 | 7.7 | 381 | 14 | 3.7 | 2 | ...... | ..... | 2,847 | 840 | 29.5 |
| Tinplate and tinware workers | 241 | 16 | 6.6 | 268 | 8 | 3.0 | 1 | ...... | ..... | 1,229 | 230 | 18.7 |
| Total | 1,738 | 150 | 8.6 | 1,944 | 80 | 4.1 | 10 | 1 | 10.0 | 11,385 | 2,396 | 21.0 |

Table 10 shows the proportionate mortality from nontuberculous respiratory diseases in occupations with exposure to metallic dust.

TABLE 10.—PROPORTIONATE MORTALITY FROM NONTUBERCULOUS RESPIRATORY DISEASES IN SPECIFIED INDUSTRIES OR OCCUPATIONS WITH EXPOSURE TO METALLIC DUST, UNITED STATES REGISTRATION AREA, 1908 AND 1909.

| Occupation group. | Deaths caused by— | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Asthma. | | Bronchitis. | | Pneumonia. | | Other respiratory diseases. | | All nontuberculous respiratory diseases. | |
| | Number. | Per cent. | Number. | Per cent. | Number. | Per cent. | Number. | Per cent. | Number. | Per cent. |
| Brass workers | ........ | ........ | 3 | 1.5 | 18 | 9.0 | 1 | 0.5 | 22 | 10.9 |
| Engravers | ........ | ........ | ........ | ........ | 3 | 2.7 | 1 | .9 | 4 | 3.6 |
| Iron and steel workers | 12 | 0.2 | 35 | .7 | 508 | 10.1 | 54 | 1.1 | 609 | 12.1 |
| Iron and steel workers (listed as other) | 2 | .3 | 11 | 1.4 | 54 | 6.7 | 11 | 1.4 | 78 | 9.8 |
| Jewelers, gold and silver workers | 2 | .3 | 8 | 1.2 | 40 | 5.8 | 7 | 1.0 | 57 | 8.3 |
| Metal workers, other | 2 | .4 | 6 | 1.3 | 49 | 10.3 | 5 | 1.1 | 62 | 13.1 |
| Printers, lithographers, pressmen | 2 | .1 | 14 | .5 | 193 | 6.8 | 41 | 1.4 | 250 | 8.8 |
| Tinplate and tinware workers | 3 | .2 | 15 | 1.2 | 104 | 8.5 | 12 | 1.0 | 134 | 10.9 |
| Total | 23 | .2 | 92 | .8 | 969 | 8.5 | 132 | 1.2 | 1,216 | 10.7 |

## PROPORTIONATE MORTALITY—INDUSTRIAL INSURANCE EXPERIENCE.

The industrial mortality experience of the Prudential Insurance Co. of America is more conclusive, in that the number of specific occupations is more representative of the industries and employments with exposure to metallic dust when considered as a group.[1] The details of the experience are set forth in Tables 11 and 12.

[1] Additional insurance experience data are contained in Bulletin No. 207 of the Bureau of Labor Statistics of the U. S. Department of Labor, entitled "Causes of Death by Occupation," Occupational Mortality Experience of the Metropolitan Life Insurance Company, Industrial Department, 1911–1913, by Louis I. Dublin, Ph. D., Washington, 1917. This experience, however, with reference to dusty trades with exposure to inorganic dust is practically limited to blacksmiths, coal miners, compositors and printers, iron molders, machinists, masons and bricklayers, painters, paper hangers, and varnishers, and plumbers, gas fitters, and steam fitters. The most recent data are for the year 1914, for the city of New York (Reprint No. 400, U. S. Public Health Service, Washington, 1917), for selected occupations. The proportionate mortality from pulmonary tuberculosis was as follows:

*Proportionate mortality (per cent of all causes) from pulmonary tuberculosis, New York City, 1914.*

| Occupation. | Years of age. | | | | | |
|---|---|---|---|---|---|---|
| | 15 to 24 | 25 to 34 | 35 to 44 | 45 to 54 | 55 to 64 | 65 and over. |
| Blacksmiths | ........ | 23.5 | 33.3 | 15.1 | 3.4 | 3.5 |
| Cigar makers and tobacco workers | 40.0 | 21.0 | 31.4 | 31.1 | 17.6 | 6.2 |
| Compositors, printers, etc | 53.0 | 66.6 | 35.7 | 27.6 | 19.2 | 10.3 |
| Machinists | 40.5 | 30.6 | 34.4 | 24.6 | 16.3 | 1.8 |
| Painters, paperhangers, and varnishers | 18.2 | 45.1 | 32.2 | 23.7 | 21.5 | 6.1 |
| Teamsters and drivers | 35.0 | 45.2 | 44.0 | 28.7 | 12.1 | 5.9 |
| All occupations | 33.6 | 33.5 | 24.8 | 15.9 | 7.8 | 1.9 |

TABLE 11.—PROPORTIONATE MORTALITY FROM PULMONARY TUBERCULOSIS AMONG WORKERS EXPOSED TO METALLIC DUST, INDUSTRIAL EXPERIENCE OF PRUDENTIAL CO., 1897 TO 1914, BY AGE GROUPS.

| Age at death. | Workers exposed to metallic dust. | | | Per cent of deaths due to pulmonary tuberculosis among all occupied males. |
|---|---|---|---|---|
| | Deaths from all causes. | Deaths from pulmonary tuberculosis. | | |
| | | Number. | Per cent of deaths from all causes. | |
| 15 to 24 years | 1,912 | 812 | 42.5 | 33.2 |
| 25 to 34 years | 2,504 | 1,243 | 49.6 | 40.9 |
| 35 to 44 years | 2,449 | 966 | 39.4 | 32.9 |
| 45 to 54 years | 1,889 | 420 | 22.2 | 19.0 |
| 55 to 64 years | 1,541 | 170 | 11.0 | 8.8 |
| 65 years and over | 1,267 | 49 | 3.9 | 2.9 |
| Age unknown | 1 | | | |
| Total, 15 years and over | 11,563 | 3,660 | 31.7 | 20.5 |

TABLE 12.—PROPORTIONATE MORTALITY FROM NONTUBERCULOUS RESPIRATORY DISEASES AMONG WORKERS EXPOSED TO METALLIC DUST, INDUSTRIAL EXPERIENCE OF PRUDENTIAL CO., 1897 TO 1914.

| Cause of death. | Deaths of workers exposed to metallic dust. | | Per cent of deaths from all causes among all occupied males. |
|---|---|---|---|
| | Number. | Per cent of deaths from all causes. | |
| Asthma | 74 | 0.6 | 0.6 |
| Bronchitis | 116 | 1.0 | 1.1 |
| Pneumonia | 1,003 | 8.7 | 8.8 |
| Other nontuberculous respiratory diseases | 182 | 1.6 | 1.4 |
| Total | 1,375 | 11.9 | 11.9 |

The insurance experience is not strictly comparable with the general mortality for the country at large in that the principle of adverse selection should be considered in view of the fact that only a considerable proportion of the adult risks accepted for industrial insurance are at entry required to submit to a thorough medical examination. A much more important factor, however, is that the occupational analysis in the Prudential experience is more strictly limited to specific occupations with metallic 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. According to Table 11, the proportionate mortality from pulmonary tuberculosis in occupations with exposure to metallic dust is 31.7 per cent for all ages, which compares with 21 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 2,504 deaths from all causes among men with exposure to metallic dust, 1,243, or 49.6 per cent, were deaths from pulmonary tuberculosis. The two groups of occupations are not identical and erroneous inferences must be guarded against which might seem justified in view of the apparent discrepancies in the results. Each class of data requires to be considered by itself, for under existing conditions no identical groupings can be made for the occupation mortality of the registration area and the more selected occupation mortality of the industrial insurance company previously referred to. The extremely high proportionate mortality from pulmonary tuberculosis, particularly at the younger ages, among occupations with exposure to metallic dust confirms the earlier conclusion that this form of dust exposure must be considered as the contributory cause of the most serious form of pneumoconiosis, or dust phthisis, as the disease has been called in a strictly scientific discussion of the subject by Collis in the Milroy Lectures, 1915.

The proportionate mortality by specific industries or occupations and by divisional periods of life is shown in Table 13, 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 scientific interpretation of the data derived, as explained, from quite different sources.

TABLE 13.—PROPORTIONATE MORTALITY FROM PULMONARY TUBERCULOSIS IN SPECIFIED INDUSTRIES OR OCCUPATIONS WITH EXPOSURE TO METALLIC DUST, INDUSTRIAL EXPERIENCE OF PRUDENTIAL CO., 1897 TO 1914, 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. |
| Artificial-flower makers | 1 | 1 | 100.0 | 2 | 1 | 50.0 | ........ | ...... | ..... | 4 | 1 | 25.0 |
| Brass workers | 91 | 53 | 58.2 | 149 | 76 | 51.0 | 146 | 64 | 43.8 | 99 | 24 | 24.2 |
| Compositors and typesetters | 795 | 368 | 46.3 | 904 | 505 | 55.9 | 851 | 350 | 41.1 | 567 | 141 | 24.9 |
| Cutlery makers | 11 | 3 | 27.3 | 11 | 5 | 45.5 | 11 | 4 | 36.4 | 8 | 1 | 12.5 |
| Die setters and sinkers | 5 | 3 | 60.0 | 10 | 2 | 20.0 | 5 | 1 | 20.0 | 4 | 1 | 25.0 |
| Electrotypers and stereotypers | 9 | 5 | 55.6 | 20 | 9 | 45.0 | 19 | 4 | 21.1 | 9 | 3 | 33.3 |
| Engravers | 71 | 28 | 39.4 | 92 | 50 | 54.3 | 74 | 35 | 47.3 | 63 | 10 | 15.9 |
| Gold beaters | 7 | 3 | 42.9 | 12 | 8 | 66.7 | 11 | 4 | 36.4 | 8 | 2 | 25.0 |
| Grinders | 17 | 7 | 41.2 | 56 | 38 | 67.9 | 74 | 44 | 59.5 | 73 | 35 | 47.9 |
| Iron and steel workers | 403 | 121 | 30.0 | 630 | 215 | 34.1 | 648 | 214 | 31.3 | 606 | 89 | 14.7 |
| Jewelers | 110 | 56 | 50.9 | 144 | 84 | 58.3 | 106 | 48 | 45.3 | 132 | 28 | 21.2 |
| Polishers | 136 | 59 | 43.4 | 230 | 129 | 56.1 | 241 | 106 | 44.0 | 173 | 43 | 24.9 |
| Pressmen | 168 | 72 | 42.9 | 151 | 72 | 47.7 | 116 | 51 | 44.0 | 45 | 9 | 20.0 |
| Tool and instrument makers | 88 | 33 | 37.5 | 93 | 49 | 52.7 | 111 | 41 | 36.9 | 98 | 33 | 33.7 |
| Total | 1,912 | 812 | 42.5 | 2,504 | 1,243 | 49.6 | 2,449 | 966 | 39.4 | 1,889 | 420 | 22.2 |

TABLE 13.—PROPORTIONATE MORTALITY FROM PULMONARY TUBERCULOSIS IN SPECIFIED INDUSTRIES OR OCCUPATIONS, ETC.—Concluded.

| Occupational 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. |
| Artificial-flower makers | 4 | 1 | 25.0 | 2 | | | | | | 13 | 4 | 30.8 |
| Brass workers | 93 | 15 | 16.1 | 55 | | | | | | 633 | 232 | 36.7 |
| Compositors and typesetters | 427 | 42 | 9.8 | 318 | 14 | 4.4 | 1 | | | 3,863 | 1,420 | 36.8 |
| Cutlery makers | 8 | 3 | 37.5 | 6 | 1 | 16.7 | | | | 55 | 17 | 30.9 |
| Die setters and sinkers | 3 | 1 | 33.3 | 1 | | | | | | 28 | 8 | 28.6 |
| Electrotypers and stereotypers | 6 | 1 | 16.7 | 2 | | | | | | 65 | 22 | 33.8 |
| Engravers | 41 | 3 | 7.3 | 43 | 1 | 2.3 | | | | 384 | 127 | 33.1 |
| Gold beaters | 4 | | | 11 | | | | | | 53 | 17 | 32.1 |
| Grinders | 55 | 14 | 25.5 | 30 | 5 | 16.7 | | | | 305 | 143 | 46.9 |
| Iron and steel workers | 550 | 48 | 8.7 | 459 | 13 | 2.8 | | | | 3,332 | 700 | 21.0 |
| Jewelers | 144 | 16 | 11.1 | 176 | 6 | 3.4 | | | | 812 | 238 | 29.3 |
| Polishers | 112 | 16 | 14.3 | 72 | 2 | 2.8 | | | | 964 | 355 | 36.8 |
| Pressmen | 27 | 3 | 11.1 | 16 | | | | | | 523 | 207 | 39.6 |
| Tool and instrument makers | 67 | 7 | 10.4 | 76 | 7 | 9.2 | | | | 533 | 170 | 31.9 |
| Total | 1,541 | 170 | 11.0 | 1,267 | 49 | 3.9 | 1 | | | 11,563 | 3,360 | 31.7 |

On account of the importance of nontuberculous respiratory diseases Table 14 is also included, showing the proportionate mortality from asthma, bronchitis, pneumonia, and other respiratory diseases among workers in occupations with exposure to metallic dust, but without reference to divisional periods of life.

TABLE 14.—PROPORTIONATE MORTALITY FROM NONTUBERCULOUS RESPIRATORY DISEASES IN SPECIFIED INDUSTRIES OR OCCUPATIONS WITH EXPOSURE TO METALLIC 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. |
| Artificial-flower makers | | | 1 | 7.7 | 1 | 7.7 | | | 2 | 15.4 |
| Brass workers | 4 | 0.6 | 1 | .2 | 51 | 8.1 | 19 | 3.0 | 75 | 11.8 |
| Compositors and typesetters | 19 | .5 | 35 | .9 | 343 | 8.9 | 55 | 1.4 | 452 | 11.7 |
| Cutlery makers | | | | | 4 | 7.3 | 1 | 1.8 | 5 | 9.1 |
| Die setters and sinkers | | | 1 | 3.6 | 4 | 14.3 | | | 5 | 17.9 |
| Electrotypers and stereotypers | | | 1 | 1.5 | 4 | 6.2 | | | 5 | 7.7 |
| Engravers | 2 | .5 | 2 | .5 | 34 | 8.9 | 5 | 1.3 | 43 | 11.2 |
| Gold beaters | | | | | 5 | 9.4 | 2 | 3.8 | 7 | 13.2 |
| Grinders | 3 | 1.0 | 6 | 2.0 | 28 | 9.2 | 9 | 3.0 | 46 | 15.1 |
| Iron and steel workers | 27 | .8 | 46 | 1.4 | 307 | 9.2 | 50 | 1.5 | 430 | 12.9 |
| Jewelers | 5 | .6 | 10 | 1.2 | 61 | 7.5 | 7 | .9 | 83 | 10.2 |
| Polishers | 5 | .5 | 5 | .5 | 77 | 8.0 | 17 | 1.8 | 104 | 10.8 |
| Pressmen | 2 | .4 | 3 | .6 | 45 | 8.6 | 9 | 1.7 | 59 | 11.3 |
| Tool and instrument makers | 7 | 1.3 | 5 | .9 | 39 | 7.3 | 8 | 1.5 | 59 | 11.1 |
| Total | 74 | .6 | 116 | 1.0 | 1,003 | 8.7 | 182 | 1.6 | 1,375 | 11.9 |

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

## ENGLISH MORTALITY STATISTICS.

In conclusion, however, it has seemed advisable to add to the preceding observations Table 15, obtained from English official sources and showing the combined mortality of tool and instrument makers, brass workers, and printers and compositors. This table may safely be considered sufficiently representative of the entire group of occupations with exposure to metallic dust in the absence of more extensive information, which, unfortunately, is not available.

TABLE 15.—MORTALITY FROM ALL CAUSES, FROM PULMONARY TUBERCULOSIS, AND FROM OTHER DISEASES OF THE RESPIRATORY SYSTEM, IN OCCUPATIONS EXPOSED TO METALLIC 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. | |
|---|---|---|---|---|---|---|
| | All occupied males. | Occupations exposed to metallic dust. | All occupied males. | Occupations exposed to metallic dust. | All occupied males. | Occupations exposed to metallic dust. |
| 15 to 19 years | 2.44 | 2.73 | 0.54 | 0.73 | 0.24 | 0.30 |
| 20 to 24 years | 4.41 | 5.28 | 1.55 | 2.73 | .48 | .45 |
| 25 to 34 years | 6.01 | 6.29 | 2.03 | 3.33 | .77 | .69 |
| 35 to 44 years | 10.22 | 11.68 | 2.74 | 5.05 | 1.66 | 1.62 |
| 45 to 54 years | 17.73 | 20.97 | 3.04 | 5.22 | 3.32 | 3.55 |
| 55 to 64 years | 31.01 | 36.03 | 2.16 | 3.91 | 6.54 | 7.94 |
| 65 years and over | 88.39 | 92.52 | 1.11 | 1.54 | 17.77 | 22.46 |

## GENERAL CONCLUSIONS.

According to this table the general death rate from all causes and the specific death rate from pulmonary tuberculosis among men in occupations with exposure to metallic dust is decidedly excessive at all ages, and extremely high during the age period 25 to 54, which, for economic reasons, is obviously of special social and medical importance. The mortality from nontuberculous respiratory diseases in the English experience was slightly below the average for occupations with exposure to metallic dust, a condition which is not confirmed by the data derived from American sources. It should be considered in this connection that many important specific employments with exposure to metallic dust show a mortality from pneumonia, asthma, and bronchitis distinctly above the average. The relative frequency of these two groups of diseases among persons employed in occupations with exposure to metallic dust occasionally involves serious difficulties in medical diagnosis and death certification, and the conclusion of Sir Thomas Oliver, with reference to miners applies to metal workers, though possibly to a lesser degree, that "it is difficult to say where and how miners with pneumoconiosis become tuberculous, but there is nothing to suggest that they become infected differently to other people." This, of course, applies to the precise process of infection rather than to the increased liability resulting from a preexisting mechanical injury to the lungs in consequence of considerable and continuous inhalation of metallic and mineral dust. As further said by Sir Thomas Oliver in this connection, "The infection must take place either in the mine, in the home, in the public house, or in some place of amusement." It may safely be asserted, however, that "in the absence of sanitary control of work places and a general conformity to sanitary rules, especially with reference to indiscriminate expectoration, the liability to tuberculous infection must be increased on account of the occupation in the case of persons employed in occupations with more than normal exposure to irritating dusts, whether of organic or inorganic origin, or both." This conclusion applies as much to occupations with exposure to metallic dust as to those with exposure to mineral dust, but of the two, under given conditions, persons engaged in the former are in all probability more liable to pulmonary tuberculosis than those engaged in the latter and less liable to nontuberculous respiratory diseases, particularly asthma and bronchitis.

## THE IRON AND STEEL INDUSTRY.

### VARIATIONS IN OCCUPATIONAL DUST EXPOSURE.

The iron and steel industry is inclusive of such a large number of more or less specialized and widely varying employments that any and all general mortality data relating thereto can not be considered conclusive concerning any one particular group of occupations. The conditions of employment in the iron and steel industry in the United States, with detailed descriptive accounts of particular occupations, were reported upon by the United States Bureau of Labor Statistics in response to a Senate resolution, in 1911. The large number of individual employments therein described proves conclusively the practical limitations of general data concerning the mortality and morbidity of iron and steel workers considered as a group. Most of these have, therefore, for the present purpose, been discussed separately in the 14 groups of occupations with exposure to metallic and mineral dusts. Out of 172,706 enumerated employees in the iron and steel industry, according to the report of the United States Bureau of Labor Statistics on Conditions of Employment in the Iron and Steel Industry, 61.9 per cent were employed in producing departments and 38.1 per cent in connection with power, mechanical operations, or the yard force. As to the branches of the industry in the producing departments, 18.2 per cent of the employees were at work on blast furnaces; 3.3 per cent at Bessemer converters; 8.5 per cent at open-hearth furnaces; 3.9 per cent at puddling mills; 0.4 per cent at crucible furnaces; 3.3 per cent at blooming mills; 3.4 per cent at plate mills; 2.6 per cent at standard rail mills; 2 per cent at structural, light rail, and other shapes mills; 1.9 per cent at miscellaneous mechanical mills; 10 per cent at bar mills; 1.4 per cent at garrett rod mills; 0.5 per cent at miscellaneous rod mills; and 2.5 per cent at tube mills. It is, therefore, shown that numerically the men employed in direct connection with producing operations at blast furnaces, Bessemer converters, open-hearth furnaces, puddling mills, and crucible furnaces constitute 34.3 per cent of the total labor force. The dust exposure in even these closely related employments varies quite considerably, aside from important variations in exposure to heat, temperature changes, etc. The remainder of the group of iron and steel workers, 27.6 per cent, were employed in iron and steel mills, including a large number of highly specialized occupations, with possibly even greater variations in exposure to dust, heat, temperature changes, etc. Conclusions applicable to the health or mortality of one group of employees, for illustration, connected with work at blast furnaces, would probably not apply to another group of employees at work in the plate mills. It is, however, quite impracticable to give individual consideration to the hygiene of all the numerous employments in the iron and steel industry, since most of the available mortality and morbidity data have reference only to the industry as a whole. The experience of several important and long-established benefit funds, if subjected to critical analysis, would undoubtedly throw much light upon important sanitary and medical conclusions concerning the health conditions in the steel industry; but thus far only a general analysis of the experience has been attempted.

### OCCURRENCE OF INJURIOUS DUST AMONG STEEL WORKERS.

The most qualified scientific investigation of the occurrence and mitigation of injurious dust among steel workers is by Dr. J. A. Watkins, of the United States Public Health Service in cooperation with the Bureau of Mines (Technical Paper 153, Washington, 1917). The report includes a brief discussion of the pathogenicity of industrial dusts, differentiating the three chief ways in which dust may act injuriously according to the character of the dust particles, (1) by irritant action, (2) by toxic action, and (3) by mechanical action. The conclusion is advanced that much of the dust inhaled never reaches the lungs because of its being retained in the nose, throat and mouth. Some of these dusts, it is pointed out, interfere with the proper physiological action of the stomach and intestines, while others have serious effects on the skin, acting as local irritants. The principal places where dust is found in steel works are storage bins, blast furnaces, gas stoves, gas washers and blowers, dolomite sheds, open-hearth furnaces, rolling mills, soaking pits, gas producers, Bessemer converters, foundries, and in connection with the grinding equipment. The observations in detail are entirely too brief for practically useful conclusions. In order to determine the extent to which the various dusts are found to be suspended in the atmosphere of the work places examined, an apparatus was used devised by Lanza and Higgins and described in Technical Paper 105, Bureau of Mines, Washington, 1915. The descriptive accounts of the dusts collected are exceptionally valuable. The description of iron ore dust is given in full as follows:

The table shows that at times iron-ore dust is suspended in the atmosphere around the ore bins in exceptionally large quantities—as much as 23.5 mmg. per 100 liters. While this dust contains many particles varying from 4 to 10 microns in size, a characteristic feature noted in the study of this dust was the enormous number of ultramicroscopic particles. The larger particles readily break up into these ultramicroscopic particles in a fluid medium. A somewhat similar occurrence probably takes place in the respiratory tract; and if so would make the removal of these particles by coughing or expectorating very difficult, if not impossible. The larger particles are irregular, roughly spherical, and have few sharp edges but some points. Iron-ore dust has no toxic action and the particles examined were not very hard. Its physiological effect on man can be surmised only, but is probably limited to that caused by the mechanical action of the particles, which act as irritating bodies where they lodge in the respiratory tract.

Additional descriptions are of coke dust, limestone dust, flue dust, graphite dust, dolomite dust, and other refractory material and roll scale. With reference to dolomite dust, it is said that—

As regards industrial hygiene, dolomite, $CaMgCO_3$, is the most important dust in a steel plant, not only because of its character and action but also because of the enormous quantities of it suspended in the atmosphere of certain working locations. The dolomite particles examined are very irregular, with few sharp points, but generally with some sharp edges, and are hard. The particles examined were 5 to 15 microns in size. Calcined dolomite contains a large percentage of free lime which on becoming moist slakes and is then very irritating to the tissues of the body, particularly those of the nose, throat, and eyes. Its effect on the delicate membranous lining of the respiratory tract can be readily surmised.

Of special interest is the descriptive statement of ganister dust, in which it is referred to as a highly siliceous sandstone, used to some extent in patching and repairing the interior of an open-hearth furnace. The silica particles examined were 5 to 20 microns in size, irregular, angular, sharp, and exceedingly hard.

The general methods of mitigating the dust menace in steel works are (1) preventing dust suspension, (2) removing suspended dust from air, and (3) providing against the inhalation of dust. A fourth method is "to house in completely the department in which there is much suspended matter and prohibit employees from working or remaining therein." The suggestions, to be entirely conclusive and practically useful, require to be further amplified by illustrations of existing methods which are known not to have been a matter of material interference with at least a moderate degree of working efficiency. It is, of course, a mere commonplace that "foremost among the methods employed for dust removal is that of an efficient system of exhausting and supplying air. A system of electric precipitation can be used, but its usefulness is limited largely to dust in flues." Both of these are extremely difficult of installation in many plants constructed in conformity with the factory methods of the past.

The observations in the report on the abatement of dust at the ore bins, the blast furnaces, and the dolomite shed are of considerable value. With reference to the dust problem in foundries it is said, in conclusion, that—

Many and diverse conditions give rise to dust in the foundry. To abate the dust a great deal of effort and every means of prevention and mitigation must be employed. Castings should be cleaned and "blasted" in a separate room where only those men needed for the work are allowed to remain. These employees should be required to wear respirators. Casting, especially the casting of brass and similar alloys, should be done in a separate building where precautions are taken to insure ample ventilation by natural and artificial means. The main foundry room should be given more floor space and, except where molds are made, should have suitable flooring of steel plate or brick. This flooring should be sprinkled with water frequently. In addition provision should be made for an abundant supply of fresh air. Grinding wheels should be supplied with an effective exhaust system, and as an additional safeguard the men engaged should be required to wear respirators.

The report is a promising indication of more qualified scientific inquiries into a field of industrial hygiene which has heretofore been practically neglected almost in its entirety.

## DUST EXPOSURE AT BLAST FURNACES.

In the report of the Bureau of Labor Statistics each important branch of the industry is separately described and much useful information is contained therein regarding occupational exposure in at least the more important employments. At the blast furnaces, for illustration, the so-called larry men are exposed to the dust of limestone, coke, and other materials, including, of course, a more or less important proportion of metallic dust. So-called bottom fillers are considerably exposed to dust in connection with the shoveling of materials into barrows, while top fillers and stove cleaners are still more exposed to dust and heat, in addition to the serious risk of overexertion, on account of the heavy physical labor required, and frequently, also, to trying weather conditions. The stove cleaners, it is explained in the report referred to, "remove the cinder, dust, and various débris that accumulate in the stoves," which obviously must involve an exceptional amount of metallic and mineral dust exposure. The so-called "dustmen," which term includes slag-dust laborers, dust wheelers, and dust-catcher men, "remove the dust which accumulates in the gas flues and in the dust catcher," and the work is particularly referred to as being "disagreeable on account of the hot dust, and likely to be dangerous if the dust is not thoroughly wetted down while being removed," which, it may be said, is not often the case. At the blast furnaces the so-called clay men "prepare and deliver the clay for the stopping of the tap hole," but the exposure here is to mineral rather than to metallic dust. Iron breakers, however, who break up the iron molds or "pigs," are in all probability subject to considerable inhalation of mineral dust mixed with minute iron particles, but in modern plants where pig-casting machines are used this risk is eliminated. These brief references to a single important branch of the steel industry illustrate the widely varying conditions of dust exposure and suggest the practical importance of much more specialized investigations than have heretofore been made into the health-injurious effects of particular occupations or groups of employment. At the blast furnaces alone 35 particular occupations are differentiated or briefly described in the report of the Bureau of Labor Statistics previously referred to.

## DUST EXPOSURE AT BESSEMER CONVERTERS.

At the Bessemer converters there are at least 29 specialized occupations, of which apparently those with most serious dust exposure are the cupola hoist men, the cupola chargers, the cupola liners, the vessel scrapers, the vessel men and vessel men's helpers, and, most of all, the bottom makers and helpers, who repair and rebuild converter bottoms. The last-named operation is of special interest and hygienic importance and is briefly described in the report of the Bureau of Labor Statistics, as follows:

The bottom consists essentially of (1) a cylindrical steel casing sloping out at the top to the diameter of the vessel, the lower part of which forms the "blast box" into which the blast is admitted by a large pipe. This casing is provided with keys or with other appliances by which it can be quickly and securely fastened to the body of the converter. (2) Above the "blast box" is the refractory bottom, which is pierced by a large number of small holes for admitting and distributing the blast in the vessel. In acid vessels these "tuyeres" or holes are formed in fire-clay bricks of special design (in practice the entire brick is known as a "tuyere") around which ganister is rammed. When the bottom is removed by the vessel men, the bottom makers and helpers cool it with water and then chip out all the ganister and knock out the "tuyere bricks." New tuyere bricks are then placed in position, and crushed moist ganister is tightly rammed around them until it is level with their top. The entire bottom is then placed in an oven where it is kept at a steady heat until thoroughly dried. In addition to this work the bottom makers' helpers in many plants also grind the refractory materials used for this purpose and also for repairing vessels and ladles.

The ganister which is used in connection with this operation gives rise to a dust of a very high degree of injuriousness, but the degree of such exposure is much less in bottom making than in the manufacture of the dust itself. Ganister mining and crushing has been described in Oliver's Dangerous Trades, in part, as follows:

Workers engaged in crushing basic slag, in the breaking of certain rocks, in the manufacture of millstones, in stonemason's work, and kindred occupations, are peculiarly liable to chronic inflammation of the air tubes, caused by the inhalation of dust of an irritant kind. This, it is believed, leads to lung fibrosis. Where the operatives form part of a large community in which individuals are employed in many and varied trades, it is conceivable that fibrosis of the lungs may be mistaken for tubercular pulmonary consumption, and it may not be realized that the cause is due to the occupation of the sufferer.

Ganister is a hard, close-grained, silicious stone which often forms the stratum that underlies the coal seam. A footnote in Dr. Percy's Fuel says: "Dinas rock is believed to be a millstone grit of the carboniferous system, and the geological equivalent of the bed termed 'ganister' at Sheffield." It is found in Yorkshire, Durham, North and South Wales, and elsewhere. When crushed and ground into dust it is used as a fire-resistant, chiefly for lining Bessemer and other steel converters, for the manufacture of bricks likely to be subjected to great and continuous heat, and it is sometimes mixed with, or substituted for, Stannington or other clays, which, together with ground cinders and old ground pot, are used for the manufacture of crucibles in which certain kinds of steel are made.

The exposure here, of course, is to mineral rather than metallic dust, but in the United States, at least, employments in connection with ganister are chiefly in the iron and steel industry, and especially in the repairing and rebuilding of converter bottoms. For a thoroughly well considered discussion of the subject the extended account in Oliver's Dangerous Trades, by Hamilton P. Smith, should be consulted.[1]

Other important occupations in connection with Bessemer converters where the dust exposure appears to be exceptional are ladle liners, ingot strippers, and cinder men, the latter cleaning up and removing the cinder and metal from the pit or floor of the Bessemer building, and taking care of the slag on the cinder dump. As explained in the report of the Bureau of Labor Statistics, this work, for the most part, "is done under conditions of great heat, and, when working around and under the vessels and ladles, of great danger of being severely burned or of receiving minor injuries."

### DUST EXPOSURE AT OPEN-HEARTH FURNACES.

Twenty occupations of the open-hearth furnaces are described in detail in the report of the Bureau of Labor Statistics, and of these occupations the following involve the most serious risk of dust exposure: Stokers, who unload the materials and sort and assemble the different grades of scrap iron in piles, etc.; charging-machine operators, who generally work on more or less dust-covered floors and in front of furnaces while discharging materials under, frequently, rather trying conditions; pitmen, who prepare the pit for casting, set the molds, build the runners, etc.; and general laborers, including ash men, ash wheelers, cinder dump men, clean-ups, grinding laborers, mixing laborers, mixing-house laborers, etc. In most of these occupations the dust exposure is quite considerable, but naturally the major portion of the dust is of a mineral nature. The highest degree of health-injurious exposure is probably in connection with the relining of the furnaces where frequently all reasonable and necessary safeguards, such as the previous spraying of the materials, etc., are neglected. Most of the work, however, is done by casual labor, so that only in rare cases are occupations of this character followed for a long period of years.

### DUST EXPOSURE AT PUDDLING MILLS.

In puddling mills the number of special occupations is not fewer than 23 and most of these involve more or less dust and heat exposure, frequently, however, quite difficult of precise ascertainment.

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[1] See also Sir Thomas Oliver's observations on slag crushing, in Allbutt and Rolleston's A System of Medicine, vol. 5, p. 457; and his remarks on ganister crushing and mining, in the same volume, p. 456; and additional observations in his Diseases of Occupation, p. 298 et seq. Sir Thomas Oliver's most recent conclusions are set forth briefly in Kober and Hanson's Occupational Diseases and Vocational Hygiene, New York, 1916, p. 222.

Puddling is a highly skilled occupation and, according to the report of the Bureau of Labor Statistics, " requires considerable experience, and the puddler's work is perhaps the hardest physical labor in the industry, and, moreover, the largest part of it is done under conditions of extreme heat." Wherever work is done under conditions of extreme heat the dust exposure is increased on account of the extreme dryness of practically all the materials used, directly or indirectly, in productive operations. Puddlers' helpers assist in the lining of the furnaces and in the charging and drawing of the metal, which naturally involves exposure to mixed mineral and metallic dust. Cinder men tap the slag from the furnace, quite frequently under rather primitive conditions, involving considerable dust exposure. Many of the other occupations resemble those previously referred to. The crucible process in steel manufacture is now of relatively small importance, but of exceptional interest from sanitary and medical points of view. Conditions vary widely in different plants, according to whether the furnaces are heated by gas, coal, or coke, and whether modern processes or the antiquated methods of an earlier period are employed. The principal occupations are melters, pullers out, and molders. The latter prepare and set the small ingot molds into which the steel is cast, and they strip the same when the cast is completed. All this involves considerable dust exposure and the liability to sudden temperature changes. Frequently these men while at work near the furnaces are not properly protected against cold drafts and other trying weather conditions. Among the unclassified employments chiefly carried on by unskilled labor are mixers, pot shakers, pot boys, pipe makers, compounders, and ladle men, all more or less exposed to considerable mixed metallic and mineral dust.

## OBSERVATIONS ON THE PHYSIQUE OF IRON AND STEEL WORKERS.

The foregoing are the principal converting branches of the modern iron and steel industry, preliminary to manufacturing processes proper. The special occupations in these are also extremely varied but in most respects they resemble, as regards at least the most dangerous employments, those previously referred to. Working generally in rolling, rod, and tube mills involves, naturally, a continuous and probably considerable exposure to the inhalation of metallic dust, aside from other more or less health-injurious conditions, such as sudden temperature changes, extreme heat, etc. As a natural process of occupational selection, most of the men employed in the iron and steel industry are physically of a superior class, and, therefore, more resistant to disease than ordinary laborers or men employed chiefly in indoor occupations. There is the additional advantage that in most of these employments the wages are above the general average, while, except in the continuous processes, the hours of labor are rarely excessive. Regarding any and all of these employments, there is at present only fragmentary information as to the health-injurious effects of the different employments, but considered in the aggregate the available data are fairly conclusive that the mortality and morbidity are not above the average. This conclusion, however, must not be carried too far, for it can not be made to apply to the numerous and thoroughly specialized occupations which are carried on under frequently very trying conditions of extreme heat, sudden temperature changes, and exposure to metallic and mineral dust.

## HEALTH-INJURIOUS CONDITIONS AT IRON AND STEEL WORKS.

W. Gilman Thompson, in his treatise on "The Occupational Diseases" (pp. 191–196), refers at some length to the iron and steel industry, chiefly to foundry men and rolling-mill men, and he includes among the health-injurious circumstances exposure to toxic gases, glare of excessive light, and irritation of the lungs from steel dust, causing pneumoconiosis. He also suggests an exceptional liability to chronic nephritis and arteriosclerosis. He quotes Röpke to the effect that in German steel mills 20 to 22 per cent of the illnesses among the workmen concern the respiratory organs. He observes that—

Iron is in no sense a chemical irritant to the body, being a natural ingredient of the hemoglobin. Iron and steel dust, however, by virtue of the hardness and sharpness of the particles, are irritant to the bronchial mucosa when inhaled, and foster the development of fibroid phthisis and subsequent acquisition of pulmonary tuberculosis. The smelting of iron and steel and various hardening processes are capable of being injurious in several ways. Thus the workmen are exposed to great heat and perspiration which is often suddenly checked, especially in winter. The excessive heat and light to which puddlers and founders are exposed when the glare from furnace doors reaches them may injure the eyes permanently, and they may acquire superficial or more serious burns. Particles of iron or steel may be driven into the skin of the face and exposed upper half of the body, marking it like tattoo. The workmen, as a result of frequent extreme changes in temperature, are prone to lumbago or myalgia and chronic rheumatism, and, from heavy lifting, frequently have sprains and muscle strain. In galvanizing sheet iron hydrochloric acid is used, the fumes of which are injurious. Various processes of steel hardening are liable to prove harmful through the action of other substances, such as the cyanides, ferrosilicon, etc. Cutlery and other articles of steel manufacture are dipped into baths of molten lead or boiling oil, the fumes from which may prove highly injurious. In the hot rooms in which smelting and hardening processes are conducted the workmen are subject to acute and chronic nasal catarrh, and Sager and Weickert have found otitis media as a further not uncommon result. Röpke (Berufskrankheiten des Ohres) has described perichondritis of the external ear caused by the packing of hard metallic dust in the auditory meatus. He also found labyrinthine inflammation in some cases.

The metallurgy of iron is of course quite closely related to metallurgical processes generally as carried on in continuation of mining industries. Smelting processes are elsewhere considered, though briefly, since thus far no extensive and conclusive investigations have been made concerning the differential occupational health hazards in the several important branches of the smelting industry with a due regard to the nature of the metallic substances produced. Conclusions applicable to copper smelters are, for illustration, quite inapplicable to quicksilver reduction works, and the same observation applies to gold and lead smelting, separately considered. As observed by Thompson—

In smelting works the laborers are much exposed to the inhalation of toxic gases from the ovens, especially carbon monoxide derived from coke or otherwise. In such cases headache, vertigo, and tinnitus are complained of, and anemia and nervousness ensue. Kayser (Wiener med. Woch. 1893, No. 41) reported a case of such poisoning in which the victim remained 36 hours in coma, and on recovery presented symptoms of labyrinthine disease. Such extreme cases are very rare. Rohrer (Haugs klin. Vortr., Bd. 1, Heft 3) reported 5 cases among furnace stokers who were subjected to the inhalation of water gas, with the result of chronic carbon monoxide poisoning. They suffered from headache, nausea, and disturbances of hearing which were both nervous and due to otitis. Erosions of the nasal septum and atrophic rhinitis were also observed occasionally.

### THE HYGIENIC MENACE OF STEEL DUSTS.

To a limited extent this observation applies also to the iron and steel industry, chiefly, of course, to work in connection with initial conversion processes. In the continuation of these processes and toward the final finishing of the product, it is quite apparent, as pointed out by Thompson, that the danger to the lungs in the cleaning of iron and steel castings is most serious, and that in open-hearth processes and in the breaking up of iron molds and castings particles of coal or charcoal and iron rust are inhaled and the workmen sweat heavily. They are, therefore, peculiarly exposed to nasal, bronchial, and middle-ear catarrh, and he remarks, in this connection, that—

The sharp particles of dust accumulate in crusts with the nasal mucus and cause ulceration and epistaxis. There may be atrophic rhinitis with loss of sense of smell and uncomfortable dryness of the nose. The atrophy may involve the mucosa of the nasopharynx, which becomes reduced in sensibility so that mucus accumulates without exciting expulsive effort. This lack of sensation may favor the further entrance into the bronchi and lungs of irritant material. Graphite and coal dust were found by Merkel embedded in the lungs in four autopsies upon men who had been employed as iron molders. Particles of steel and iron dust which reach the pulmonary alveoli choke them up and become embedded in their walls, where they excite perialveolar irritation with inflammatory products, chiefly fibrous.

### MORTALITY OF GRINDERS AND POLISHERS.

These observations bear directly upon the extremely important practical question of differentiating fibroid phthisis from ordinary pulmonary tuberculosis as modified by conditions of employment in the metal trades. The more delicate methods of manufacture with exposure to iron and steel dust have been briefly described under grinders, polishers, and tool and instrument makers, as well as less important allied occupations. A statement, however, by W. Gilman Thompson, based on experience had at Sheffield, England, during the eight years ending with 1909, among steel grinders and polishers in the hardware industries may be here referred to, it being stated that the death rate was 30.4 per 1,000, of which, however, one-half was attributable to tuberculosis and more than one-sixth to other pulmonary diseases. Thompson properly emphasizes the fact that this class of workmen is representative of a selected group as to age and original physical strength, so that the excessive mortality is on that account decidedly more significant. Thompson also refers to the mortality of Solingen, which is the center of the German cutlery industry, where during 1910 the general mortality from tuberculosis was 1.8 per 1,000, while in the cutlery and tool industry it was 9.3, and he quotes in this connection from a report of the State Board of Health of Massachusetts for the year 1907, with special reference to the tool industry at Northampton, Mass., that the grinders and polishers employed in these industries showed a mortality from pulmonary diseases, including tuberculosis, of nearly 73 per cent of the mortality from all causes. He also makes mention of a rather rare case of pulmonary emphysema reported to the New York State Bureau of Labor which resulted from manufacturing steel wool. He remarks in conclusion that—

In foundries, rolling mills, steel-plate works, and the like, the lifting of heavy weights tends in time to strain the circulation and give rise to cardiac hypertrophy. Excessive sweating in these occupations leads to lessening of the fluidity of the blood and induces excessive thirst, which the workmen often assuage with quantities of beer and other alcoholic drinks. The combination of vascular strain and alcoholism leads to early arteriosclerosis, which in turn results in hypertrophy of the heart. When large quantities of cold fluids are drunk acute gastrointestinal catarrh is very liable to ensue.

### DUST EXPOSURE IN THE CHIPPING OF IRON AND STEEL CASTINGS.

Among the minor but important health-injurious processes in the iron and steel industry a brief reference should be made to iron and steel "chipping." This employment has been briefly described by Hayhurst, as follows:

Chipping of iron and steel castings is another exceedingly dusty and also dangerous procedure from the flying particles which are created by the use of both hand or pneumatic tools.

The reference is particularly to the danger of eye injuries, but the metallic-dust hazard in this employment is of even greater importance. Hayhurst suggests that outside of the use of respirators and individual goggles it is advisable to protect the ears by cotton, for where pneumatic tools are used the deafening noise is productive of shocks to the nervous system. Previous to the chipping castings are usually subjected to the so-called process of tumbling, which consists in the placing of a number of castings, as described by Hayhurst, "in a revolving cylinder, called a 'rattler,' in order to shake off the mold dust and to smooth down certain imperfections." He explains that the cylinder which contains the material should be entirely inclosed, since an immense amount of dust is created, but where this is not practicable an efficient air exhaust or blast system may be used for the control of the dust hazard. In employments of this character most of the labor, however, is of a casual nature and it is extremely rare to meet with men who have been exposed to the same occupational hazard for a long period of time.[1]

### MORTALITY OF IRON AND STEEL WORKERS—UNITED STATES REGISTRATION AREA.

The mortality of iron and steel workers has 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, limited to the years referred to. According to the census report, out of 5,035 deaths from all causes, 853, or 16.9 per cent, were from pulmonary tuberculosis. The details of the mortality of iron and steel workers, by divisional periods of life, are shown in Table 16, compared with the mortality of all occupied males, and of farmers, planters, and farm laborers.

[1] Considerable progress has been made in the direction of perfecting methods of eye protection, as illustrated by exhibits at the National Exposition of Safety and Sanitation, New York City, under the auspices of the National Safety Council and the American Museum of Safety, Grand Central Palace, New York City, 1917. A permanent exhibit of safety goggles or other methods of eye protection is maintained at the American Museum of Safety, 18 West Twenty-fourth Street, New York City.

TABLE 16.—PROPORTIONATE MORTALITY FROM PULMONARY TUBERCULOSIS OF IRON AND STEEL WORKERS, OF ALL OCCUPIED MALES, AND OF FARMERS, PLANTERS, AND FARM LABORERS, UNITED STATES REGISTRATION AREA, 1908 AND 1909, BY AGE GROUPS.

| Age at death. | Iron and steel workers. | | | All occupied males. | | | Farmers, planters, and farm laborers. | | |
|---|---|---|---|---|---|---|---|---|---|
| | 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 of deaths from all causes. | | Number. | Per cent of deaths from all causes. | | Number. | Per cent of deaths from all causes. |
| 15 to 24 years | 460 | 91 | 19.8 | 34,985 | 9,837 | 28.1 | 6,130 | 1,441 | 23.5 |
| 25 to 34 years | 915 | 239 | 26.1 | 56,001 | 17,326 | 30.9 | 6,665 | 1,748 | 26.2 |
| 35 to 44 years | 1,084 | 253 | 23.3 | 63,093 | 15,128 | 24.0 | 7,227 | 1,377 | 19.1 |
| 45 to 54 years | 992 | 166 | 16.7 | 68,903 | 9,910 | 14.4 | 10,224 | 1,234 | 12.1 |
| 55 to 64 years | 754 | 64 | 8.5 | 69,254 | 5,231 | 7.6 | 14,836 | 999 | 6.7 |
| 65 years and over | 826 | 39 | 4.7 | 113,469 | 2,992 | 2.6 | 45,510 | 1,105 | 2.4 |
| Age unknown | 4 | 1 | 25.0 | 618 | 51 | 8.3 | 203 | 16 | 7.9 |
| Total, 15 years and over. | 5,035 | 853 | 16.9 | 406,323 | 60,475 | 14.9 | 90,795 | 7,920 | 8.7 |

TABLE 17.—PROPORTIONATE MORTALITY FROM NONTUBERCULOUS RESPIRATORY DISEASES OF IRON AND STEEL WORKERS, OF ALL OCCUPIED MALES, AND OF FARMERS, PLANTERS, AND FARM LABORERS, UNITED STATES REGISTRATION AREA, 1908 AND 1909.

| Cause of death. | Deaths of iron and steel workers. | | Deaths of all occupied males. | | Deaths of farmers, planters, and farm laborers. | |
|---|---|---|---|---|---|---|
| | Number. | Per cent of deaths from all causes. | Number. | Per cent of deaths from all causes. | Number. | Per cent of deaths from all causes. |
| Asthma | 12 | 0.2 | 1,031 | 0.3 | 262 | 0.3 |
| Bronchitis | 35 | .7 | 3,522 | .9 | 1,049 | 1.2 |
| Pneumonia | 508 | 10.1 | 31,889 | 7.8 | 6,333 | 7.0 |
| Other nontuberculous respiratory diseases. | 54 | 1.1 | 4,280 | 1.1 | 824 | .9 |
| Total | 609 | 12.1 | 40,722 | 10.0 | 8,468 | 9.3 |

Table 16 is suggestive of a rather high but not particularly excessive mortality from pulmonary tuberculosis; but Table 17 shows that in addition thereto there is a mortality from nontuberculous respiratory diseases of 12.1 per cent for iron and steel workers. Of this group of diseases asthma causes a proportionate mortality of 0.2 per cent; bronchitis, 0.7 per cent; pneumonia, 10.1 per cent; and other respiratory diseases, 1.1 per cent. Combining pulmonary tuberculosis and nontuberculous respiratory diseases, the proportionate mortality from all lung diseases is 29 per cent, which must be considered relatively high, since the group of iron and steel workers includes those in many occupations not exposed to particularly health-injurious conditions. The table confirms the results of other investigations into the mortality of iron and steel workers of the United States and other countries.

## MORTALITY OF IRON AND STEEL WORKERS—INDUSTRIAL INSURANCE EXPERIENCE.

The general vital statistics of the iron and steel industry are, for reasons elsewhere discussed at some length, of rather limited practical utility. The most useful data for the United States are the industrial insurance experience statistics of the Prudential Insurance Co., including for the industry considered as a whole, 3,332 deaths from all causes, of which 700, or 21 per cent, were from pulmonary tuberculosis. The details of this experience, on account of the large number of deaths included, are of exceptional interest, and especially so with reference to the younger ages.

Table 18.—PROPORTIONATE MORTALITY FROM PULMONARY TUBERCULOSIS AMONG IRON AND STEEL WORKERS, 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 iron and steel workers, 1897 to 1914, from— | | Per cent of deaths from pulmonary tuberculosis among— | |
|---|---|---|---|---|
| | All causes. | Pulmonary tuberculosis. | Iron and steel workers. | Males in registration area, 1900 to 1913. |
| 15 to 24 years | 403 | 121 | 30.0 | 27.0 |
| 25 to 34 years | 630 | 215 | 34.1 | 30.5 |
| 35 to 44 years | 684 | 214 | 31.3 | 23.4 |
| 45 to 54 years | 606 | 89 | 14.7 | 14.7 |
| 55 to 64 years | 550 | 48 | 8.7 | 7.9 |
| 65 years and over | 459 | 13 | 2.8 | 2.6 |
| Total, 15 years and over | 3,332 | 700 | 21.0 | 13.9 |

It is shown in Table 18 that the proportionate mortality from pulmonary tuberculosis among iron and steel workers considered as a group is only slightly excessive at ages under 35, but quite decidedly so during the age period 35 to 44, while during the remainder of life the mortality conforms to the normal. Considering that the group represents many widely different occupations, it is self-evident that the data must be interpreted with exceptional caution, but it would seem a safe inference that the physical strain and stress at the younger ages is a factor of some importance in the excessive proportionate mortality from pulmonary tuberculosis at ages 35 to 44. In addition to the relatively high proportionate mortality from pulmonary tuberculosis, pneumonia is also relatively common, the nontuberculous respiratory diseases being accounted for as follows: Asthma, 0.8 per cent; bronchitis, 1.4 per cent; pneumonia, 9.2 per cent; and other respiratory diseases, 1.5 per cent. Combining all the nontuberculous respiratory diseases, it appears that 12.9 per cent of the mortality was caused by diseases of this group, which, combined with the 21 per cent of deaths from pulmonary tuberculosis, indicates that nearly 34 per cent of the mortality from all causes in the iron and steel industry is directly attributable to diseases of the lungs.

The iron and steel workers considered as a group in the mortality experience of the Prudential Co. are made up of puddlers, rollers, heaters, furnace tenders, laborers, and miscellaneous employees. In view of the fact that heretofore no thorough analysis has been presented even of the principal groups of the iron and steel industry, the details of the present analysis are included, even though for certain occupations the data are quite insufficient for a definite conclusion, for, as shown by the table concerning laborers, the large majority of workmen in the iron and steel industry are not further designated as regards the specific occupation followed than that it is stated that they are "laborers at iron and steel works."

## MORTALITY OF PUDDLERS.

The mortality of puddlers includes 251 deaths from all causes, 26, or 10.4 per cent, of the deaths being from pulmonary tuberculosis. This low phthisis mortality is of special significance, in view of the relatively high mortality from nontuberculous respiratory diseases, which is accounted for as follows: Asthma, 0.8 per cent; bronchitis, 1.6 per cent; pneumonia, 12 per cent; other respiratory diseases, 2 per cent; and for all nontuberculous respiratory diseases combined, 16.3 per cent; which compares with 12.1 per cent for all occupations in the iron and steel industry. The details for pulmonary tuberculosis are shown in Table 19.

TABLE 19.—PROPORTIONATE MORTALITY FROM PULMONARY TUBERCULOSIS AMONG PUDDLERS, 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 puddlers, 1897 to 1914, from— | | Per cent of deaths from pulmonary tuberculosis among— | |
|---|---|---|---|---|
| | All causes. | Pulmonary tuberculosis. | Puddlers. | Males in registration area, 1900 to 1913. |
| 15 to 24 years | 4 | | | 27.0 |
| 25 to 34 years | 21 | 4 | 19.0 | 30.5 |
| 35 to 44 years | 36 | 9 | 25.0 | 23.4 |
| 45 to 54 years | 60 | 5 | 8.3 | 14.7 |
| 55 to 64 years | 74 | 5 | 6.8 | 7.9 |
| 65 years and over | 56 | 3 | 5.4 | 2.6 |
| Total, 15 years and over | 251 | 26 | 10.4 | 13.9 |

## MORTALITY OF ROLLERS.

The mortality of rollers includes only 112 deaths from all causes, of which 20, or 17.9 per cent, were from pulmonary tuberculosis.

The proportionate mortality was relatively high at ages 35 to 44, as shown by Table 20.

TABLE 20.—PROPORTIONATE MORTALITY FROM PULMONARY TUBERCULOSIS AMONG ROLLERS, 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 rollers, 1897 to 1914, from— | | Per cent of deaths from pulmonary tuberculosis among— | |
|---|---|---|---|---|
| | All causes. | Pulmonary tuberculosis. | Rollers. | Males in registration area, 1900 to 1913. |
| 15 to 24 years | 12 | 1 | 8.3 | 27.0 |
| 25 to 34 years | 21 | 6 | 28.6 | 30.5 |
| 35 to 44 years | 17 | 5 | 29.4 | 23.4 |
| 45 to 54 years | 20 | 4 | 20.0 | 14.7 |
| 55 to 64 years | 16 | 3 | 18.8 | 7.9 |
| 65 years and over | 26 | 1 | 3.8 | 2.6 |
| Total, 15 years and over | 112 | 20 | 17.9 | 13.9 |

In addition to the mortality from pulmonary tuberculosis the mortality from other respiratory diseases was accounted for as follows: There were no deaths from asthma, but the mortality from bronchitis was 3.6 per cent; from pneumonia, 8.9 per cent; from other respiratory diseases, 0.9 per cent; and from all nontuberculous respiratory diseases combined, 13.4 per cent, which compares with 16.3 per cent for puddlers, and 12.1 per cent for all employees in the iron and steel industry.

## MORTALITY OF HEATERS.

The mortality of heaters is even less representative, in that there were only 51 deaths from all causes, of which 8, or 15.7 per cent, were from pulmonary tuberculosis.

TABLE 21.—PROPORTIONATE MORTALITY FROM PULMONARY TUBERCULOSIS AMONG HEATERS, 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 heaters, 1897 to 1914, from— | | Per cent of deaths from pulmonary tuberculosis among— | |
|---|---|---|---|---|
| | All causes. | Pulmonary tuberculosis. | Heaters. | Males in registration area, 1900 to 1913. |
| 15 to 24 years | 11 | 3 | 27.3 | 27.0 |
| 25 to 34 years | 6 | 1 | 16.7 | 30.5 |
| 35 to 44 years | 6 | 3 | 50.0 | 23.4 |
| 45 to 54 years | 11 | | | 14.7 |
| 55 to 64 years | 10 | 1 | 10.0 | 7.9 |
| 65 years and over | 7 | | | 2.6 |
| Total, 15 years and over | 51 | 8 | 15.7 | 13.9 |

In so far as the data can be relied upon the mortality from pulmonary tuberculosis was distinctly excessive. The mortality from nontuberculous respiratory diseases in this group is accounted for as follows: Asthma, 2 per cent; pneumonia, 5.9 per cent; all nontuberculous respiratory diseases combined, 7.8 per cent. There were no deaths from bronchitis or other respiratory diseases.

#### MORTALITY OF FURNACE TENDERS.

The mortality of furnace tenders is represented by only 62 deaths from all causes, of which 4, or 6.5 per cent, were from pulmonary tuberculosis. The details of the experience are shown in Table 22.

TABLE 22.—PROPORTIONATE MORTALITY FROM PULMONARY TUBERCULOSIS AMONG FURNACE TENDERS, 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 furnace tenders, 1897 to 1914, from— | | Per cent of deaths from pulmonary tuberculosis among— | |
|---|---|---|---|---|
| | All causes. | Pulmonary tuberculosis. | Furnace tenders. | Males in registration area, 1900 to 1913. |
| 15 to 24 years | 4 | | | 27.0 |
| 25 to 34 years | 7 | | | 30.5 |
| 35 to 44 years | 11 | 3 | 27.3 | 23.4 |
| 45 to 54 years | 9 | 1 | 11.1 | 14.7 |
| 55 to 64 years | 16 | | | 7.9 |
| 65 years and over | 15 | | | 2.6 |
| Total, 15 years and over | 62 | 4 | 6.5 | 13.9 |

The mortality from other respiratory diseases in this group is accounted for as follows: Pneumonia, 6.5 per cent, and other respiratory diseases, 1.6 per cent; all nontuberculous respiratory diseases combined, 8.1 per cent. There were no deaths from asthma or bronchitis.

#### MORTALITY OF LABORERS AT IRON AND STEEL WORKS.

Laborers and allied unskilled employments not specifically returned are obviously within the group of general employees at iron and steel works, and they are represented by 2,788 deaths from all causes, of which 628, or 22.5 per cent, were from pulmonary tuberculosis. The details of the experience are shown in Table 23.

TABLE 23.—PROPORTIONATE MORTALITY FROM PULMONARY TUBERCULOSIS AMONG LABORERS, ETC., IRON AND STEEL WORKS, 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 laborers, etc., 1897 to 1914, from— | | Per cent of deaths from pulmonary tuberculosis among— | |
|---|---|---|---|---|
| | All causes. | Pulmonary tuberculosis. | Laborers. | Males in registration area, 1900 to 1913. |
| 15 to 24 years | 361 | 113 | 31.3 | 27.0 |
| 25 to 34 years | 569 | 202 | 35.5 | 30.5 |
| 35 to 44 years | 604 | 189 | 31.3 | 23.4 |
| 45 to 54 years | 492 | 77 | 15.7 | 14.7 |
| 55 to 64 years | 422 | 38 | 9.1 | 7.9 |
| 65 years and over | 340 | 9 | 2.6 | 2.6 |
| Total, 15 years and over | 2,788 | 628 | 22.5 | 13.9 |

Of the mortality from other respiratory diseases, 0.8 per cent were deaths from asthma, 1.2 per cent from bronchitis, 9.1 per cent from pneumonia, 1.5 per cent from other respiratory diseases, and 12.6 per cent from all nontuberculous respiratory diseases combined.

### MORTALITY OF MISCELLANEOUS EMPLOYEES AT IRON AND STEEL WORKS.

The remaining occupations, including nail makers, forgemen, iron melters, etc., are combined in the group of miscellaneous iron and steel workers in Table 24. There are only 68 deaths reported in this group, of which 14, or 20.6 per cent, were from pulmonary tuberculosis.

TABLE 24.—PROPORTIONATE MORTALITY FROM PULMONARY TUBERCULOSIS AMONG MISCELLANEOUS IRON AND STEEL WORKERS, 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 miscellaneous iron and steel workers, 1897 to 1914 from— | | Per cent of deaths from pulmonary tuberculosis among— | |
|---|---|---|---|---|
| | All causes. | Pulmonary tuberculosis. | Miscellaneous iron and steel workers. | Males in registration area, 1900 to 1913. |
| 15 to 24 years | 11 | 4 | 36.4 | 27.0 |
| 25 to 34 years | 6 | 2 | 33.3 | 30.5 |
| 35 to 44 years | 10 | 5 | 50.0 | 23.4 |
| 45 to 54 years | 14 | 2 | 14.3 | 14.7 |
| 55 to 64 years | 12 | 1 | 8.3 | 7.9 |
| 65 years and over | 15 | ........ | ........ | 2.6 |
| Total, 15 years and over | 68 | 14 | 20.6 | 13.9 |

The excessive mortality from pulmonary tuberculosis in this group is of special significance, in that most of the men are exposed to arduous strain, heat, dust, weather changes, etc. The mortality from other respiratory diseases in this group is as follows: Asthma, 2.9 per cent; bronchitis, 7.4 per cent; pneumonia, 10.2 per cent; or, from all nontuberculous respiratory diseases combined, 20.6 per cent. It is, therefore, shown that both tuberculous and nontuberculous lung diseases are proportionately more common in this relatively small but important group, however ill defined, than among heaters, furnace tenders, rollers, and puddlers.

### EVIDENCE OF UNSATISFACTORY HEALTH CONDITIONS.

The experience, of course, is too limited for entirely safe conclusions, but it is distinctly suggestive of more or less unsatisfactory health conditions, apparently predisposing to both pulmonary tuberculosis and nontuberculous respiratory diseases. It is, therefore, regrettable that there should be no other statistics useful for the present purpose, for regardless of the considerable development of the iron and steel industry in England and Wales, the employees are not separately returned, except under the rather general term of nail, anchor, chain, and other iron and steel manufactures. This group included, according to the census of 1901, 220,000 males above the age of 15 years, of whom 216,000 were actively at work. It is said in the report of the registrar-general that—

> In this industry the mortality at every stage of life is above the standard for occupied and retired males, the excess ranging from 4 per cent at ages 20 to 25, to 25 per cent at ages 65 and upward. At every stage of life the death rate exceeds the average for metal workers generally. In the main working period the comparative mortality figure is 1,187, or 18 per cent above the standard. These workers appear to suffer heavily from influenza and respiratory diseases, the former being above the standard by 29 per cent and the latter by 79 per cent. The mortality from diseases of the circulatory system is also above the average by one-fifth part, but on the other hand that from alcoholism and liver disease and from suicide is below the standard.

It should be said, however, in this connection that there has been a marked decline in the mortality of the group under consideration during the preceding decade, equivalent to a reduction of nearly 25 per cent, the decline having occurred in practically every group of diseases excepting cancer. The decline was most noticeable in the case of influenza, phthisis, and respiratory diseases. The data, however, must be used with caution in view of the fact that the group includes too many widely different industries and employments to be strictly representative for any one of them.

**ENGLISH MORTALITY STATISTICS.**

The same observations, unfortunately, apply to other important occupations in the iron and steel industry with more or less exposure to metallic dust, combined in a single group in the official English statistics under " Engine, machine, boiler makers; fitters, millwrights, engine fitters, etc." This group in 1901 was represented by 351,000 persons, of whom 345,000 were actively at work. It is said with reference to this group that—

In these occupations taken together the death rates were below the standard for occupied and retired males at every age group except 55 to 65 years, the rates for boiler makers being below those for engine fitters at ages under 25 and over 65 years but above them throughout the main working period of life. The comparative mortality figure from all causes was 913, or 9 per cent below the standard; the figure for engine makers being 893, or 11 per cent below the average, while that for boiler makers was 1,032, or 3 per cent above it. Among these workers collectively the mortality from nervous diseases slightly exceeded the standard, but from digestive diseases and from accident and suicide their mortality was below it. If the figures for engine fitters and boiler makers be compared, it will be seen that the first-mentioned workers experienced higher mortality than the latter from influenza, phthisis, and Bright's disease, but under every other heading the mortality of boiler makers exceeded that of engine fitters. Engine fitters appear indeed to be by far the healthiest section in the entire class of metal workers.

The preceding observations can not be said to apply with even approximate conclusiveness to the iron and steel industry as the term is generally understood and used in the United States. Most of the occupations involve a fair amount of metallic-dust exposure which under given conditions, such as, for illustration, in the case of boiler makers, may assume serious consequences. The relative mortality from phthisis among engine makers, fitters, millwrights, etc., or what in the United States would generally be considered machinists, in the broad sense of the term, was only 88 against 100 for occupied and retired males, and the corresponding mortality from nontuberculous respiratory diseases was only 85; but for boiler makers the relative mortality from phthisis was 80, while for nontuberculous respiratory diseases it was 119. In contrast, it may be pointed out that the relative mortality from phthisis for cutlers and scissors makers was 285, and for file makers, 207. It may further be said in this connection that the relative mortality from nontuberculous respiratory diseases was 178 for cutlers and scissors makers, and 184 for file makers. In each and every comparison of this kind the mortality of occupied and retired males from the diseases stated is taken as 100.

## RECENT ENGLISH OCCUPATIONAL-DISEASE INVESTIGATIONS.

Some exceptionally interesting observations on "Industrial diseases prevailing amongst iron and steel workers in the Middlesbrough district of England," by J. Watkin Edwards, have been made available through the British Medical Journal (July 22, 1916). In a brief outline of the conditions which influence life and health in industry it is observed that—

(*a*) The effects of overcrowding are more harmful during active work than when workers are at rest; and

(*b*) The evils of overcrowding are aggravated by:

(1) Exposure to changes of temperature;
(2) Inhalation of dust and irritating particles;
(3) Absorption of chemical poisons; and
(4) The effects of undue strain and exertion.

A formula is presented according to which if the amount of air inspired while at rest equals 1, the amount inspired when standing erect is 1.3, and while walking at the rate of 4 miles per hour is 5. It is, therefore, suggested that every effort should be made in industrial towns toward making the lot of the workmen, both while at work and when off work, as perfect as possible. In the district of Middlesbrough pneumonia prevails to an alarming extent, being nearly four times as frequent as pulmonary tuberculosis, and more than three times as common as bronchitis. It is explained, however, that "these figures do not at all fully represent the amount of industrial disease prevailing in the town for there are many minor complaints which do not appear as causes of death, but which give patients a great deal of pain and practitioners a great deal of trouble." The local adverse influences which appear to affect the general death rate, especially with reference to the mortality from industrial diseases, are said to be:

(1) Working at high temperatures.
(2) Long hours of work, fatigue, insufficient rest, sleep, and recreation.
(3) Working at night.
(4) Careless exposure to cold and wet.
(5) Intemperance.
(6) Inhalation of dust.
(7) Inhalation of poisonous gases, such as CO.
(8) Trauma.

With special reference to pulmonary tuberculosis it is stated that—

This condition was the cause of 70 deaths amongst males. The causes which lie at the root of its prevalence are:

(*a*) Inhalation of dust at the works (where it is chiefly composed of inorganic particles), but especially in our streets and dwellings and places where people congregate. The disease known as pneumoconiosis is known to kill large numbers of Staffordshire potters, Cornish and Transvaal miners, and Sheffield grinders. Dust from any cause, especially that produced in the manufacture of manure from basic slag, causes bronchitis, asthma, chronic cough and emphysema, and pneumonia, and, no doubt, predisposes the body to the attacks of the tubercle bacillus. As these dust diseases develop insidiously, the workmen engaged in such occupations should have their chests examined periodically, and any signs of commencing disease should be regarded as a disqualification for that particular kind of employment.

## MORTALITY FROM PNEUMONIA AMONG ENGLISH IRON AND STEEL WORKERS.

On account of the exceptional mortality from pneumonia among males in the Middlesbrough district, it is of interest to note that during the working period of life, that is, ages 25 to 65, the death rate in the county boroughs of the North of England was 1.6 per 1,000; in Sheffield it was 1.2 per 1,000; in Middlesbrough, among females, 0.9 per 1,000; and in Middlesbrough, among males, 3.4 per 1,000. It is said in this connection that "The death rate from pneumonia in Middlesbrough is between two and three times higher than in the county boroughs of the North, in Sheffield, and in the country generally among males between the ages of 25 and 65 years, while it is between three and four times higher than that among females in Middlesbrough." With respect to possible occupational causes, in explanation of the excessive mortality from pneumonia, the following conditions are emphasized:

(*a*) Working in high temperatures with sudden exposure to cold, strong currents of air, and to powerful blasts of fiery and suffocating gases.
(*b*) Inhalation of dust of various kinds, and especially dust given off in the manufacture of slag manure.
(*c*) Injuries of any kind, especially to the chest.
(*d*) Excessive fatigue, especially after nightwork.
(*e*) Careless habits after leaving work.
(*f*) Intemperance in food and drink.

In the majority of cases it is held that "the disease is conveyed by autoinfection. A condition of lowered resistance, due to one or more of the above causes, furnishes a state of ill health favorable to the growth of an organism either already present in the mouth or throat of the patient or inhaled with dust or bad air." It is therefore suggested that patients who have suffered from pneumonia (as well as those who have not) should exercise the greatest care in keeping their teeth, mouth, and throat in a healthy condition. On account of the fact that pneumonia in Middlesbrough is of a very fatal type, accounting for one-fifth of all the deaths in 1911, it is advised that—

The sputum should be carefully destroyed as soon as possible. For this purpose the patient should expectorate into squares of paper or into small cardboard receptacles containing a layer of common salt or other suitable disinfectant, and the whole destroyed at frequent intervals by fire. Every reasonable care should be taken to prevent the patient coughing into the faces of the attendants, or onto the bedclothes, or upon the floor; such accidents frequently happen, especially in the case of semiconscious patients. The infected spots should be scrupulously cleaned with turpentine or spirit, and the clothing of the nurses and of those in attendance should be protected by overalls. The rooms in which pneumonia patients have been treated should be thoroughly disinfected, and I am glad to observe that this is now being undertaken by the municipality.

### GENERAL CONCLUSIONS.

The foregoing observations regarding pneumonia are of special importance in view of the obvious conclusion that the disease is unquestionably increased in frequency and possibly in severity by more or less continuous and considerable exposure to irritating metallic and mineral dust. That similar conditions prevail, though probably to a lesser degree, in the United States is made evident by a recently issued technical paper by the United States Bureau of Mines on Health Conservation at Steel Mills, by J. A. Watkins, of the United States Public Health Service. The paper includes observations on the medical supervision of employees, hospital facilities, fatigue as a cause of occupational disability, the relation of industrial buildings to the health of employees, noise as a cause of lowered efficiency, ventilation, temperature and humidity, hours of duty, washing and sanitary facilities, drinking water, food, etc. There are, however, no observations in this interesting discussion on industrial diseases as such, and no reference whatever to the dust menace as common to a number of special processes in the iron and steel industry, chiefly, of course, in grinding and polishing during the final processes of manufacture. The discussion is, therefore, general and has reference rather to sanitary conditions than to occupational hazards, and a much more specialized investigation would be necessary to establish the occupational-disease hazard in the American steel industry as carried on under modern conditions at such model plants as that at Gary, Ind., of which an admirable descriptive account was published in the Engineering and Mining Journal for December 26, 1908.

## METAL GRINDERS.

### THE HYGIENE OF METAL GRINDING.

The grinding trade includes a large variety of employments, of which metal grinding, by either the dry or wet process, is hygienically as well as industrially the most important. The grinding of metal probably involves as much exposure to decidedly health-injurious conditions as does any other employment, if not more so. Chiefly as the result of the inhalation of relatively large quantities of fine metallic dust, and not inconsiderable quantities of fine mineral dust, the mortality from pulmonary tuberculosis in this occupation is decidedly above the normal for occupied males generally. While the sanitary and other conditions injuriously affecting the health of metal grinders never have been so notoriously bad in the United States as in England or in continental Europe, the observed mortality of this occupation as carried on in this country fully warrants the most serious conclusions as to the health-injurious effects of this group of employments.

The mortality of metal grinders has been discussed by James H. Lloyd, M. D., in his treatise on "Diseases of occupations," included in the Twentieth Century Practice of Medicine, published in 1895. Lloyd, after calling attention to the well-known fact that the trade of the grinder is conspicuous above all others for the suffering that is entailed from the inhalation of metallic dust, describes in detail the different processes of grinding and their relation to health. He says in part:

Grinding edge tools is of two kinds—wet and dry. The latter method is by far the more injurious, as, naturally, it raises far the greater amount of dust. For some tools both methods are used—the mixed method. The tools ground are scythes, saws, table knives, machine knives, various other kinds of edge tools, files, penknives, razors, scissors, forks, needles, etc. A great difference in their bad effects is observed among the branches of the trade according as the grinders use the wet or dry method and according to the tool ground. The smaller objects are far the most trying and exacting upon health. The worst of all branches are the fork grinding and needle grinding. This is because in grinding these small objects the workman is obliged to lean close over the stone and therefore inhales large quantities of the dust, and also because the dry grinding is used.

The dust raised by grinding is composed largely of minute bits of steel. According to Hall, 12 razor blades forged in the rough, which weigh 2 pounds and 4 ounces, lose 10 ounces in the process of grinding. This loss represents so much fine metallic dust, mingled of course with dust from the stone. This statement gives some idea of the immense amount of dust produced by dry grinding. According to Holland the concrete masses of this dust formed in needle grinding have almost the specific gravity of iron.

### TYPICAL DISEASES OF GRINDERS.

In discussing the symptoms of the diseases typical of grinders as the result of their employment, Lloyd points out further that—

They are those of a slowly advancing bronchitis with asthma and sometimes with emphysema; later dilated bronchi with excavation are observed; then, consolidation, and breaking down of lung tissue occur as the terminal processes. The exact relationship of these processes to a tubercular infection in grinders is an interesting and important subject, which, of course, did not receive much light from the earlier writers. They endeavored, in fact, to draw distinctions between true "consumption" and grinders' "asthma," but the state of pathological knowledge in their day was not such as to permit them to do otherwise. It is quite evident from reading their reports of cases that they had to do with a disease that was essentially tubercular, but it would be interesting to have the exact relationship of this infection to the grinders' unwholesome occupation investigated by the methods of modern bacteriology. I do not know whether this has ever been done. There can be no doubt that the influence of the grinder's trade is that of a predisposing cause. The inhalation of the irritating particles of steel into the lungs causes a constant catarrhal bronchitis and pneumonitis, with increase of connective tissue; and this prepares the soil for a tubercular infection which characterizes the latter stages of the disease.

## INJURIOUSNESS OF DRY-GRINDING PROCESSES.

A recent and more qualified discussion of the health-injurious circumstances of dry and wet grinding is by Oliver, who, in his Diseases of Occupation, goes fully into all the details concerning the trade, including a brief account of the corresponding conditions in the cutlery manufacture of Germany, at Solingen:

So far as the two methods of grinding cutlery are concerned, the dry method is, from a health point of view, the more dangerous to the workers. The dust is dry, and is in the form of a very fine powder, which readily reaches the lungs owing to the attitude of the men when at work. Steel grinders sit astride the grinding stone on a saddle, and as they lean forward keeping close to their work, they can not but inhale some of the dust, which is a mixture of steel and stone. Forks and needles are generally ground by the dry method; knives, scissors, and razors by the wet. Some are ground by both methods, e. g., the backs of razors and scissors are ground by the dry method and the remainder of the blade by the wet. It was in 1865 that Dr. T. C. Hall, of Sheffield, drew attention to the high death rate of steel grinders from pulmonary phthisis. The average age at death of steel grinders was at this period only 29 years, but of late this has improved. Dr. Hall's statistics referred to dry grinding. In wet grinding the running stone passes through a thin layer of water in a trough below the stone, so that, as its surface is always kept wet, comparatively little dust is given off during the process of grinding; but while the atmosphere is clearer of dust, the floors and walls of the workshop are damp and cold. The grinding is carried on in rooms called "hulls," which are bounded by three blank walls; the windows are without glass. Where dry grinding is carried on there are fans, but these often prove ineffective. It is no uncommon thing to find men engaged in different processes in one large room, so that the dust which is generated affects not only the workman sitting at his own grinding stone, but the other inmates of the room as well. In Sheffield it has been ascertained that in every 1,000 deaths among steel grinders pulmonary phthisis is the cause of 345 and other respiratory diseases 295; that is, collectively pulmonary diseases account for 64 per cent of the entire mortality, whereas among the adult population of the country generally phthisis accounts for 144 deaths per 1,000 and other respiratory diseases 182, or collectively 32.6 per cent. Steel grinders die comparatively young. Dr. Sinclair White, in Dangerous Trades, page 414, says that 458 grinders in every 1,000 die between the ages of 35 and 55, compared with 261 in every 1,000 of the entire male population of the country. Only 140 grinders out of every 1,000 reach the age of 55 and upward, whereas for every 1,000 of the adult male population 391 reach 55 years and upward. Sinclair White is of the opinion that phthisis is not so rife among steel grinders as formerly. In Dr. Hall's time the average age at death from phthisis was 29 years; at present it is 43.[1]

### IMPROVEMENT IN THE HEALTH OF GERMAN CUTLERY GRINDERS.[2]

With reference to conditions in Germany and the remarkable improvement which has followed the introduction of sanitary precautions, rational methods of ventilation, and other means of dust prevention, Oliver holds:

In the town of Solingen and the neighborhood it is estimated that there are 29,000 persons employed in making cutlery. Here all sorts of steel goods are made—knives, forks, scissors, and swords. A good deal of the work is done by the people in their homes, and it is interesting to know that the home industry is rather encouraged by the local authority, which provides the men with gas and electric power. So prevalent is pulmonary consumption among the grinders in Solingen that it has attracted the attention of the Government factory department. In the 10 years 1885–1895, 72.5 per cent of the deaths among knife grinders in the Solingen district was due to phthisis, against 35.3 per cent for the rest of the population over 14 years of age, and an official examination showed that out of 1,250 grinders only 85 men were over 45 years of age. Dr. Shadwell speaks approvingly of the methods adopted in some of the Solingen factories to deal with the removal of dust. Oldendorf, in writing about the grinders at Solingen, states that 24.7 per cent reached 50 years of age and 3.3 per cent 70; that at Runsched 33.8 per cent reached 50 years and 8 per cent 70; while at Kronenberg the numbers were 32.9 and 8.7, respectively. The mean age at death of grinders employed in the dry methods was 39.4, of workers in iron 48.3, and of the rest of the male population 54.4 years. Taking all ages, the deaths from tuberculosis per 100 cases were for grinders 78.3, iron workers 59, other persons 46.[3]

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[1] Diseases of Occupation, Thomas Oliver, pp. 230, 231, London, 1908.

[2] In this connection see "Gesundheitsbuch für die Kleineisen-Industrie," von Dr. G. D. Orthmann, Berlin, 1899; "Gewerbliche Gesundheitspflege," von Dr. A. Bender, Stuttgart, 1906; "Handbuch der Arbeiterkrankheiten," von Dr. Theodor Weyl, Jena, 1908.

[3] Diseases of Occupation, Thomas Oliver, p. 232.

## SANITARY PRECAUTIONS IN GERMAN CUTLERY SHOPS.

A very interesting account of the mortality of cutlery grinders in Solingen was also included in the Report of the Chief Inspector of Factories and Workshops of England for 1906, from which an abstract is made to emphasize the sanitary and labor conditions required for the reduction of the mortality of grinders to a minimum:

The atmosphere of Solingen is bright and clear. It is seldom that black smoke is seen escaping from the factory chimneys. This is largely the result of careful firing and the use of coal briquettes instead of ordinary coal, which avoids the use of slack coal. The day's actual work is nine hours; on Saturday work ceases at 5.30 p. m. The factories in Solingen are said to be marvels of order and cleanliness; the floors are of concrete and the air space for each worker must be at least 565 cubic feet. All the grinding stones are protected by guards. The walls of the workrooms are limewashed every year; the floors are swept every evening and damp-wiped once a week. The "raising" of grindstones is never undertaken during working hours except under a stream of water or unless the stone is entirely inclosed in casing except at the working place of the raising tool. The floors are kept clean and provision is made for the removal of the dust during grinding. Cutlery manufacture is recognized as a dangerous trade in Solingen, and in recent years considerable improvement has taken place in the means to prevent dust. In Solingen the grindstones and polishing wheels are run toward the worker; in Sheffield they are run away from the worker, so that the dust has an upward tendency and flies into the room.[1]

The subject is also considered in the Report of the Chief Inspector of Factories and Workshops for 1907, in which the rules or police regulations governing the trade at Solingen are republished in full. A remarkable improvement in the health of the workmen has followed the introduction of these rules.[2]

## MORTALITY OF SHEFFIELD METAL GRINDERS.

Some exceptionally interesting and useful mortality data of metal grinders have been published for a period of years by the city of Sheffield, England, but unfortunately the statistics were discontinued subsequently to 1910. Table 25 shows the mortality in detail of 2,490 grinders, of whom 1,070, or 43 per cent, died from pulmonary tuberculosis, with an additional mortality of 621, or 24.9 per cent, from nontuberculous respiratory diseases.

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[1] Report of the Chief Inspector of Factories and Workshops, 1906, pp. 107-109.

[2] For additional references on the occupational diseases of German file makers and related industries, see Albrecht, Handbuch der Praktischen Gewerbehygiene, Berlin, 1896, pp. 96 and 796; Sommerfeld, Handbuch der Gewerbekrankheiten, Berlin, 1898, p. 365 (including statement that average age at death for file cutters dying from pulmonary tuberculosis was only 41.2 years and from all other diseases 46.1 years). Of special importance is the more extended discussion of this occupation in Weyl's Handbuch der Arbeiterkrankheiten, Jena, 1908, pp. 80, 91, 106, 135 et seq.

TABLE 25.—PROPORTIONATE MORTALITY FROM PULMONARY TUBERCULOSIS AND FROM OTHER RESPIRATORY DISEASES COMPARED WITH THAT FROM ALL CAUSES, AMONG GRINDERS IN SHEFFIELD, ENGLAND, 1889 TO 1910, BY AGE GROUPS.

[Source: Annual reports of the medical officer of health, Sheffield, England. Similar returns are not available in these reports subsequent to 1910.]

| Age at death. | Deaths from all causes. | Deaths from pulmonary tuberculosis. | | Deaths from respiratory diseases other than pulmonary tuberculosis. | |
|---|---|---|---|---|---|
| | | Number. | Per cent of deaths from all causes. | Number. | Per cent of deaths from all causes. |
| Under 25 years | 98 | 43 | 43.9 | 22 | 22.4 |
| 25 to 34 years | 299 | 173 | 57.9 | 51 | 17.1 |
| 35 to 44 years | 515 | 303 | 58.8 | 81 | 15.7 |
| 45 to 54 years | 687 | 336 | 48.9 | 169 | 24.6 |
| 55 to 64 years | 548 | 178 | 32.5 | 184 | 33.6 |
| 65 years and over | 343 | 37 | 10.8 | 114 | 33.2 |
| Total | 2,490 | 1,070 | 43.0 | 621 | 24.9 |

According to this table, at ages under 25 of every 100 deaths from all causes 43.9 are from pulmonary tuberculosis, the proportion increasing to 57.9 per cent at ages 25 to 34, and 58.8 per cent at ages 35 to 44. Subsequently to this period the proportion declines to 48.9 per cent at ages 45 to 54, and to 32.5 per cent at ages 55 to 64; at ages 65 and over the proportion of deaths from pulmonary tuberculosis is only 10.8 per cent of the mortality from all causes. The corresponding mortality from nontuberculous respiratory diseases must also be considered excessive at practically every period of life.

In view of the frequent use of the term "grinders' phthisis," as based chiefly upon the morbidity experience of Sheffield grinders,[1] the following observations by J. M. Beattie, M. D., are of interest. The extract is from a paper on the "Hygiene of the steel trade," published in the Transactions of the Royal Sanitary Institute for 1912:

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. The much more serious problem—the prevention of infection with *B. tuberculosis*—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 the cutlers and grinders die from tuberculosis and not from nontuberculous fibrosis of the lung.

Let me protest against the loose use of the word "phthisis." Rightly or wrongly, phthisis is now understood by medical men to mean

[1] Regarding health conditions among Sheffield grinders see "The Vital Statistics of Sheffield," by G. C. Holland, M. D., London, 1843, pp. 152–205; "Unhealthy Trades," by B. W. Richardson, Lectures before the Society of Arts. Reprinted in Scientific American Supplement No. 9 (Feb. 26, 1876); "Mortality of Dusty Trades in Sheffield," by Scurfield. British Medical Journal, Aug. 22, 1908, p. 480; "Annual Reports on the Health of Sheffield, England," Special Tables and Observations on Mortality in Sheffield Trades, 1889–1907.

tuberculosis of the lung 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 get at satisfactory statistics, and we can therefore only regard the figures given as approximate.

### MORTALITY OF GRINDERS—INDUSTRIAL INSURANCE EXPERIENCE.

No extended scientific study, medical or otherwise, has been made of grinders' phthisis, or the occurrence of pulmonary tuberculosis among the grinders in the United States, but some suggestive observations on different aspects of the grinders' trade have been reported upon in detail by the division of occupational diseases of the Ohio State Board of Health. The only conclusive mortality data for the United States are the industrial insurance mortality statistics of the Prudential Insurance Co., limited, however, to 305 deaths, of which 143, or 46.9 per cent, were caused by pulmonary tuberculosis. This percentage is not much at variance with the corresponding figure for Sheffield grinders, but is, in part, no doubt, the result of important differences in age distribution, since the maximum number of deaths in the United States occurred at ages 35 to 44, against ages 45 to 54 in the English experience. The excess in the mortality of grinders from pulmonary tuberculosis is brought out with sufficient clearness and conclusiveness in Table 26, in which comparison is made with the corresponding mortality of males in the registration area.

TABLE 26.—PROPORTIONATE MORTALITY FROM PULMONARY TUBERCULOSIS AMONG GRINDERS, 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 grinders, 1897 to 1914, due to— | | Per cent of deaths due to pulmonary tuberculosis among— | |
|---|---|---|---|---|
| | All causes. | Pulmonary tuberculosis. | Grinders. | Males in registration area, 1900 to 1913. |
| 15 to 24 years | 17 | 7 | 41.2 | 27.0 |
| 25 to 34 years | 56 | 38 | 67.9 | 30.5 |
| 35 to 44 years | 74 | 44 | 59.5 | 23.4 |
| 45 to 54 years | 73 | 35 | 47.9 | 14.7 |
| 55 to 64 years | 55 | 14 | 25.5 | 7.9 |
| 65 years and over | 30 | 5 | 16.7 | 2.6 |
| Total, 15 years and over | 305 | 143 | 46.9 | 13.9 |

According to this table, the proportionate mortality of grinders from pulmonary tuberculosis is excessive at all ages, but most pronounced at ages 25 to 34, when out of every 100 deaths from all causes, 67.9 are from pulmonary tuberculosis, against 30.5 per cent for males in the registration area. The data, while limited, may be accepted as trustworthy regarding the mortality of grinders from pulmonary tuberculosis in the United States at the present time. The evidence is sufficient to show that the disease is of excessive frequency among grinders at every divisional period of life, and very considerably above the normal for the general male population.

### MORTALITY OF INSURED GRINDERS—MEDICO-ACTUARIAL EXPERIENCE.

The foregoing observations are sustained by the medico-actuarial experience, which, however, is only with reference to the mortality from all causes. According to this experience, which includes cutlers, scissors grinders, ax, plow, and other steel grinders, but excludes foremen and superintendents, the actual mortality among 5,988 employees exposed to risk one year was 43 deaths, while the expected mortality was 36.69, or 17 per cent in excess; in other words, to every 100 deaths expected on the basis of the normal experience there were among the group considered 117. When the age factor, however, is taken into account, it appears that at ages under 40 the actual mortality was less than the expected, while there was a rapid and very considerable rise in the excess at ages over 40. Unfortunately, the numbers under observation are insufficient for strictly scientific conclusions. The results, in detail, are given in Table 27.

TABLE 27.—MORTALITY FROM ALL CAUSES AMONG CUTLERS AND SCISSORS, AX, PLOW, AND OTHER STEEL GRINDERS (EXCLUDING FOREMEN AND SUPERINTENDENTS), BY AGE GROUPS—MEDICO-ACTUARIAL INVESTIGATION.

| Age at death. | Number exposed to risk 1 year. | Actual deaths. | Expected deaths. | Ratio of actual to expected deaths. |
|---|---|---|---|---|
| 15 to 29 years | 3,208 | 12 | 14.55 | 82 |
| 30 to 39 years | 1,841 | 9 | 10.19 | 88 |
| 40 to 49 years | 667 | 10 | 6.17 | 162 |
| 50 to 59 years | 254 | 12 | 5.04 | 238 |
| 60 years and over | 18 | ........ | .74 | ........ |
| Total | 5,988 | 43 | 36.69 | 117 |

### SANITARY INVESTIGATIONS BY THE OHIO STATE BOARD OF HEALTH.

Some very useful observations on the health of grinders have been included in the report of the Ohio State Board of Health, by Hayhurst, who points out that—

The process of metal grinding is one closely associated with foundry work and assembling processes upon both iron and soft metals. It properly includes also the dressing of castings by other means than grinding, such as "sand blasting," "rattling" in tumbling machines, and "chipping" by means of steel tools. Sand blasting has been considered elsewhere, while a word will be given here to each of the other subsidiary processes. Metal grinding is usually performed with emery wheels, which may be stationary or may be moved about over large surfaces by means of a swing-belt attachment. Occasionally it is done mechanically by a series of traveling emery wheels, which pass up and down over the surfaces to be ground. Sometimes it is done by belts covered with emery or other exceedingly hard abrasive substances. Carborundum and corundum, two substances of diamondlike hardness, are the chief abrasives used.

In the investigation by Hayhurst, including 64 establishments employing a total of 1,979 male wage earners, modern methods of work were observed in 42 places, fairly modern methods in 14, and crude or antiquated methods in the remaining 8. Health appliances, especially those consisting of blower systems to remove the dust created, were considered good in 20 places, of only partial efficiency in 13, and found entirely absent in the remaining 31. In 20 of the work places other processes than metal grinding were carried on in the same quarters, such as sand blasting, forging, welding, polishing, buffing, etc. This condition is quite common throughout the dusty trades, and illustrates the difficulty, if not the impossibility, of completely separating one injurious process from another. As a broad generalization, however, the present classification may be considered sufficient for the purpose. The Hayhurst investigation, while limited to the State of Ohio, may be considered fairly conclusive for the country at large, although it is pointed out that—

It is probable that country-wide statistics would be much more accurate, both because of the larger number of deaths and because persons with bronchial or respiratory diseases have a strong tendency to migrate to western States.

### MORTALITY EXPERIENCE OF THE STOVE MOUNTERS' INTERNATIONAL UNION.

The investigation concludes with an interesting table of statistics derived from a report submitted by the Stove Mounters' International Union for the United States and Canada. These workers are engaged only about one-fifth of their time in metal grinding, and usually they are employed without the advantage of any protective devices whatever. Most of the time, however, they work in an atmosphere more or less contaminated with fine metallic and mineral dust. Table 28 is as follows:

TABLE 28.—PER CENT OF DEATHS FROM EACH SPECIFIED CAUSE AMONG STOVE MOUNTERS TO WHOM DEATH BENEFITS HAVE BEEN PAID BY THEIR ORGANIZATION DURING THE PAST FIVE YEARS, IN THE UNITED STATES AND CANADA (UNDER DATE OF SEPT. 17, 1914).

| Cause of death. | Per cent. |
|---|---|
| Tuberculosis | 27.95 |
| Heart disease | 20.93 |
| Accident | 11.67 |
| Pneumonia | 9.31 |
| Other preventable causes | 13.88 |
| Degenerative diseases | 9.23 |
| All other causes | 7.03 |
| Total | 100.00 |

### GENERAL CONCLUSIONS.

The available evidence is, therefore, sufficiently conclusive that metal grinding in probably any and all of its various forms must be considered one of the most injurious occupations inciting a special predisposition of the workers to tuberculous and nontuberculous respiratory diseases. Aside therefrom, the Hayhurst investigation ascertained in 17 plants an occurrence of 22 cases of industrial diseases, as follows: Chronic lead poisoning, 5 cases; pulmonary siderosis, 9; frequent attacks of brass poisoning, 2; bronchitis, 2; pneumonia, 1; tuberculous empyema, 1; brush burns of the hands, 1; conjunctivitis, 1.

The results seem to indicate generally unsatisfactory working conditions, and they sustain the statement made by Hayhurst that—

> The better control of the dust is the first essential, while shorter work hours, alternation of work to overcome monotony, and the features mentioned under the respective hazards above, as well as medical examination and supervision, are necessary to control health in this entirely unnatural and hazardous process.

Concerning the conflicting character of the official vital statistics of grinders, it is stated in this connection, in the report on the draft regulations proposed to be made for factories in which the grinding of metals and the racing of grindstones is carried on, by Alfred Herbert Lush (Parliamentary paper Cd. 4913, London, 1909) that—

> The figures were not in all respects easy to reconcile; but it was clearly established that both the wet and the dry grinders were affected by diseases of the respiratory organs, and especially by fibrosis of the lungs and by phthisis, to an extent far beyond the average of occupied males, the mortality from phthisis amongst them being six times that average. The men who enter these trades are usually above the ordinary standard of physique and vigor, because weakly men are unsuited to the work; yet the proportion of damaged lives found by Dr. Collis was very heavy, and the duration of life is nearly the lowest of all the trades. The cutlers, who are said to be as a rule of weaker physique to begin with, suffer less from phthisis and have longer lives; but they appear to be more liable to the minor diseases due to dust irritation, and in no respect can their health conditions be considered satisfactory.

This report is an exceptionally valuable contribution to the practical study of dusty trades, and should be consulted in further amplification of the observations on the special circumstances and conditions tending to increase the exceptional liability of grinders to pulmonary tuberculosis.[1]

[1] See in this connection "The story of the grinding wheel," by C. W. Blakeslee, in The Iron Age, reprinted in the Scientific American Supplement No. 2125, Sept. 23, 1916. Mention should also be made of the report on the draft regulations proposed for factories and workshops in which the process of file cutting by hand is carried on, by Chester Jones (Parliamentary paper Cd. 1658, London, 1903).

## POLISHERS.

The polishing of metal ware is a widely diversified trade, and the term "polisher" is one of general rather than of special significance. Under the term are included metal polishers and buffers working upon steel, brass, gold, and silverware, but no data are available which would permit of a proper classification of polishers according to the metal or material manipulated.

### POLISHING PROCESSES IN RELATION TO DUST.

The health-injurious effects of this employment have been recognized by all who have written upon the mortality of dusty trades, and the more important facts are summarized by Arlidge, in part, as follows:

After being shaped and ground to the required dimensions, the next business is to burnish or polish the articles. This is accomplished by wheels covered by leather, and also by a thick bundle of linen rags cut and bound together in the form of a wheel, and which, by rapid rotation, assumes the character of a solid mass, and, at the same time, one so soft as to serve better than any other contrivance for the purpose of surface polishing. To assist in giving polish to the articles made, various powders are employed; for example, emery, whiting, rouge, powdered pumice, etc. The use of these materials adds vastly to the dust of the trade and to its pernicious results; but no data are in existence to indicate what is its share in the causation of disease as compared with the dust of the grindstones. Still, no question exists that these polishing powders, differing as they do among themselves in physical qualities, differ likewise in the range of their effects upon the lungs.

The rather involved circumstances affecting the polishers' health and mortality are also discussed in The Workers of the Nation, by Mr. Gilson Willets, whose attention appears to have been attracted by the particularly health-injurious conditions of the employment, and whose conclusions are decidedly suggestive:

Metal polishers who have reached the age of 40 often look like old men. There can hardly be found a trade more deleterious to health, say those who follow it. Among the harmful conditions may be mentioned the liability of the workmen to get their lungs full of flying and impalpable dust, which is composed of metal, minerals, and cotton fiber. They are also, in many cases, deprived of the proper supply of light, and great injury to the eyes thus arises. It is not easy to wear goggles or glasses, as the operator's sight must be of the keenest in order to detect blemishes. There are laws for the protection of this class of workmen, but they are too seldom employed. New York statutes require that at each polishing lathe there shall be an exhaust fan to carry off the dust, that each operative shall have 250 cubic feet of air space, and plenty of light. It has been claimed that not in 5 per cent of the shops do these desirable provisions prevail. A buffing wheel, making 2,500 revolutions per minute, has wrecked many constitutions. From it, as the polisher applies the metal, a cloud of dust arises, made of particles of cloth and metal, and that is what the operator breathes. Generally the windows are hermetically sealed. Often the walls and floors are covered with the accumulation of years. In the process of brightening silver-plated material there is given forth by the wheel a cloud of dust of which crocus is a large constituent, while from the plating room come fumes of nitric acid. In the process of polishing chandeliers there is much dust set free, which is composed of particles of brass, and permeates the air of the shop. Metal polishers often do not care to complain, because their wages are high. Here is a good field for activity among the factory inspectors, who should force employers to maintain proper conditions in the shops.[1]

### SICKNESS EXPERIENCE OF THE METAL POLISHERS' UNION.

More recent evidence has been presented in the published sickness and mortality experience of the Metal Polishers' Union, regarding which it has been stated that—

The treasury of this union, in spite of the fact that the men are steady and have no special temptations to excess, was found to be constantly exhausted. The reason is that the death claims eat up all the funds. An investigation of these claims showed that many of the men were dying from pulmonary tuberculosis. There were some deaths from accident, a few suicides, but the rest were all from pulmonary diseases—and pneumonia was very rare as compared with phthisis. The statistics for the last four years show that in 1903, 45 metal polishers died, of whom 43 succumbed to some lung trouble. In 1904 there were but 38 deaths among the metal polishers, of which only 3 were due to other causes than pulmonary disease. In 1905 there were 70 deaths among the metal polishers, 65 of which were due to some form of lung trouble. In New York City a local union having 170 men working exclusively on the precious metals had 8 death claims in two years, 7 being due directly to tuberculosis, while 400 men employed in all the other branches of the same industry have had but 3 deaths from this cause in the same space of time.

A medical journal, commenting upon the above-quoted facts at the time of their publication, argued very pointedly to the effect that—

It would seem from these statistics that even the cleanest kinds of dust, without a trace of infectious material in them, may still prove a source of the greatest possible danger and be the indirect cause of tuberculosis. This has been known for some time, but so startling a confirmation of it is sure to emphasize the necessity for taking every precaution for the avoidance of dust. Even what might seem to be the most innocuous of dirt particles may, when inspired, constitute foci of irritation in which tubercle bacilli may readily find a favorable nidus for implantation and growth.

The results of the earlier investigations by the Metal Polishers' Union are in part confirmed by the statistics of the Metal Polishers,

[1] The Workers of the Nation, Vol. I, p. 57.

Buffers, Platers, Brass, and Silver Workers' Union of North America, which, for the 5-year period from 1909 to 1914 include 242 deaths from all causes, of which 31.9 per cent were from tuberculosis. The details of the mortality analysis are as follows:

TABLE 29.—NUMBER AND PER CENT OF DEATHS DUE TO EACH SPECIFIED CAUSE, AMONG METAL POLISHERS, BUFFERS, ETC., 1909 TO 1914.

| Cause of death. | Number. | Per cent. |
|---|---|---|
| Tuberculosis | 77 | 31.9 |
| Pneumonia | 31 | 12.9 |
| Heart disease | 31 | 12.9 |
| Violence (including 6 suicides) | 19 | 7.9 |
| Other preventable causes | 20 | 8.0 |
| Other degenerative diseases | 57 | 23.5 |
| All other causes | 7 | 2.9 |
| Total | 242 | 100.0 |

Table 29 is derived from the report by Hayhurst on "Industrial Health Hazards," 1915, in connection with which there has been published a quotation from an official letter stating in explanation that—

You will note from the report the large per cent of our members that die from pulmonary tuberculosis. All of these deaths we believe were contracted by working at this trade, but the sad feature is that at least 95 per cent of those that contract consumption, working at our dangerous trade, will not acknowledge they have the disease until they are too far gone for recovery. They then quit the trade and try to get a position out in the air, often as collectors, driving laundry wagons, on a farm, or, if fortunate enough, go West. These we believe eventually succumb to the disease contracted while working at the trade. We lose all track of them and have no record. If it were possible to keep this record, the percentage of deaths in our trade would be enormous.

In addition to the table, it is said that the median age at death of the 242 metal polishers, buffers, etc., was 40.1 years, while for those who died of tuberculosis it was 37.27 years. Most of the men who enter this trade start work as mere boys, between 16 and 18 years of age, so that the health-injurious consequences are of increased economic significance.

## POLISHING PROCESSES IN VARIOUS INDUSTRIES.

The observations by Hayhurst in connection with polishing and buffing are of exceptional value, in that they are based upon an extended personal investigation, including 51 plants, in 11 different cities, employing a total of 846 wage earners. Since the surrounding circumstances of polishers and buffers vary considerably on account of the numerous industries in connection with which such processes are carried on, it may be stated in this connection that among the industries investigated in Ohio were those manufacturing brass and bronze products, electrical apparatus, mirror making, cash registers, stoves and furnaces, foundry and machine shop products, coffin fixtures, cutlery and tools, copper, tin and sheet metal goods, automobiles and parts, jewelry, regalia, scales and balances, sewing machines and parts, scientific instruments, fiber combs, aluminum combs, signs and advertising novelties, etc. It is, therefore, quite clear that the statistical data concerning the mortality of a group of employees classified merely as polishers and buffers, and without reference to the special line of work in connection with which these particular processes are carried on, can not be entirely conclusive. Hayhurst in the report referred to points out that—

Dust in the breathing atmosphere was a negligible hazard in 12 places, fairly so in 17 more, but was bad in the remaining 22. It consisted chiefly of iron, steel, brass and bronze alloys, other soft metals, glass, etc., which were being worked upon, as well as the components of the polishing wheels (emery, silica, etc.) and of the buffing wheels (cotton and lint fibers, glue substances, etc.). In some places it was kicked up from the floors because of inefficient cleaning, and also dry sweeping during work hours. These dusts are, of course, the most harmful to which workers may be subjected, since they are exceedingly hard, crystalline, and very fine, or irritating, and, in the majority of instances, poisonous. There are so many consumptives in the trade that the infection factor is also added.

### VENTILATION AND SANITARY CONDITIONS.

With special reference to ventilation, it is stated that conditions were good in 16 places, fairly so in 17, but the air was close and confined and often contaminated with various fumes and gases from other processes in the remaining 18. Constant standing in a partially stooped posture with very little variation is referred to as an additional hazard in this industry. As regards the special liability to the contraction of communicable diseases, this was considered exceptionally serious in 24 places and considerably so in at least 18 more, "due particularly to promiscuous spitting on dusty floors and the absence of cuspidors." As to the use of protective devices, it is said that, "Occasionally some men were seen who were wearing respirators and endeavoring by this means to filter out the dust from the air which they inhaled."

Aside from the dust hazard, polishers and buffers were found to be subject to a liability to poisoning by lead, potassium cyanide, nitric-acid fumes, phenol, amyl acetate, benzine, alum, crude paraffin, furnace gas fumes, brass fumes, plating fumes, and acid-dipping fumes. The general health appearance of the workers in 24 plants was found to be good, in 13 it was bad, and in 14 more it was only fair. Positive evidence of industrial disease was observed in 8 plants, including 17 cases. Hayhurst concludes that—

As the constant breathing of harmful dust and the continual assuming of unnatural and strained postures are foreign to the physiology of the human organism, it is highly necessary that dust be kept out of the breathing atmosphere and to introduce measures which will vary the work for this class of workers. Unfortunately, it is looked upon as a skilled trade and this makes it difficult to introduce work variations. This does not detract, however, from its hazardous character. The toll of deaths from preventable causes bears this out. It is a process of modern times. One point which particularly impressed our investigators was that where blower systems were installed they were often very inefficient at the time of inspection and were said to be so most of the time. There appears to be but one way of getting around this—to make it somebody's business in each such room to see that such systems are in working order and to provide for compensation for this purpose. A metal or wooden "chest protector" prevents harmful pressure against the person. Other features, the liability to poisoning, etc., require the same precautions as elsewhere. Especially should medical supervision be adopted for this class of workers, as they are at a process which appears to take 20 or 25 years off of their lives.

## DUST HAZARDS IN BUFFING.

Some rather interesting additional observations in connection with the special dust hazard of buffing are contained in a descriptive account of the hazards of the tin and copper smith's industry by Charles C. Dominge, of the New York Fire Insurance Exchange (Weekly Underwriter, Nov. 6, 1909), in part as follows:

The buffing process is the most hazardous of all on account of the liability of spontaneous combustion. A very fine dust or lint is thrown off the buffers in this process. This dust is very hazardous, as the buffing wheels are in many cases saturated with oil used in polishing, and if allowed to fall to the floor, or accumulate in corners where oil or grease may be, it becomes an easy source of spontaneous combustion. In most plants a small blower system empties the dust into a barrel about half full of water located in a metal-lined room. A standard condition would call for a blower system similar to that used in woodworking establishments, only, of course, on a smaller scale. The blowers should lead directly on the outside of building to the roof, discharging their contents into a "cyclone" or separator, whence an outside duct carries the lint to a fireproof vault (with vent) detached at least 5 feet from main risk. Inspectors should satisfy themselves that there are no defects in the system, and should follow same from start to finish.

## MORTALITY OF BUFFERS, FINISHERS, AND POLISHERS—MEDICO-ACTUARIAL EXPERIENCE.

The precautions called for by the introduction of adequate measures for the control of the fire hazard are quite certain to react favorably upon the sanitary conditions of the industry. In American life-insurance experience, metal burnishers, buffers, finishers, and polishers, excluding foremen and superintendents, have proven decidedly unfavorable as a class of risks at ages 30 to 59, with an excessive mortality of about 14 per cent. The results of the medico-actuarial investigation with reference to this group of employees are shown in Table 30. The effect of medical selection must be taken into account.

TABLE 30.—MORTALITY FROM ALL CAUSES AMONG METAL BURNISHERS, BUFFERS, FINISHERS, AND POLISHERS, EXCLUDING FOREMEN AND SUPERINTENDENTS, BY AGE GROUPS—MEDICO-ACTUARIAL INVESTIGATION.

| Age at death. | Number exposed to risk 1 year. | Actual deaths. | Expected deaths. | Ratio of actual to expected deaths. |
|---|---|---|---|---|
| 15 to 29 years | 7,601 | 28 | 34.47 | **81** |
| 30 to 39 years | 5,500 | 35 | 30.78 | **114** |
| 40 to 49 years | 1,422 | 14 | 12.35 | **113** |
| 50 to 59 years | 316 | 7 | 6.15 | **114** |
| 60 years and over | 35 | 2 | 1.27 | **157** |
| Total, 15 years and over | 14,874 | 86 | 85.02 | **101** |

The available evidence regarding the unhealthfulness of this group of occupations is, therefore, quite conclusive. In view of the relatively large proportion of young persons, both men and women, employed at polishing and buffing, the required sanitary precautions are of special importance. The efforts of the Buffers and Polishers' Union to bring the most trying conditions to public attention are deserving of appreciation. The rigid enforcement of laws enacted to compel factories and workshops where polishing and buffing are being done to install exhaust fans to minimize the dust danger may be laid down as a principle of labor legislation of the first order of importance. Among the dusty trades there are few more typical, on the one hand, of the health-injurious consequences of the continuous inhalation of metallic and mineral dust, and, on the other, of the far-reaching practical possibilities of effective ventilating devices so constructed as to remove the largest possible quantity of dust at the point of origin and of preventing general air pollution to the largest attainable degree.

### MORTALITY OF POLISHERS—INDUSTRIAL INSURANCE EXPERIENCE.

The most conclusive mortality statistics concerning polishers are the industrial insurance experience data of the Prudential Insurance Co. of America for the period 1897 to 1914, including 964 deaths from all causes, of which 355, or 36.8 per cent, were from pulmonary tuberculosis.

TABLE 31.—PROPORTIONATE MORTALITY FROM PULMONARY TUBERCULOSIS AMONG POLISHERS, 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 polishers, 1897 to 1914, from— | | Per cent of deaths from pulmonary tuberculosis among— | |
|---|---|---|---|---|
| | All causes. | Pulmonary tuberculosis. | Polishers. | Males in registration area, 1900 to 1913. |
| 15 to 24 years | 136 | 59 | 43.4 | 27.0 |
| 25 to 34 years | 230 | 129 | 56.1 | 30.5 |
| 35 to 44 years | 241 | 106 | 44.0 | 23.4 |
| 45 to 54 years | 173 | 43 | 24.9 | 14.7 |
| 55 to 64 years | 112 | 16 | 14.3 | 7.9 |
| 65 years and over | 72 | 2 | 2.8 | 2.6 |
| Total, 15 years and over | 964 | 355 | 36.8 | 13.9 |

According to Table 31, the proportionate mortality of polishers from pulmonary tuberculosis is relatively excessive at all ages, but particularly so at ages 25 to 34, at which 56.1 per cent of the deaths of polishers from all causes are from pulmonary tuberculosis, against an expected proportion of 30.5 per cent. The excess in the proportionate mortality is, however, significant and suggestive at all ages, and sufficiently so to warrant the final conclusion that the mortality from pulmonary tuberculosis in this occupation must be considered as decidedly above the normal for the general population, although somewhat below the corresponding average for grinders.

## CARD GRINDING.

The so-called "carding" of the cotton in the manufacture of cotton textiles is an exceedingly important process. Good carding depends upon good grinding, for if the grinding is not done to perfection, the setting of the cards can not be done with anything like accuracy. The surface of the grinding rollers is usually covered with emery-filleting, and the grinding itself is principally done by the large grains of emery with which the outer surface of the roller is covered. There is, therefore, a mixed exposure of metallic and vegetable fiber dust, particularly in the cleaning process, since, when the grinding is considered sufficient or "finished," the cards must be well brushed to clear away the dust, etc. The object of carding is to "disentangle the fibers of cotton and lay them lengthwise and parallel with each other." This process necessarily results in the production of a considerable amount of fine fluff, of vegetable fiber origin, intermixed with the metallic dust resulting from the use of emery substances. The quantity of emery dust generated in this process is, however, apparently not very serious, and more importance is attached to the cotton-fiber dust which must necessarily tend to increase the health-injurious nature of this, as well as all other employments in the carding room. Whether there is any essential difference in the health and mortality of card grinders as differentiated from carders is difficult to determine in the absence of trustworthy statistical information.

Such observations as have been made regarding the personal physical appearance of employees in connection with this process have been suggestive of health-injurious results. The total number of persons reported as being employed at card grinding during the census year was only 1,091, of which 1,087 were males and 4 females. On account of the small number reported employed, the age returns can not be considered conclusive. Card grinding, apparently, is quite often carried on in connection with other employments in the carding room, and this is especially true of small cotton mills.

### FILE CUTTING.

The specific effect of this occupation on health and longevity is medically recognized in the term "file-cutters' disease," which is a form of pneumoconiosis. The occupation is rarely carried on entirely by itself, and there are no trustworthy data regarding even the approximate number of men employed in this industry. The making of rasps and files is generally carried on in connection with other branches of the toolmaking industry. An important center of manufacture is the city of Newark, N. J., but no conclusive data regarding the mortality of men employed in this occupation have been made available through local vital statistics. How far file cutters require to be differentiated from file grinders is not ascertainable at the present time.

#### VARIATIONS IN OCCUPATIONAL EXPOSURE.

Much of the modern work is done on wet grindstones, by means of which the dust hazard has been materially reduced. Workers on dry emery wheels are, of course, excessively exposed to a mixed dust hazard of metallic and mineral origin. Aside from the dust hazard, there is a liability to lead poisoning in connection with the hardening process. By some authorities the hardening process is considered more injurious than the dust exposure. The occupation is briefly discussed in the Report of the Massachusetts State Board of Health upon the Sanitary Condition of Factories, etc., 1907, in part, as follows:

In the manufacture of files the workmen are exposed to a double danger, namely, exposure to metallic dusts and contact with metallic lead. The best files are cut by hand, no machine having as yet been invented which can produce their equal. The blanks are first ground smooth with the aid of stones, and in this operation considerable mineral and steel dust is caused. During the process of cutting the file lies on a base of lead and the lines are cut by a chisel struck by a heavy hammer. The leaden bed offers sufficient resistance, while at the same time it is sufficiently yielding to prevent a sharp recoil. As the file is cut it is constantly brushed off, usually with the hand, which thereby becomes to a certain extent coated with very fine particles of lead, and the air becomes more or less impregnated with lead and steel dust. A common habit of file cutters in manipulating the file is to wet the finger and thumb with the tongue, thus conveying to the mouth particles of lead, which, through the acts of conscious and involuntary swallowing, gain access to the stomach. The work is very laborious, and the attitude which the workmen are obliged to assume is one which does not admit of normal respiratory movements, since they sit at a bench and stoop over the file. The workmen of this class are notoriously careless, and are inclined to reject the idea that their calling is not free from danger; but, although in the establishments visited an occasional workman was observed to be pale and sickly in appearance, it must be admitted that as a class they looked well and strong. Five shops of this class, employing from 5 to 70 persons (150 in all), presented reasonably good hygienic conditions. All showed fairly good ventilation, and but two were not well lighted. In two, employing, respectively, 8 and 60 workmen, considerable dust was perceptible in the air.

In 1903 the British Government published a report on the proposed draft regulations relating to the process of file-cutting by hand, which among other observations includes the statement that—

The trade of file cutting by hand is one that may be distinctly classed as dangerous and certainly in need of regulation; in addition to this, in Sheffield at all events, the trade is, generally speaking, carried on under most insanitary conditions. The principal danger to the worker arises from the handling of the lead bed on which the file is cut, and from inhaling the lead dust produced by the blows of the hammer in cutting the files, and in brushing the files when cut. * * * It seems to be the better opinion that the danger arising from the handling of the lead bed was greater than that from the inhalation of the dust. As the result of using the lead bed the file cutter by hand is peculiarly liable to plumbism and to nervous and urinary diseases. Phthisis is also a disease to which the file cutter is subject considerably in excess of workers in most other trades; this seems to be due to the insanitary conditions under which he works acting on a system already enfeebled by the mischief of the lead. * * * The expression "file maker" includes file cutters by machinery as well as file cutters by hand. Now, as file cutting by machinery does not involve the use of the lead bed and is not carried on under the insanitary conditions prevailing in file cutting by hand, file cutting by machinery can not be said to be a dangerous trade. It is therefore obvious that the mischief amongst file cutters by hand is greater than that given by the tables as occurring amongst file cutters as a whole.

The subject has also been discussed in the Third and Fourth Interim Reports of the Dangerous Trades Committee of the British Home Office, 1898–99. In the absence of strictly conclusive mortality data with a due regard to ages at death and the causes thereof, the available information must be considered rather inconclusive.

### DESCRIPTIVE ACCOUNT OF SANITARY CONDITIONS IN OHIO.

Hayhurst has reported, for Ohio, the results of an investigation of four establishments employing 108 male wage earners, including some machine file cutting in two establishments. It is stated that there were no special devices which could be designated as health appliances in any of the plants, even the forges in a large plant being without hoods and vents. According to this investigation—

Dust was a hazard to grinders in all places, although the principal work was done in the wet on large grindstones. The friction heat present, however, with the flying of sparks, caused a certain amount of fine dust to escape, in spite of the water. There were a number of unprotected emery wheels. Polishing was also done by sand blasts. A small but constant amount of dust was also produced during cutting which always contained some lead scraped loose from the "bed" which supported the file. Workers' faces were also quite close to the work. None of the places visited was exemplary in matters of cleanliness and order, while in three there was plenty of dirt and waste accumulations. A dirt floor was present in one place located in basement-like quarters. Dampness was a feature of the work in the grinding rooms, where the water occasionally escaped from the grindstones and soaked up the floors. The lighting of the quarters was good in two places and poor in the other two, in one of which oil lamps were depended upon for the principal illumination. The general ventilation of quarters was fair to good. The ceilings in one place were scarcely 7 feet high. Contamination existed from heating ovens, forge gases, tempering pots, and annealing furnaces, and from crude heating arrangements in two places. The question of fatigue is not debatable, at least for the skilled workers. There is an unusual amount of reduplication of the same movements and monotony in the hand cutting process (from continuous mallet and chisel work) and also in grinding, with the assumption of awkward, stooped postures in both processes and pressure against the body. It is estimated that the cutter strikes 45,000 blows a day in turning out his quota of files. In one plant practically all work was piecework, while noise was excessive from trip hammers. The workday was 9 hours in the smallest place and 10 hours in the other three, with one-half hour for a noon recess. The liability to the contraction of communicable diseases was considerable in all places, due to the use of common drinking cups, promiscuous spitting upon the floors, and in dust and dirt accumulations, the absence of washing facilities in two places, poor toilet arrangements, and the presence of dust and dirt from the processes. The liability to industrial poisoning was considerable for the hand cutters where soft lead plates were used beneath the files worked upon, due to the creation of a fine dust and to the lack of personal care in keeping the soiled fingers away from the lips. Again, in the lead tempering process (part of the tempering was done by heating in charcoal and coke and then immersing in brine), there were the same hazards as described under this process elsewhere. Chronic or slow lead poisoning is the form of the disease most likely to be present, although the personal factor of carelessness might produce acute poisoning in a short space of time.

In addition to the foregoing observations it is pointed out that special emphasis was placed upon the risk of lead poisoning, and that in some places there appeared to be an unnecessary exposure to dust from grinding processes which apparently could have been easily equipped with a blower system. Reference is also made to a statement by Sir Thomas Oliver that—

The death rate of the cutters from pulmonary phthisis and lead poisoning exceeds the mortality standard of ordinary occupied males by 90 per cent, and after 35 years of age it is still higher.

#### FILE CUTTING BY HAND AND BY MACHINERY.

The conclusion advanced in the report on the draft regulations concerning the process of file cutting by hand, that file cutting by machinery removes part of the hazard, is sustained by the Ohio investigation. That the risk has elsewhere been recognized is brought out by the fact that the German Imperial Board of Health has issued a special circular concerning health precautions to file makers, the text of which, however, has not been available for the present purpose.

W. Gilman Thompson refers to the industry in his treatise on "The Occupational Diseases," in part, as follows:

In cutting the ribs of files the articles are imbedded in a block of lead, which offers the proper degree of resistance or rebound when the cutting chisel is struck by the hammer. Much lead dust, besides iron filings, is thus produced, and the workmen have the habit of moistening the fingers in the mouth to obtain a firmer grasp upon the cutting instrument. Thus they both swallow and inhale much lead dust. Wooden or tin blocks may be used to replace the lead, but are less satisfactory. The increasing use of file-making machinery is doing much to lessen the frequent cases of lead poisoning which characterize this trade, but as the machines strike from 400 to 1,000 blows a minute they raise considerable lead dust.

#### LEAD POISONING.

Thompson quotes White to the effect that "out of 100 English file cutters examined by him 74 exhibited the results of lead poisoning, while the mortality of the trade was found to be excessive. Leaning over the work and raising the lead dust by hammering constitute the special risk, apparently." Thompson also quotes Sprenger, according to whom "among 93 file makers examined in Berlin more than 5 per cent were afflicted with lead poisoning after having been at work a little more than two years."

Apparently the risk of lead poisoning is more serious than the inhalation of metallic and mineral dust; but, as said before, accurate and conclusive data concerning this occupation are not at present available. The only statistical reference of value occurs 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:

File makers experience more than twice the average mortality from nervous diseases and nearly four times the average from Bright's disease, but cutlers experience comparatively little excess of mortality from either of these causes. In both industries the mortality from phthisis is enormous, the figure for cutlers being nearly three times and that for file makers more than twice the standard, and in both occupations the mortality from respiratory diseases approaches double the standard. Both these workers, however, experience a low mortality from influenza, from alcoholism and liver disease, and from accident, while among file makers the mortality from cancer is also less than normal.

### GENERAL CONCLUSIONS.

This statement sustains the earlier conclusion that this occupation is not readily separated from other employments, chiefly the manufacture of cutlery and tools, with which it has much in common. The general conclusion is that the employment is one involving serious dust hazards demanding more qualified medical and administrative consideration.

### TOOL AND INSTRUMENT MAKERS.

The manufacture of tools and instruments includes a large number of grinders and polishers, but it is not possible to classify the occupations in detail. In the United States census statistics the industry includes cutlery manufacture, while in English mortality statistics the group comprehends tool, file, and saw makers, cutlers and scissors makers, and needle and pin makers. The statistics of 1910 for the United States return 20,212 males of known ages, 10 years or over, employed in this industry as previously defined, and of this number 3,669, or 18.2 per cent, were 45 years of age or over. The proportion attaining to old age was, therefore, somewhat larger than expected, considering the high rate of mortality of grinders and polishers, and others employed in the manufacture of tools, instruments, etc.

### SANITARY CONDITIONS OF EMPLOYMENT IN MASSACHUSETTS.

A special investigation into the sanitary conditions of this employment was made by the Massachusetts State Board of Health in 1907, and the report included a number of very valuable and suggestive references to conditions unfavorable to health and life, from which the following extracts are made:

From a sanitary point of view, the one important part of this industry is the reduction of the surface of the article in process of manufacture from the roughness of the original casting to the smoothness and brilliancy so necessary and desirable in the finished product. This involves successive treatment by wet grinding, dry grinding on emery and corundum wheels, and polishing with rouge on buffing wheels. Each of these processes, even that of wet grinding on large, coarse, and finer stones, causes to be cast into the air large amounts of fine dust, made up of very fine particles of steel and of the abrasive substance. In establishments properly equipped and conducted, provision is made to reduce the danger of this dust to a minimum by means of hoods connected with a system of exhaust fans or blowers. In spite of the precautions taken to protect their health, a very large proportion of grinders recklessly remove the hoods, and thus expose themselves unnecessarily to this especially dangerous form of dust. They assert that they prefer freedom of movement with dust to the protection afforded by hoods.

The workmen are not, as a class, long lived; indeed, the nature of the work is not compatible with longevity, and a person entering upon it in middle life is unlikely to follow it many years. Whatever the age at which the trade is taken up, a man in sound health who has followed it a few years is an acknowledged rarity. A study of the death returns of the city of Northampton, which is one of the centers of this industry, for the past 12 years, yields facts which can be interpreted in only one way. During this period tuberculosis is given as the cause of death in no less than 54.5 per cent of those whose occupation is indicated by "grinder" or "polisher," and in 45.4 per cent of those designated generally as "cutlers," and of the latter 36.4 per cent died of pneumonia. Taken together, the "grinders," "polishers," and "cutlers" returns show that, during this period, diseases of the lungs were responsible for 72.73 per cent of their mortality. As was shown in the preliminary report on this industry, the tuberculosis death rate for cutlers in Northampton is four times as high as that for the entire adult male population.

### DIFFICULTIES IN EFFECTIVE VENTILATION.

A difficult problem in the cutlery and tool industry is how to secure effective ventilation, and many of the factories and workshops inspected were found to be seriously defective in this respect. A large proportion of the workmen, including many young boys, are exposed to considerable dust, chiefly, of course, in the grinding and polishing departments. While much has been done to improve the sanitary conditions by artificial ventilation, there has been but a very indifferent cooperation on the part of the operatives themselves, and many in fact are interfering with the arrangements made for their protection to the extent of removing the hoods and exhaust pipes installed for the purpose of carrying off the dust.

### VITAL STATISTICS OF ENGLISH TOOL AND CUTLERY MAKERS.

The most valuable official statistics are those for England and Wales, published at decennial intervals in the supplements to the reports of the registrar general of births, deaths, and marriages. Only two comparatively recent investigations are here referred to. The first of these, for the three years ending with 1892, included 2,529 deaths from all causes, of which 505, or 20 per cent, were from pulmonary tuberculosis. Of diseases of the respiratory system other than pulmonary tuberculosis, 384 deaths were from bronchitis, 286 from pneumonia, and 78 from other diseases of this group, a total of 748, or 29.6 per cent, of the mortality from all causes. Combining the mortality from pulmonary tuberculosis and other respiratory diseases, it is found that 49.5 per cent of the deaths of tool and instrument makers, as previously defined, were from diseases of the lungs and air passages.

The most recent English mortality statistics of tool and cutlery manufacture 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:

In the occupation as a whole the mortality at ages under 25 is below the standard for occupied and retired males; but among file makers the death rate at these ages exceeds the standard. Beyond age 25 the mortality in the whole occupation, as well as among cutlers and file makers, considerably exceeds the standard. At ages 45 to 65 years the death rate among cutlers is 72 per cent and that of file makers is 84 per cent above the average. Within the main working period of life the comparative mortality figure for the whole occupation is 1,315, or 31 per cent, above the standard. The mortality from lead poisoning is nine times and that from phthisis is nearly double the standard, and these workers suffer excessively from nervous, circulatory, respiratory, and urinary diseases. On the other hand, the mortality from alcoholism and liver disease and from accident is about half the average. Among cutlers and file makers the comparative mortality figures considerably exceed the average for the entire occupation, the figure for the former being 56 per cent above the standard for all occupied and retired males, while that for the latter is 69 per cent in excess. Indeed, these two occupations appear to be the most unhealthy in the whole group of workers in metal. It should be mentioned in this place that the occupation of file maker is one that is specially liable to lead poisoning, the mortality figure for plumbism being no less than 56, whilst among all occupied and retired males the mortality is represented by unity.

File makers experience more than twice the average mortality from nervous diseases and nearly four times the average from Bright's disease, but cutlers experience comparatively little excess of mortality from either of these causes. In both industries the mortality from phthisis is enormous, the figure for cutlers being nearly three times and that for file makers more than twice the standard, and in both occupations the mortality from respiratory diseases approaches double the standard. Both these classes of workers, however, experience a low mortality from influenza, from alcoholism and liver disease, and from accident, while among file makers the mortality from cancer is also less than normal.[1]

## MORTALITY FORM PULMONARY TUBERCULOSIS AND NONTUBERCULOUS RESPIRATORY DISEASES.

The English occupation mortality statistics for men employed at tool, instrument, and cutlery making are quite conclusive of the more or less unfavorable effects of this industry on health. In Table 32 a comparison is made of the mortality from all causes among men in this group with 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 ages 45 or over, when the general mortality of this class exceeds the general average by from 8.24 to 12.26 per 1,000.

TABLE 32.—MORTALITY FROM ALL CAUSES AMONG TOOL, INSTRUMENT, AND CUTLERY MAKERS, 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 tool, instrument, and cutlery makers. | | |
|---|---|---|---|---|
| | | 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 | 2.09 | − 0.35 | 86 |
| 20 to 24 years | 4.41 | 3.32 | − 1.09 | 75 |
| 25 to 34 years | 6.01 | 6.32 | + .31 | 105 |
| 35 to 44 years | 10.22 | 13.65 | + 3.43 | 134 |
| 45 to 54 years | 17.73 | 25.97 | + 8.24 | 146 |
| 55 to 64 years | 31.01 | 42.05 | +11.04 | 136 |
| 65 years and over | 88.39 | 100.65 | +12.26 | 114 |

The preceding table is self-explanatory. A more extended comparison, however, is made in Table 33, in which the mortality of tool, instrument, and cutlery makers from pulmonary tuberculosis and other respiratory diseases is compared with the normal mortality of occupied males from these diseases by divisional periods of life. The comparison shows that at ages 25 and over the mortality from pul-

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

monary tuberculosis is excessive among tool, instrument, and cutlery makers, and decidedly so at ages 35 to 64, inclusive. The table further shows that the mortality from other respiratory diseases is excessive among men in this class, but decidedly so at ages 45 or over, reaching the highest rate at ages 65 and over, when the excess is 7.69 per 1,000. The two tables, derived from English experience, fully confirm the previous conclusion that the mortality of tool, instrument, and cutlery makers is excessive when comparison is made with the normal mortality of occupied males generally, and that this excess is largely because of a high degree of frequency of pulmonary tuberculosis, particularly at ages 25 to 64, when the excess is from 0.91 to 4.09 per 1,000.

TABLE 33.—MORTALITY FROM PULMONARY TUBERCULOSIS AND FROM OTHER DISEASES OF THE RESPIRATORY SYSTEM AMONG TOOL, INSTRUMENT, AND CUTLERY MAKERS, 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 tool, instrument, and cutlery makers. | | | Death rate per 1,000 for all occupied males. | Death rate for tool, instrument, and cutlery makers. | | |
| | | 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 | 0.17 | −0.37 | 31 | 0.24 | 0.23 | −0.01 | 96 |
| 20 to 24 years | 1.55 | 1.57 | + .02 | 101 | .48 | .56 | + .08 | 117 |
| 25 to 34 years | 2.03 | 2.94 | + .91 | 145 | .77 | 1.14 | + .37 | 148 |
| 35 to 44 years | 2.74 | 5.90 | +3.16 | 215 | 1.66 | 2.01 | + .35 | 121 |
| 45 to 54 years | 3.04 | 7.13 | +4.09 | 235 | 3.32 | 5.40 | +2.08 | 163 |
| 55 to 64 years | 2.16 | 5.26 | +3.10 | 244 | 6.54 | 10.42 | +3.88 | 159 |
| 65 years and over | 1.11 | 1.97 | + .86 | 177 | 17.77 | 25.46 | +7.69 | 143 |

## MORTALITY OF TOOL AND CUTLERY MAKERS—UNITED STATES REGISTRATION AREA.

The mortality of American tool and cutlery makers has been reported upon by the Division of Vital Statistics of the United States Census Bureau only for the year 1909, and no subsequent information has been made public, so that the data are of rather limited value. According to the census report, out of 241 deaths of tool and cutlery makers from all causes, 58, or 24.1 per cent, were from pulmonary tuberculosis, which compares with 17.8 per cent for jewelers and 29.5 per cent for printers, lithographers, and pressmen. On account of the rather peculiar age distribution the general average, however, for all ages can not be safely utilized for comparative purposes. The details of the mortality of tool and cutlery makers by divisional periods of life are shown in Tables 34 and 35.

TABLE 34.—PROPORTIONATE MORTALITY OF TOOL AND CUTLERY MAKERS FROM PULMONARY TUBERCULOSIS, UNITED STATES REGISTRATION AREA, 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 | 22 | 4 | 18.2 |
| 25 to 34 years | 37 | 15 | 40.5 |
| 35 to 44 years | 45 | 19 | 42.2 |
| 45 to 54 years | 38 | 10 | 26.3 |
| 55 to 64 years | 42 | 8 | 19.0 |
| 65 years and over | 56 | 2 | 3.6 |
| Age unknown | 1 | | |
| Total, 15 years and over | 241 | 58 | 24.1 |

TABLE 35.—PROPORTIONATE MORTALITY OF TOOL AND CUTLERY MAKERS FROM NONTUBERCULOUS RESPIRATORY DISEASES, UNITED STATES REGISTRATION AREA, 1909.

| Cause of death. | Deaths from nontuberculous respiratory diseases. | |
|---|---|---|
| | Number. | Per cent of deaths from all causes. |
| Asthma | | |
| Bronchitis | 3 | 1.2 |
| Pneumonia | 23 | 9.6 |
| Other nontuberculous respiratory diseases | 3 | 1.2 |
| Total | 29 | 12.0 |

Table 34 emphasizes a decidedly excessive proportionate mortality from pulmonary tuberculosis among tool and cutlery makers at ages 25 to 64, inclusive. There is also, as shown in Table 35, a relatively high proportionate mortality from nontuberculous respiratory diseases, equivalent to 12 per cent of the mortality from all causes, chiefly attributable to pneumonia. The proportion of deaths from pneumonia is 9.6 per cent of the deaths from all causes, which compares with 5.8 per cent for jewelers and 6.8 per cent for printers, lithographers, and pressmen, according to the data derived from the same official American sources.

## MORTALITY OF TOOL AND INSTRUMENT MAKERS—INDUSTRIAL INSURANCE EXPERIENCE.

The only other available mortality data of tool and instrument makers are derived from the industrial insurance experience of the Prudential Insurance Co. of America for the period 1897 to 1914, including 533 deaths from all causes, of which 170, or 31.9 per cent, were from pulmonary tuberculosis. Table 36 is not, however, strictly comparable with Table 34 on account of probably important differences in the classification of the occupations considered.

TABLE 36.—PROPORTIONATE MORTALITY FROM PULMONARY TUBERCULOSIS AMONG TOOL AND INSTRUMENT MAKERS, 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 tool and instrument makers, 1897 to 1914, from— | | Per cent of deaths from pulmonary tuberculosis among— | |
|---|---|---|---|---|
| | All causes. | Pulmonary tuberculosis. | Tool and instrument makers. | Males in registration area, 1900 to 1913. |
| 15 to 24 years | 88 | 33 | 37.5 | 27.0 |
| 25 to 34 years | 93 | 49 | 52.7 | 30.5 |
| 35 to 44 years | 111 | 41 | 36.9 | 23.4 |
| 45 to 54 years | 98 | 33 | 33.7 | 14.7 |
| 55 to 64 years | 67 | 7 | 10.4 | 7.9 |
| 65 years and over | 76 | 7 | 9.2 | 2.6 |
| Total, 15 years and over | 533 | 170 | 31.9 | 13.9 |

According to this table the proportionate mortality from pulmonary tuberculosis is excessive at every divisional period of life, but particularly so at ages 25 to 34, at which, of the mortality from all causes, 52.7 per cent is from pulmonary tuberculosis. The data for this group of occupations are not, of course, entirely conclusive, in that the group considered includes a number of special employments of a varying degree of metallic-dust exposure. Since tool and instrument manufacturing is frequently combined with the cutlery and related trades the latter must be taken into account for comparative purposes. In all of these trades grinding, polishing, and buffing are incidental operations, and, though elsewhere separately considered, these are practically inclusive of the entire group of tool and instrument-making and the cutlery industries.

### GENERAL CONCLUSIONS.

With a due regard to these rather serious limitations it is safe to conclude that, considered as a group, the manufacture of tools and instruments must be considered as one of the distinctly unhealthful trades, and primarily so on account of continuous and considerable exposure to the inhalation of metallic dust.

### SAND BLASTING.

This is a rather obscure occupation, regarding which the literature is of very limited extent. The census of 1910 returns only 101 persons employed as sand blasters in connection with the iron and steel industry, but in all probability the number so employed is much larger.

There are no occupation mortality data regarding this employment, which, from a hygienic point of view, is of considerable importance.

### DESCRIPTIVE ACCOUNT OF SAND-BLASTING PROCESSES.

The most useful discussion of this occupation occurs in Hayhurst's Ohio Survey of Health Hazards, as follows:

Sand blasting is a process in which fine sand or similar hard substance is forced through a pipe by compressed air against objects either for the purpose of cleaning their surfaces or of giving them an etched, frosted, or rough effect. Hence the process is used upon a considerable variety of materials. As it is very rapid, usually only a few workers are so employed even in very large establishments. Our investigations covered the process in 9 different industries, viz, automobiles, cars, carriages, electrical apparatus, brass, iron, glass, cutlery and tools, and machine manufacture. There were 51 wage earners, all males, found so employed. For some work considerable skill is necessary, but in the majority of instances it is a process for unskilled labor. Retention at the process was good in 3 places, fair in 3, and very brief in the remaining 3. Health appliances, consisting of isolation of the process in a room by itself and within a cupboard through which the worker inserted his hands, or the wearing of a helmet covering the entire head—these features were found good in 3 places, fair in 3, and practically absent in the remaining 3. Instructions to limit the dust in order to conserve the health of the worker were good in 5 places, but very little attention was paid to the same in the remaining 4. In but 1 place did the workers enjoy the privilege of a sick-benefit association. The work was done in the same quarters with other processes in 3 instances, so that other workers were exposed to the fine dust created. Of all the employees, 13 were over 40 years of age and 38 under 40.

### DUST AND OTHER HEALTH HAZARDS.

Dust in the breathing atmosphere was a negligible factor in 2 places, a fair hazard in 4, and bad in 3. Cleanliness of quarters took about the same proportions. Dampness was no feature of the process, nor were harmful light effects. Heat, due to the proximity to other processes as a rule, was bad in 1 place, fair in 2 more, and no feature in the remaining 6. Cold weather, due to performing the work, protected only by a roof, was a feature in 2 places. Fatigue was not a special hazard, although hurrying piecework, monotony, and constant standing were features in one-third of the places. The workday was from 9 to 10 hours in all places. The noon recess was 1 hour in 1 place, three-quarters of an hour in 3, and one-half hour in 5 places. The liability to the contracting of communicable diseases was negligible in 3 places, a fair risk in 5, and bad in 1, due, principally, to the breathing of fine dust in quarters where there was promiscuous spitting, absence of cuspidors, inadequate washing facilities and improper closets, and the failure to inquire into the fitness of the workers for such work. Poisoning was no feature. The general factors favoring stimulantism were the irritating effects of fine dust inhaled and swallowed and the absence of good drinking-water facilities in some places. The health appearance of the workers was not good in one-third of the places. The workers' complaints were the breathing of dust, skin irritation in hot weather, and the inefficiency of some of the hoods used, while in 1 place the manager said they were having it done at night because it made so much dust. *Comments.*—Such work should be done in a manner to keep the dust away from the employee, such as confining the process within an impervious cupboard, through which armholes are made, or having it done in a dust-tight room in which the worker should be supplied with an impervious suit and helmet, to which is attached an air tube supplying him with fresh outdoor air under pressure. The simple wearing of respirators, even of helmets, without such air tubes is not at all efficient, as can be demonstrated by noting the amount of fine dust settled upon the workmen's features when such coverings are removed. Many places substitute sand blasting by cleaning small pieces in a rattler.

The occupation was inquired into by the New York State Factory Investigating Commission and briefly referred to in its second report (Vol. II, pp. 420 and 479, 1913). It is said that—

Sand blasting is still done in closed bins or basements by ancient and crude methods, without any other protection to the workers than a cloth over the mouth and nose. The fumes from pouring molds are allowed to disseminate in the air of shops, fume vents being found in but few plants. Temperatures are often very high, especially near the furnaces.

With special reference to the use of respirators in connection with this process, it is stated that—

Neither in sand blasting nor in lead works nor in any other occupation where the presence of poisonous gases and excessive amounts of dust vitiate the air have respirators been uniformly used. The managers and owners resort to the same plea, viz, the ignorance of the worker and his willful abandonment and neglect of these protective appliances. Few of these managers provide their employees with them, and still fewer make their use compulsory.

A brief descriptive account of the process of sand blasting in connection with castings, in open sheds, is given by Hanson, in his "Dangers to workers from dusts and fumes, and methods of protection," in Bulletin 127, published by the United States Bureau of Labor Statistics. "It is observed in connection with the process that men who do the work are not properly protected, since the helmet does not prevent the inhalation of very fine steel, iron, or brass dust."

With reference to sand blasting castings in closed rooms, an "improved helmet" is described, but even this appliance is considered an inadequate protection.

### MOST DANGEROUS OF ALL MINERAL-DUST HAZARDS.

The most recent and thoroughly well-considered observations concerning sand blasting are by W. Gilman Thompson, and on account of their importance they are quoted in full from his treatise on "The Occupational Diseases":

The sand blast is an apparatus constructed to blow a stream of sand by means of compressed air with great force against metal castings, to clean them from the earth which adheres from the casting molds and to smooth roughened surfaces. It is also employed in cleaning stone and marble buildings and for the roughening of the surface of glass to make "ground glass" and sometimes to mark patterns upon glass, which is partially protected. Sand blasting constitutes probably the most dangerous of all the mineral-dust hazards, and it is impossible to engage in the work without protection of the eyes and face, for the sharp particles of fine silicious sand are driven with such force against the objects operated upon that they rebound toward the workman, and, despite the use of long hose to conduct the blast away from the operator, the surrounding air is constantly filled with flying sand, resembling a sandstorm in the desert. The helmets in use for sand blasting can not have glass windows, but fine wire netting shields the eyes, and cloths are inserted to breathe through.

An important method of reducing the risk of dust from the sand blasting of metal castings is covered by a recent patent of C. Wedemeyer, of Hamburg. The operator stands in a cabinet directing the sand blast away from himself toward the casting. Over his head, at an angle of 45°, a strong blower fan directs a stream of air also upon the casting with such force that the dust of both sand and metal is blown downward toward the opening of a large exhaust tube just above the floor. In this manner a strong, continuous draft blows the dust away from the operator and out of the cabinet through the aspirator duct, which is connected with a powerful exhaust fan.

The descriptive illustration by Thompson, in addition to the photographic reproductions of sand-blasting processes by Hanson, in Bulletin 127 of the United States Bureau of Labor Statistics, previously referred to, emphasize the necessity for thoroughly effective safety precautions, more or less in conformity to the German method, under which the operator is inclosed in a room or cabinet in which he directs the blast of sand and compressed air against the casting in front while a strong air current is forced from directly above his head by a fan and passes outward toward a revolving, aspirating drum on the right. The illustration used by Thompson is from Rauch und Staub (ii, Feb. 5, 1912).

#### COMBINED METALLIC AND MINERAL DUST EXPOSURE.

The preceding statements suggest the existence of more or less health-injurious conditions, the control of which at present appears to receive inadequate technical consideration. Conditions, of course, must vary according to the quality and degree of fineness of the sand used. In the handling of sand in glass factories serious respiratory difficulties have been experienced in much the same manner as in sand-blasting operations, though apparently to a lesser degree. The occupation, though of rather limited extent, is obviously one which demands more qualified technical consideration regarding its hygienic aspects and the probably quite needless waste of life and health. Of course in the actual operation of sand blasting there results a mixture of metallic and mineral particles, of which the former are distinctly more injurious to health than the latter. It is for this reason that the occupation has been included among employments where the chief exposure is to metallic dust. As measured by the quantity of dust exposure, however, sand blasting more properly belongs to the group of employments with exposure to mineral dust. Thompson for these reasons includes sand blasting under occupations where the chief exposure is to mineral dust.

### PROTECTIVE, SAFETY, AND SANITARY DEVICES.

The most recent discussion of sand blasting with special reference to safety and sanitary considerations is by Joseph Brinker, in the Scientific American for September 2, 1916, who describes in some detail the work of the operator in one room while the blast is carried on in another, and under conditions which practically exclude the dust hazard or at least the major portion of the same. It is explained at the outset that the preparing of metal surfaces for a covering of paint has given rise to the extensive use of the sand blast, especially in connection with the manufacture of automobiles. It is said that—

> When the outfits are constructed of sufficient size to accommodate large surfaces such as mud guards, hoods, and bodies, the problem of protecting the workmen has presented serious difficulties.

After explaining that various forms of safety devices for the protection of the operator during the sand blasting have been tried, including the common respirator with a sponge through which the operator breathes, though often under serious difficulties, and various forms of helmets similar to the one used in diving, in which fresh air is supplied under pressure, it is pointed out that—

> The first renders it difficult to breathe; the second type is often so cumbersome that it is discarded by the workmen at their own peril. In fact the history of the use of safety sand-blast devices has proven conclusively that when these may be used or detached at will by the workmen, they are usually discarded, even if such neglect constitutes positive danger.

This difficulty has apparently been overcome in the apparatus described by Brinker which makes it necessary for the operator to use the safety helmet if he is to work at all. A brief explanation of the new method is as follows:

Each sand-blast room is a small compartment of the double-hopper type in which the heavy particles of the sand used in the cleaning process are drawn out of the lower hopper and the lighter particles out of the upper by air suction. The material to be cleaned is laid on a grating between the two hoppers. It is introduced into the compartment through a door at one end. The sand-blast operator's head-dress, which is of canvas with a fine-mesh copper screen at the front, is securely attached to the inside of a curtain which forms the front wall of the compartment. This curtain is fastened to sliding metal doors which can be moved horizontally from side to side. In this way it is impossible for the operator to see into the interior of the compartment until he puts his head in the helmet. This being accomplished, he stands on the floor outside the compartment, moving along as is necessary in the progress of his work by pushing the sliding metal doors to either side with his elbows.[1]

## GOLD-LEAF MANUFACTURE.

The work of the gold-leaf beater is nearly all handwork, except in the operation of the rolling machines. The trade is carried on to-day in about the same manner as in ancient times. The weight of the hammer used averages 18 pounds, which is more than that of the hammer used by the average blacksmith. Girls, as a rule, are employed in connection with the less arduous operations and the final packing of the gold leaves in boxes and packages. The tissue used in connection with this process is coated with red chalk, the dust of which, of course, enters into the atmosphere of the rooms, usually badly ventilated. One of the chief difficulties in connection with the ventilation is the fact that the slightest draft of air will carry the scrap of gold leaf from one anvil to another and make packing operations difficult or impossible. Evidence that the fine particles of gold enter the atmosphere is found in the fact that workmen with beards turn in less waste gold than clean-shaven workmen, and they are now required to wash before leaving the shop, the water being filtered for the recovery of the metal contained therein.

### EARLY OCCUPATIONAL-DISEASE OBSERVATIONS.

Thackrah, writing in 1832, held that goldbeating must be considered a distinct employment, aside from the metal trade generally. Goldbeaters are about half the day engaged in beating the metal with heavy hammers and the rest in spreading the gold leaf on paper. By this change in employment the process affords an excellent alternation of labor and comparative rest. In his opinion the men were not exposed to health-injurious conditions and were generally healthy

[1] Of much practical importance is a descriptive account of the dustless Hoevel self-contained sandblast automatic machine and a description in detail of a novel sand-blast room, in Safety, published by the American Museum of Safety for January, 1918.

and robust.[1] It is difficult, however, to accept these conclusions in their entirety. The work of the goldbeater is carried on in rooms the air of which is more or less contaminated and where provision for proper ventilation is extremely difficult if not impossible. The work is often commenced at rather early ages and, in Europe at least, quite a considerable proportion of young persons are employed. Whether gold dust is itself injurious has never been scientifically determined, but it is quite probable that it is less injurious than other metallic dust.

### DESCRIPTIVE ACCOUNT OF MANUFACTURING PROCESSES.

The number of goldbeaters in the United States is small, only 607 male and 76 female workers having been enumerated in 1910. An interesting account of the process of manufacture, by Edward Williston Trentz, is as follows:

The goldbeater receives his material in the form of a ribbon about an inch wide and 24 feet long. This ribbon is first cut into 200 squares and placed in the " cutch," which is a pile of square pieces of a peculiar paper, part animal and part vegetable in composition, the preparation of which is a secret. A square of gold is placed between each two leaves and the whole mass is ready for the first beating. This is done with an iron hammer, weighing from 12 to 17 pounds, while the cutch rests upon a granite block which is supported by a heavy wooden post.

Under the heavy measured blows of the hammer the sheets of gold begin to stretch or expand until, in half or three-quarters of an hour, they have reached the edges of the cutch. They are then removed and, with a thin strip of bamboo, are cut into quarters, so that the 200 pieces become 800. Next comes the " shoder," a collection of 800 pieces of skin, 4 inches square, made from the intestines of cattle. As in the cutch, each piece of gold is placed between two leaves of skin, and bands of parchment or vellum are slipped over the whole pile to keep it together. Another beating, this time with a hammer weighing from 8 to 10 pounds, now follows. This takes about an hour, during which the sheets of gold are all the time expanding.

The last stage is the " mold," which, like the cutch and the shoder, is composed of alternate leaves of gold and skin, but the mold is about 5 inches square and made up of goldbeater's skin. The preparation of this is a jealously guarded trade secret.

A mold contains 1,000 sheets. After the second beating the workman takes from the shoder a single leaf of gold at a time, handling it with bamboo pinchers and, when necessary, smoothing it with a rabbit's foot. With the strip of bamboo he cuts each sheet into quarters again, so that the original 200 have now become 3,200. One shoder, therefore, contains more than enough gold to fill three molds.

The final beating in the mold is done with a 7-pound hammer and requires from three to four hours. By this time the gold leaf should have expanded again to the edge of the skins and should be of the

[1] Effects of Arts, Trades, and Professions on Health and Longevity, by C. Turner Thackrah, London, 1832, p. 48.

requisite thinness, which is determined by holding it up to the light. If it transmits green rays, it is done, and will measure about one two-hundred-and-eighty-thousandth ($\frac{1}{280,000}$) of an inch in thickness.

The hammers used in beating gold are slightly convex on the face. The art of the workman consists in so striking that the gold will always be thinnest in the center. He must pound with evenness all over the square in order that the sheets of gold may expand without losing their form, but at the same time he must keep the thickest part near the edges, so that when the sheets are finally trimmed to size the thicker portions may fall in the waste to be recast. No machinery has ever been devised which will do this successfully.

The tools of the craft are interesting and peculiar. The rabbit's foot is exceedingly soft and just oily enough to prevent the gold from sticking, and the bamboo pliers and cutting slips are the only things with which it is possible to do this delicate work. The gold does not adhere to the fibers of the reed as it does to steel. The goldbeater performs all this work standing. The use of the heavy hammers in such continuous pounding would, one would think, impose an almost intolerable strain upon the hands and arms. The men say, however, that their arms never ache. The only place where "it catches them" is in the bend of the knee. The lack of strain upon the arms is accounted for by the fact that the hammer rebounds. It is an astonishing but by no means rare thing to see a goldbeater change hands while the hammer is in the air and without losing a stroke.

### MORTALITY OF GOLD-LEAF BEATERS—INDUSTRIAL INSURANCE EXPERIENCE.

On account of the limited extent of the occupation there are no general vital statistics, but a fairly trustworthy basis of information is furnished by the proportionate mortality statistics of the Prudential Insurance Co. of America, as given in Table 37.

TABLE 37.—PROPORTIONATE MORTALITY FROM PULMONARY TUBERCULOSIS AMONG GOLDBEATERS, 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 gold beaters, 1897 to 1914, from— | | Per cent of deaths from pulmonary tuberculosis among— | |
|---|---|---|---|---|
| | All causes. | Pulmonary tuberculosis. | Gold beaters. | Males in registration area, 1900 to 1913. |
| 15 to 24 years | 7 | 3 | 42.9 | 27.0 |
| 25 to 34 years | 12 | 8 | 66.7 | 30.5 |
| 35 to 44 years | 11 | 4 | 36.4 | 23.4 |
| 45 to 54 years | 8 | 2 | 25.0 | 14.7 |
| 55 to 64 years | 4 | | | 7.9 |
| 65 years and over | 11 | | | 2.6 |
| Total, 15 years and over | 53 | 17 | 32.1 | 13.9 |

There were 53 deaths from all causes, of which 17, or 32.1 per cent, were from pulmonary tuberculosis. The proportionate mortality was exceedingly heavy at ages under 45, reaching a maximum at ages 25 to 34, when of the mortality of gold beaters from all causes 66.7 per cent was from pulmonary tuberculosis. The rather limited number of observed cases does not warrant final conclusions, but the statistical evidence would seem to confirm the view that the mortality from tuberculosis in this occupation is distinctly above the average.

### GENERAL CONCLUSIONS.

The sanitary problems in this industry are complicated by the fact that, as a rule, the work is carried on in small shops in which it is difficult to apply rational principles of factory hygiene. The actual amount of gold dust inhaled is probably relatively small and, in so far as the tuberculosis problem is complicated by the dust factor, it is quite probable that other surrounding circumstances react more unfavorably upon the system than the relatively small amount of metallic dust inhaled during the gold-beating process. As observed by W. Gilman Thompson, "Owing to the value of the metal, where gold is being filed or beaten strong ventilation currents can not be used without dissipating the precious gold dust." Thompson mentions a case personally known to him of a goldbeater's shop "in which there are no general ventilators and the windows have to be kept closed, but at intervals small hoods are let down over the worktables and the room is kept well aired." How far it would be feasible to improve upon this method is merely a matter of conjecture. The industry, while of small extent, is, however, strictly within the classification of unhealthful trades and deserving of more careful attention on the part of the sanitary authorities.

### JEWELERS.

The manufacture of jewelry in all its branches involves a large variety of manipulations, including the melting and refining of small quantities of the precious metals, and the handling, shaping, cutting, and polishing of precious stones. An important part of the industry is engraving and die cutting, which, however, for the present purpose, is separately considered as a well-defined occupation, and although often included with jewelers, is equally often included with printers and compositors. Most of the articles made by jewelers are of small dimensions, such as chains, rings, brooches, pins, and buckles, which require painstaking care in handling and continuous eye-straining attention in shaping and polishing. Aside from the use of gold and silver, many other metals and mineral substances are employed, such as jet, coral, tortoise, bone, ivory, etc. Zinc is also extensively used as an alloy and for coloring purposes. The gems must be cut with extreme care, and the work of the diamond polisher and lapidary constitutes, next to that of the gold and silver smith, important separate branches of the trade. The manufacture of artificial gems, made of a paste, chiefly of a vitreous substance prepared from rocks and crystals of flint powder, subsequently treated with nitric acid with lead and borax as a flux, forms another important subdivision of the industry.

### ASCERTAINED UNHYGIENIC CONDITIONS.

The work of the jeweler is naturally an indoor occupation, involving a stooping position, much like that of the engraver. The workshops are generally small and the ventilation is usually poor. The dust generated in the processes of hammering, cutting, shaping, grinding, polishing, etc., is considerable, but very minute, and not easily observed. The dust accumulations are preserved and sold to refining plants for remelting and the recovery of precious substances. The health problem is complicated by the universal use of blowpipe apparatus and of gas for heating purposes. In large factories the use of machinery is increasing, but chiefly in connection with the manufacture of imitation jewelry and stones.

The unhygienic condition of many jewelry workshops and the general effect of this employment on health were discussed at some length in an early treatise by Thackrah, from which is quoted the following:

> The jewelers' workrooms are generally crowded, and the atmosphere consequently fouled by respiration, animal effluvia, and the smoke of lamps, as well as by the specific exhalations of the manufacture. Its temperature is generally raised, and in summer the heat is excessive. The labor is light, but the confinement to a leaning posture, with the head much depressed, and the elbows generally fixed to the sides of the trunk, for 10, 14, or 16 hours a day, is irksome and injurious. Intemperance is general, and dram drinking especially prevalent. The disorders of which jewelers principally complain are pains and soreness of the chest, disorders of the stomach and liver, and plethoric affections of the head. They enter the employ at about 13 or 14 years of age and are obliged to abandon it generally at 45 to 50.[1]

Thackrah continues that "an old jeweler is seldom to be found, and leaving work, they seem to leave the world as well." That this rather unfavorable view regarding the health conditions in the jewelers' trade is not exaggerated is made evident by the fairly trustworthy vital statistics of the trade. The English mortality data of jewelers and allied occupations for the three years ending with 1902 include 2,823 deaths from all causes, of which 598, or 21.2 per cent, were from pulmonary tuberculosis.

In addition to a high mortality from pulmonary tuberculosis there were 164 deaths from bronchitis and 247 from other respiratory dis-

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[1] Effects of Arts, Trades, and Professions on Health and Longevity, by C. Turner Thackrah, London, 1832, p. 115.

eases, a total of 1,009 deaths, or 35.7 per cent, from diseases of the lungs and air passages in the mortality from all causes.[1]

### DESCRIPTIVE ACCOUNT OF THE JEWELRY INDUSTRY.

The conditions of employment in the jewelry industry, with special reference, however, to England and Wales, have been admirably described by Arlidge, in part as follows:

> Mere dealers in jewelry incur no liability to sickness or to a high mortality, except so far as confinement to their shops and insanitary surroundings concur to produce it. On the other hand, some special health conditions are connected with the manufacture of jewelry—of gold, silver, and precious stones. The incidentals are close, very sedentary work, and with it a bent attitude whilst sitting; close application of the eyes, much artificial light, heat from furnaces, crucibles, and the blowpipe, and acid fumes. The working with precious stones entails the minutest attention and observation, together with strong visual exertion and most delicate manipulation with the fingers and forceps or other tools in use. The lapidary's wheel is a source of dust from the polishing powders used—for the most part rouge, emery, and diamond dust—and, as we learn from Proust (Ann. d'Hygiene Publique, 1878), it is likewise a cause of lead poisoning when a lead cylindrical rod is used for polishing cameos. In this proceeding the cameo is held against the revolving rod, and from time to time moistened with a mixture of tripoli powder and vinegar, whence arises a dust consisting of acetate of lead. Nitric acid is largely employed for dipping and to brighten the surface of jewelry, and where many persons are employed in the same shop, and that not well ventilated, there is enough nitrous acid vapor given off to become a source of throat, chest, and stomach irritation. The frequent contact of the acid also with the skin provokes sores, eczematous eruptions, and cutaneous fissures, besides doing injury to the nutrition of the nails. The leaning position of jewelers over their work aggravates all the other unhealthy incidents of their occupation. The evils of dust production attend the makers of polished steel ornaments in a much higher degree than lapidaries by reason of the larger quantity of polishing materials needed and the constant use of brushes.

Arlidge also directs attention to the sedentary character of the jewelers' work, its confinement, and the bent position long sustained, aside from the more or less injurious but very common method of artificial lighting and the heat proceeding from constantly burning gaslights and gas jets used for blowpipes to melt solder and heat soldering irons. In addition there is the waste of burnt gases, the acid vapors, and last, but not least, the dust from polishing stones and settings, all of which, according to Arlidge, "represent a series of health conditions suggestive of the production of phthisis, bron-

[1] The English data include watch and clock makers, makers of scientific instruments, and other more or less closely allied trades. For this reason the English statistics are not strictly comparable with other data for jewelers and are not, therefore, presented here in tabular form.

chitis, anemia, and general debility with digestive troubles—an inference borne out by statistics." He concludes, however, that there is much encouragement in the favorable aspects of the industry, in that the health-injurious conditions referred to are, for the most part, remediable by sanitary arrangements, "foremost among which are ample working space and effective ventilation." These, however, are unfortunately frequently wanting, quite generally so in the smaller establishments.

### MORTALITY FROM TUBERCULOSIS AND PNEUMONIA.

Among the watchmakers and jewelers in Scotland, according to the latest published official statistics, "the death rates from tuberculosis and pneumonia are not decidedly different from the corresponding death rates of all males," but the mortality from bronchitis, which is of considerable practical importance in this connection, could not be determined. Since in the corresponding investigations for England and Wales the mortality of jewelers from all causes was fairly normal, it is rather suggestive that in a similar study of the mortality of jewelers in Paris and Switzerland the death rates should have been excessive. The manufacture of jewelry includes, of course, quite a number of specific employments, carried on under widely varying conditions, but no strictly scientific study has been made with a due regard to such variations and the health-injurious circumstances of particular employments as would be necessary for the end in view.[1]

### MORTALITY OF JEWELERS—UNITED STATES REGISTRATION AREA.

The mortality of jewelers has been reported upon for the two 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 of rather limited value. The information includes jewelers, clock and watch repairers, as well as gold and silver workers. According to the census report, out of 686 deaths of jewelers, including those in allied employments, as previously explained, 122, or 17.8 per cent, were from pulmonary tuberculosis. This relatively low average figure for all ages is, however, materially modified by reference to the proportionate mortality according to divisional periods of life. The low average proportion for all ages is accounted for by the peculiar age distribution of jewelers, which, considered as a group, includes quite a large number of deaths at ages 45 and over and a comparatively small proportion at the

[1] Conditions surrounding the industry of jewelry, clock, and watch making in Switzerland are clearly and exhaustively set forth in "Enquête sur le Travail à Domicile chez les Bijoutiers du Canton de Genève," by Dr. André de Maday and Mme. Marthe de Maday-Hentzelt, Geneva, 1911.

younger ages. In contrast, for illustration, to the mortality in the printing trades the proportion of deaths of jewelers at ages 45 and over out of the mortality at all ages was 65.2 per cent compared with 44 per cent for printers, lithographers, and pressmen, as derived from the same official American sources. The details of the mortality by divisional periods of life are shown in Table 38.

TABLE 38.—PROPORTIONATE MORTALITY OF JEWELERS 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 deaths from all causes. |
| 15 to 24 years | 66 | 33 | 50.0 |
| 25 to 34 years | 78 | 31 | 39.7 |
| 35 to 44 years | 94 | 22 | 23.4 |
| 45 to 54 years | 128 | 18 | 14.1 |
| 55 to 64 years | 142 | 12 | 8.5 |
| 65 years and over | 177 | 6 | 3.4 |
| Age unknown | 1 | | |
| Total, 15 years and over | 686 | 122 | 17.8 |

It is here shown that the proportionate mortality from pulmonary tuberculosis at the younger ages was quite excessive, having been 50 per cent at ages 15 to 24, and 39.7 per cent at ages 25 to 34. Compared with that of printers, lithographers, and pressmen, however, the proportionate mortality from pulmonary tuberculosis was relatively lower, with one important exception, at all ages over 25. The same conclusion applies to nontuberculous respiratory diseases, as shown in Table 39, which, in the aggregate, account for 8.3 per cent of the mortality from all causes among jewelers against 8.8 per cent among printers, lithographers, and pressmen considered as a group. The table, in a general way, confirms the data derived from other sources, and quite clearly indicates that the health conditions in the jewelry trade are far from satisfactory.

TABLE 39.—PROPORTIONATE MORTALITY OF JEWELERS FROM NONTUBERCULOUS RESPIRATORY DISEASES, UNITED STATES REGISTRATION AREA, 1908 AND 1909.

| Cause of death. | Deaths from nontuberculous respiratory diseases. | |
|---|---|---|
| | Number. | Per cent of deaths from all causes. |
| Asthma | 2 | 0.3 |
| *Bronchitis* | 8 | 1.2 |
| Pneumonia | 40 | 5.8 |
| Other nontuberculous respiratory diseases | 7 | 1.0 |
| Total | 57 | 8.3 |

## 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,

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[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 type-casting 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 scien-

[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.

tific 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

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[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 1 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, against 2.30 for all 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 undefined 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 | 94 |
| 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.

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[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.

## MORTALITY OF ENGRAVERS—UNITED STATES REGISTRATION AREA.

The mortality of engravers has been reported upon for the year 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, limited to the year referred to. According to the census report, out of 112 deaths of engravers from all causes 23, or 20.5 per cent, were from pulmonary tuberculosis. The details of the mortality by divisional periods of life are shown in Table 54.

TABLE 54.—PROPORTIONATE MORTALITY OF ENGRAVERS FROM PULMONARY TUBERCULOSIS, UNITED STATES REGISTRATION AREA, 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 | 10 | 5 | 50.0 |
| 25 to 34 years | 23 | 8 | 34.8 |
| 35 to 44 years | 20 | 5 | 25.0 |
| 45 to 54 years | 15 | 1 | 6.7 |
| 55 to 64 years | 19 | 3 | 15.8 |
| 65 years and over | 25 | 1 | 4.0 |
| Total, 15 years and over | 112 | 23 | 20.5 |

According to this table the mortality from pulmonary tuberculosis is relatively high at the younger ages, but the data are too limited for entirely safe conclusions. In a general way, however, they confirm other statistics derived from American and foreign experience. As shown in Table 55, the mortality of engravers from nontuberculous respiratory diseases was relatively low, or only 3.6 per cent of the mortality from all causes, the deaths being limited to pneumonia and other nontuberculous respiratory diseases, excluding asthma and bronchitis.

TABLE 55.—PROPORTIONATE MORTALITY OF ENGRAVERS FROM NONTUBERCULOUS RESPIRATORY DISEASES, UNITED STATES REGISTRATION AREA, 1909.

| Cause of death. | Deaths from nontuberculous respiratory diseases. | |
|---|---|---|
| | Number. | Per cent of deaths from all causes. |
| Asthma | | |
| Bronchitis | | |
| Pneumonia | 3 | 2.7 |
| Other nontuberculous respiratory diseases | 1 | .9 |
| Total | 4 | 3.6 |

## MORTALITY OF ENGRAVERS—INDUSTRIAL INSURANCE EXPERIENCE.

A large number of engravers are employed by the Bureau of Engraving and Printing of the United States Government, which in the past had most of its bank notes and postage stamps printed by private concerns. In former years no doubt serious objections were properly raised against the conditions under which Government employees were at work in the Bureau of Engraving and Printing; but most of the earlier disadvantages have been done away with. The health conditions have correspondingly improved and the more or less inevitable degree of dust exposure has been reduced to a minimum. The vital statistics of this branch of the Government service if published would be of considerable practical value. At the present time the only available data are the industrial insurance mortality statistics for the period 1897 to 1914, covering 384 deaths, of which 127, or 33.1 per cent, were from pulmonary tuberculosis. The details of this analysis are given in Table 56.

TABLE 56.—PROPORTIONATE MORTALITY FROM PULMONARY TUBERCULOSIS AMONG ENGRAVERS, 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 engravers, 1897 to 1914, from— | | Per cent of deaths from pulmonary tuberculosis among— | |
|---|---|---|---|---|
| | All causes. | Pulmonary tuberculosis. | Engravers. | Males in registration area, 1900 to 1913. |
| 15 to 24 years | 71 | 28 | 39.4 | 27.0 |
| 25 to 34 years | 92 | 50 | 54.3 | 30.5 |
| 35 to 44 years | 74 | 35 | 47.3 | 23.4 |
| 45 to 54 years | 63 | 10 | 15.9 | 14.7 |
| 55 to 64 years | 41 | 3 | 7.3 | 7.9 |
| 65 years and over | 43 | 1 | 2.3 | 2.6 |
| Total, 15 years and over | 384 | 127 | 33.1 | 13.9 |

## GENERAL CONCLUSIONS.

The general conclusions regarding engravers, including photoengravers, are briefly summarized by Dr. Kober, in Kober and Hanson's Diseases of Occupation and Vocational Hygiene (p. 615), as follows:

The work of engraving upon steel, copper, or other material involves not only considerable eyestrain, but also, in the absence of suitable work benches, a faulty position which interferes with the respiratory movements. Steel and copper plate engravers are also exposed to mercury, and makers of stamping devices and seals to lead and the fumes of nitric acid. The latter agent is likewise employed in mints in connection with the coinage of money. According to Sommerfeld, cited by Zadek, 73.6 per cent of all the deaths among this class of workers in Berlin were caused by diseases of the respiratory system, inclusive of 62.1 per cent from tuberculosis; this is in part accounted for by the fact that so many weaklings engage in this pursuit. Visual defects, neurasthenia, and diseases of the digestive system are also quite common. Plate printers who have to look constantly at bright plates suffer not only from eyestrain but occasionally also from conjunctivitis and even retinitis. Photo-engravers handle benzol for dissolving rubber films, alcohol, and ether, in collodium films, strong acetic acid for the removal of films; they are also exposed to gas fumes and ammonium dichromate in sensitizing copper plates, and to ferric chloride and nitric acid fumes in etching. The Report of the Photo-engravers' Union for 1914, cited by Hayhurst, discloses the fact that out of 217 deaths since 1903, 88, or nearly 41 per cent, were due to tuberculosis. During the year 1914 five cases of bichromate and one case of cyanide poisoning were reported.

Apparently the dust hazard is, by the writer, considered of minor importance, which is not in conformity with the results of specialized statistical investigations into the mortality of engravers and allied occupations. Specific occupational diseases are unquestionably of considerable scientific interest, but they are of minor importance in comparison with the excessive amount of pulmonary tuberculosis directly or indirectly attributable to the employment, and more or less subject to control by effective methods of sanitation.

## BRASS WORKERS.

Brass workers, exclusive of brass polishers and buffers, who have been separately considered, constitute a large group of widely diversified and often quite different employments. Brass casting, founding, and molding are arduous occupations exposing to the inhalation of considerable quantities of mineral dust more or less mixed with metallic ingredients. Whether brass dust, as such, is more injurious than the dust of iron and steel, for illustration, has not been determined. In the evidence submitted to the Departmental Committee on Compensation for Industrial Diseases by the National Society of Amalgamated Brass Workers,[1] including about 7,000 members, it was stated that about 2,000 of these were engaged in casting. The trade was said to be divided into pattern making, chasing, casting, finishing, burnishing, polishing, and putting together. The corresponding classification of the trade in the United States follows practically similar lines.[2] Of the divisions mentioned, casting and founding were considered the most injurious to health. Burnishing was held to be less injurious than polishing, but the so-called putting together was

[1] Great Britain, Home Department, Minutes of Evidence, Departmental Committee on Compensation for Industrial Diseases, 1906, p. 75 et seq.

[2] The number of brass workers in the United States in 1910 was 46,722, and of this number 3,062 were women.

stated to be decidedly unhealthful on account of the use of white lead. Evidently, in so diversified a trade the degree of dust exposure must vary widely, and at best the degree of injury can only be measured approximately upon the basis of more or less indefinite mortality data. The exposure of brass workers to dust inhalation is only one of a number of specific factors in a trade decidedly injurious to health and life, and of these mention may be made of the exposure to fumes and vapors generated in the smelting processes. Brass founders' ague is a well-defined occupational disease, the symptoms of which are tightness of the chest with indefinite nervous sensation, followed by fever and previous sweating. Zinc and other fumes inhaled are the chief causes of this ailment, and it is quite probable that the lung injury resulting from the inhalation of fine particles of metallic dust is a material contributory cause in brass founder's ague. Arlidge, in summing up the views of other authorities on brass workers' disease, points out that—

Besides brass founding, there are other departments in the brass-working business that are damaging to health; and chiefly so by reason of the dust produced. These branches are brass casting, turning, filing, and polishing. The soft nature of brass is opposed to the development of very fine and acuminated particles, and its weight to its rising very freely and to its diffusion in the air. Nevertheless, those turning and filing it show clearly, by their clothes and hair, that it is largely dispersed, the latter getting green, as happens with brass founders. The inhalation of brass dust operates in similar fashion to that seen in connection with other metallic dusts, provoking bronchial catarrh, which advances to bronchitis and ends in fibrosis. It is reported by some writers that phthisis is unusually prevalent, but no reliable statistics are available to support this statement.

### SANITARY CONDITIONS IN THE BRITISH BRASS INDUSTRY.

More recent investigations in England fully confirm these earlier conclusions. In 1894 a departmental committee was appointed by the secretary of state to report upon the conditions of work as affecting the health of operatives in the manufacture of brass and kindred amalgams. In its report, which was published in 1896, the committee stated as the result of its investigation, first, that brass workers as a class were extremely liable to diseases of the respiratory organs, and, second, that brass founders' ague, so called, was found to result from the inhalation of fumes given off by the molten brass at the time of pouring, but in a less degree it was attributed to the contamination of the workers' food by the fumes, and that this danger was in proportion to the amount of zinc used in the alloy. The subject was also reported upon in much detail in the Report of the Chief Inspector of Factories and Workshops for the year 1905. From this report the following suggestive extracts are made:

Altogether some 500 brass workers were examined, and in addition to the filling in by each one of them of the appended form, note was made of the height, weight, chest measurement, and strength of grasp; the heart, lungs, gums, and teeth were, whenever practicable, examined, and the condition as to anemia, paresis, general health, and prevalence of brass founders' ague was determined.

The result of the replies of 216 casters and 199 polishers and others to the question, Do you consider that your health has been in any way injured by working in brass? was that 22.7 per cent of the casters and 11.6 per cent of the polishers and others said they had suffered. This is perhaps the strongest evidence obtained in the inquiry that the casters are exposed to more trying conditions of work than are other brass workers.

The nature of the injury was, as a rule, only very vaguely expressed; in the case of the casters it was nearly always either "fumes" or "sulphur," and in that of the polishers "dust." In one casting shop, where 19 strip casters were examined, of whom 9 said they suffered, illness or discomfort was attributed in some cases to resin fumes in addition to those ordinarily present. Among the casters there were indications that the older the workers were, and also that the earlier the age of commencement of work, the more did they say they had suffered, facts which could not be observed in the case of the polishers.

In 8 casters (3.9 per cent) definite physical signs in the lungs were found, and similarly in 3 (1.5 per cent) of the polishers and others. In two of the casters these pointed to chronic phthisis, while the remainder pointed to bronchial catarrh. I am not inclined to draw any conclusions from these facts, because (1) the number of observations is too small, (2) the examination in some of the factories was carried out under great disadvantages, owing to the impossibility of securing a quiet room, and (3) it is well known that persons who are the subjects of disease of the lungs in any marked degree are not likely to be found at work.

Very strong evidence of the beneficial effect of good exhaust ventilation in connection with all kinds of polishing operations, and indirectly of the lowered state of health from the nonremoval of the dust, was obtained at one factory. Here the opinion of the occupier was that the installation had paid for itself over and over again in the better work which was turned out by the men, and by the improved tone among them resulting from the absence of the obnoxious dust. The remarks of the polishers bore this out. One said, "Worked for 18 years before the fan was put in, when the dust used to make me feel sick, but it is not so now." A second said, "I prefer this shop to any other." A third, "I never worked in a cleaner shop"; and a fourth, "The fan is a great improvement."

A large amount of fluff, sand, and lime is given off in the process of polishing with calico mops. It is not, therefore, difficult to understand (even although actual injury to health from it may be hard to prove) that removal of the dust is welcomed as tending to make the work healthier. A sample of dust taken from under a polishing bob was submitted to Dr. Thorpe, who reported: "This sample contains a large proportion of fiber, the loss on ignition amounting to 37.6 per cent. The metallic portion of the residue—copper, zinc, lead, and iron—amounts to 10.56 per cent of the total sample. The lead present equals 0.22 per cent of the total samples, or 2.1 per cent of the above metallic constituents, or, excluding the iron, 2.33 per cent. Microscopically brass dust collected from near an emery wheel showed all the appearances of an injurious metallic dust—fine particles with irregular jagged edges."

Oliver concludes his observations regarding the hygiene of this employment with the following statement:

The necessity of personal cleanliness on the part of workmen and of well-ventilated workshops is apparent. Means ought to be provided for a ready escape of the fumes and for the removal of dust. The workshops ought to be cleaned at least once a year and the walls whitewashed. Hot and cold water should be provided for the men to wash in. The workmen themselves have found out by experience that milk is both a prophylactic or preventive as well as a curative agent. While the use of respirators seems called for, the men can not work well in them. Women and persons under 18 years of age are not allowed to work in the casting shop.

### ENGLISH MORTALITY STATISTICS OF BRASS WORKERS.

The most recent English mortality statistics of brass workers are for the three years ending with 1902, referred to in the report of the registrar general, in part, as follows:

The mortality of these workers is somewhat below the standard at ages 15 to 20 and 25 to 35 years, but above the standard at every other age group. In the main working period of life their comparative mortality figure is 1,154, or 15 per cent above the average; the greatest excess of mortality occurring under the head of phthisis, the figure for which disease is above the average by 45 per cent. The mortality from diseases of the nervous, circulatory, respiratory, and urinary systems, as well as from suicide is also above the average. These workers are only slightly liable to fatal influenza, and their mortality from alcoholism and liver disease is also low. They likewise suffer less than the average from fatal accident.[1]

The English occupation mortality statistics for brass workers are quite conclusive of the more or less unfavorable effects of this industry on health. In Table 57 a comparison is made of the mortality from all causes of men in this group with occupied males generally, and the result is quite suggestive of conditions in this trade more or less unfavorable to life and health, but in particular at ages 35 to 64, when the general mortality of this class exceeds the general average by from 2.57 to 5.59 per 1,000.

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

TABLE 57.—MORTALITY FROM ALL CAUSES OF BRASS WORKERS, 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 brass workers. | | |
|---|---|---|---|---|
| | | 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 | 2.22 | −0.22 | 91 |
| 20 to 24 years | 4.41 | 5.13 | + .72 | 116 |
| 25 to 34 years | 6.01 | 5.86 | − .15 | 98 |
| 35 to 44 years | 10.22 | 12.79 | +2.57 | 125 |
| 45 to 54 years | 17.73 | 20.90 | +3.17 | 118 |
| 55 to 64 years | 31.01 | 36.60 | +5.59 | 118 |
| 65 years and over | 88.39 | 83.78 | −4.61 | 95 |

The preceding table is self-explanatory. A more extended comparison is made in Table 58, in which the mortality of brass workers from pulmonary tuberculosis and respiratory diseases other than tuberculosis is compared with the normal mortality of occupied males from these diseases by divisional periods of life. The comparison shows that at ages 20 to 64, inclusive, the mortality of brass workers from pulmonary tuberculosis is excessive by from 0.42 to 1.79 per 1,000, the excess being greatest at ages 35 to 44. The table further shows that the mortality from respiratory diseases other than tuberculosis is excessive among men in this class, but decidedly so at ages 55 and over, when the excess is from 1.29 to 2.88 per 1,000. The two tables derived from English experience fully confirm the previous conclusion that the mortality of brass workers is excessive when comparison is made with the normal mortality of occupied males generally, and that this excess is largely because of the high degree of tuberculosis frequency, particularly at ages 25 to 54.[1]

[1] An excellent account of the comparative social and health conditions of brassworkers, entitled "Brassworkers of Berlin and of Birmingham," was published by P. S. King & Son, London, in 1910. This is a joint report by a representative of a large brassworks, the secretary of the National Society of Amalgamated Brassworkers, and a representative of the Birmingham Hospital. The report includes an interesting account of the Brassworkers' Trade Union and general observations on the German compulsory health insurance system.

TABLE 58.—MORTALITY FROM PULMONARY TUBERCULOSIS AND FROM OTHER DISEASES OF THE RESPIRATORY SYSTEM AMONG BRASS WORKERS, 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 brass workers. | | | Death rate per 1,000 for all occupied males. | Death rate for brass workers. | | |
| | | 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 | 0.49 | −0.05 | 91 | 0.24 | 0.24 | .......... | 100 |
| 20 to 24 years | 1.55 | 2.17 | + .62 | 140 | .48 | .52 | +0.04 | 108 |
| 25 to 34 years | 2.03 | 2.93 | + .90 | 144 | .77 | .60 | − .17 | 78 |
| 35 to 44 years | 2.74 | 4.53 | +1.79 | 165 | 1.66 | 2.05 | + .39 | 123 |
| 45 to 54 years | 3.04 | 4.61 | +1.57 | 152 | 3.32 | 3.94 | + .62 | 119 |
| 55 to 64 years | 2.16 | 2.58 | + .42 | 119 | 6.54 | 9.42 | +2.88 | 144 |
| 65 years and over | 1.11 | .44 | − .67 | 40 | 17.77 | 19.06 | +1.29 | 107 |

## INVESTIGATIONS BY THE ILLINOIS COMMISSION ON OCCUPATIONAL DISEASES.

A number of special investigations have been made of the brass industry in the United States, but chiefly with reference to the occurrence of brass poisoning, or "brass founders' ague." One of the most important of these investigations is by E. R. Hayhurst, the results of which were published by the Illinois Commission on Occupational Diseases. Brass being an alloy composed of copper and zinc, the actual degree of metallic dust exposure in the different processes is quite considerable. No specialized investigations have been made to ascertain the relative degree of dust exposure at the furnaces and the foundries and in connection with manufacturing processes. The dust inhaled is, of course, more or less mixed, and in the majority of cases may be more mineral than metallic in character. The so-called "brass chills," or "brass founders' ague," occurs almost exclusively in brass foundries and never in the more specialized manufacturing processes. According to Hayhurst, however, in addition to brass founders' ague there is a distinct liability to respiratory diseases.

### MORTALITY OF BRASS MOLDERS IN OHIO.

An investigation made in Ohio for the three years, 1910 to 1912, included 43 deaths of brass molders and brass workers, of whom 14, or 32.7 per cent, died from pulmonary tuberculosis. It is pointed out in this connection in Hayhurst's report on Health Hazards that "While the number of total deaths reported is small, the high rate of consumption is in harmony with observations concerning this industry reported elsewhere." Old age is rarely attained among persons employed in the brass industry, and, according to Sir Thomas Oliver, out of 1,200 brass casters in Birmingham (England) only 10 were found to be living beyond 60 years. How far this inferior longevity is the result of dust exposure is not, perhaps, directly ascertainable, but there are reasons for believing that the excessive mortality from tuberculous diseases among brass workers bears some relation to the relatively considerable and practically continuous exposure to metallic and mineral dust.

This exposure, of course, is exceptionally great in grinding and polishing brass, which are elsewhere discussed in detail without particular reference, however, to the brass industry. The sanitary conditions of the industry are, as a general rule, far from satisfactory, and in the Ohio investigation, for illustration, "in no place were means adopted to confine and remove brass fumes during pouring." The general construction of brass foundries was determined as hygienically good in 42 places, fairly so in 21, and unsatisfactory in the remaining 43. All of the special processes, such as core making, metal grinding, casting cleaning, machine-shop practice, polishing and buffing, involve a more or less definite hazard of dust exposure. The air conditions in the foundry processes of the brass-working plants investigated in Ohio were found to be good in only 17 places, fair in 41, and decidedly hazardous to the health of the workers in 48.

## MEDICAL ASPECTS OF THE BRASS INDUSTRY IN CONNECTICUT.

The medical aspects of the brass industry in Connecticut have been investigated and reported upon by W. Gilman Thompson, who states that:

The inhalation of powdered brass, the dust of brass filings, etc., irritates the respiratory mucosa and lungs. The metal may also be swallowed after inhalation into the mouth, or conveyance to the mouth by unclean hands or food or plug tobacco. In this manner chronic poisoning in time results, with symptoms which differ considerably from those of the ague, above described. Chronic bronchitis is usually to be found and sometimes fibroid phthisis and tuberculosis. The digestive system is deranged, and the victim complains of dyspepsia, anorexia, gastro-intestinal catarrh, nausea, vomiting, thirst, irregular action of the bowels, occasional intestinal colic, and a metallic taste in the mouth. The tartar on the teeth may become green from a deposit of copper salts. Headache and general muscular pains are common, and the patients often become neurotic, depressed, and hypochondriacal.

The evidence obtainable by means of such investigations would, therefore, seem to sustain the statistical data derived from American and foreign sources.

**MORTALITY OF BRASS WORKERS—UNITED STATES REGISTRATION AREA.**

The mortality of brass workers has been reported upon for the year 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, limited to the year referred to. According to the census report, out of 201 deaths of brass workers, 64, or 31.8 per cent, were from pulmonary tuberculosis. The details of the mortality by age groups are shown in Table 59.

TABLE 59.—PROPORTIONATE MORTALITY OF BRASS WORKERS FROM PULMONARY TUBERCULOSIS, UNITED STATES REGISTRATION AREA, 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 | 25 | 16 | 64.0 |
| 25 to 34 years | 42 | 21 | 50.0 |
| 35 to 44 years | 35 | 11 | 31.4 |
| 45 to 54 years | 48 | 8 | 16.7 |
| 55 to 64 years | 26 | 4 | 15.4 |
| 65 years and over | 25 | 4 | 16.0 |
| Total, 15 years and over | 201 | 64 | 31.8 |

TABLE 60.—PROPORTIONATE MORTALITY OF BRASS WORKERS FROM NONTUBERCULOUS RESPIRATORY DISEASES, UNITED STATES REGISTRATION AREA, 1909.

| Cause of death. | Deaths from nontuberculous respiratory diseases. | |
|---|---|---|
| | Number. | Per cent of deaths from all causes. |
| Asthma | | |
| Bronchitis | 3 | 1.5 |
| Pneumonia | 18 | 9.0 |
| Other nontuberculous respiratory diseases | 1 | .5 |
| Total | 22 | 10.9 |

Table 59 is extremely suggestive and indicates an excessive frequency of pulmonary tuberculosis among brass workers, which term unquestionably includes a considerable number of polishers and buffers. Aside from the relatively high proportion of deaths from pulmonary tuberculosis of 31.8 per cent in the mortality from all causes, other nontuberculous respiratory diseases as shown in Table 60 cause a mortality of 10.9 per cent, or, respectively, 1.5 per cent from bronchitis, 9 per cent from pneumonia, and 0.5 per cent from other respiratory diseases. The table in a general way confirms the data derived from other sources, and obviously suggests the relative unhealthfulness of employment in the brass industries, without specific reference, however, to the particular occupations, as to which the information is not available.

The results of this analysis of the available American vital statistics of brass workers for the registration area are further confirmed by the corresponding statistics derived from the industrial insurance experience of the Prudential Insurance Co.

### MORTALITY OF BRASS WORKERS—INDUSTRIAL INSURANCE EXPERIENCE.

TABLE 61.—PROPORTIONATE MORTALITY FROM PULMONARY TUBERCULOSIS AMONG BRASS WORKERS, 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 brass workers, 1897 to 1914, from— | | Per cent of deaths from pulmonary tuberculosis among— | |
|---|---|---|---|---|
| | All causes. | Pulmonary tuberculosis. | Brass workers. | Males in the registration area, 1900 to 1913. |
| 15 to 24 years | 91 | 53 | 58.2 | 27.0 |
| 25 to 34 years | 149 | 76 | 51.0 | 30.5 |
| 35 to 44 years | 146 | 64 | 43.8 | 23.4 |
| 45 to 54 years | 99 | 24 | 24.2 | 14.7 |
| 55 to 64 years | 93 | 15 | 16.1 | 7.9 |
| 65 years and over | 55 | | | 2.6 |
| Total, 15 years and over | 633 | 232 | 36.7 | 13.9 |

The experience shown in Table 61 includes 633 deaths from all causes, of which 232, or 36.7 per cent, are from pulmonary tuberculosis. The proportionate mortality from pulmonary tuberculosis is decidedly excessive at all ages under 65. In support of the statistics quoted by Sir Thomas Oliver regarding the proportion of brass workers attaining to old age, it is suggestive that out of 633 deaths of brass workers at all ages, 55, or only 8.7 per cent, should have attained to ages 65 and over. The statistics of Sir Thomas Oliver, however, apparently have reference to brass founders alone, who are unquestionably exposed to greater health hazards than brass workers generally. Unfortunately the data for a specialized analysis by occupations, in detail, are not available for the brass industry at the present time.

### GENERAL CONCLUSIONS.

In a general way the insurance mortality statistics confirm the data and observations derived from other sources. The dust hazard in the brass working trade is, of course, only one of many health-injurious conditions inherent in the industry, all of which are suggestive of the exceptional urgency of thoroughly efficient sanitary precautions, and the use of protective devices on the part of those most seriously affected by the liability to brass poisoning and its related respiratory affections.

## ARTIFICIAL FLOWERS.

This occupation is not strictly within the group of trades, industries, or occupations with continuous and considerable exposure to metallic dust. It is, however, included in view of the observations by Sir Thomas Oliver, that the workers employed in the manufacture of artificial flowers, chiefly French roses, especially the double roses, "complain of headache, nasal catarrh, dryness of the throat, probably from the dust, and also of vomiting." In addition, he observes, "In at least one-third of those who suffer, the symptoms are those of metallic poisoning, for on examination of the red leaves of the roses several are found to contain salts of lead." He draws particular attention to the health-injurious effects of this group of occupations upon the young women engaged in salesrooms where artificial flowers are collected and distributed, and states that "a few of them show a tendency to laryngeal and pulmonary catarrh, attended by a cough, owing to the dust given off by the flowers. Upon a microscopic examination of the expectoration it was found that particles of dust contained therein were identical with those given off from the flowers."

### PROCESSES OF ARTIFICIAL-FLOWER MAKING.

An extended account of the processes of artificial-flower making in the United States, by Walter O. Lincoln, is published in the Weekly Underwriter, New York, March 17, 1914. The different processes are not indicative of a considerable amount of dust exposure, although mention is made of the use of tinsel including mica in its composition. In connection with the manufacture of leaves it is stated that the claim is made on good authority that "the gas-heated presses are injurious to the health of the operators, who are required to sit many hours with the lower limbs extended under the press, with gas burners near by, which overheat the abdomen and cause stomach trouble." There are, however, no intimations that the manufacture of leaves or flowers involves a particular hazard of metallic or mineral dust exposure.

A brief reference occurs in the Second Report of the New York State Factory Investigating Commission (Vol. II, p. 1156), according to which "The danger in this industry was reputed to be from the use of the arsenic greens for the purpose of dyeing and dusting the material." The different processes are briefly described in the 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. | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 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 employments 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 | 105.4 |
| 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. | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 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

[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.

among workers in occupations with exposure to mineral dust, without reference to divisional periods of life:

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 |
| Glass workers, 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."

sarily vary widely, but from a hygienic point of view the essential difference arises out of the mechanical and chemical properties of the dust produced in the quarrying, the dressing, and the polishing of the different varieties, which are too numerous to permit of even a brief technical description.

### EARLY OBSERVATIONS ON HEALTH-INJURIOUS CONDITIONS.

The health of stone and marble cutters has, from earliest times, been held to be notoriously bad, and the hygienic importance of this trade was recognized by Ramazzini, who, as far back as 1705, discussed the subject in an entire chapter in his work on Diseases of Tradesmen, stating that—

> In hewing marble or stones out of the rock, in polishing and cutting them, they oftentimes suck in, by inspiration, the sharp, rough, and cornered small splinters or particles that fly off; so that they are usually troubled with a cough, and some of them turn asthmatic and consumptive. * * * Our medical histories give many instances of stones found in the stomach and lungs of these workmen, for which we can assign no other material cause but the dusty particles taken in at the mouth and gradually gathered into a heap. * * * Withal, all possible caution must be used to avoid the sucking in of these minute particles at the mouth.

From the earliest to the most recent observers upon the health conditions in this trade, the conclusions have been decidedly unfavorable and suggestive of circumstances more or less possible of material improvement. Oliver, in his Diseases of Occupation, remarks, with special reference to stonemasons:

> The occupation of the stonemason and of the quarryman has for long been regarded as one in which a higher death rate from lung disease occurs than in most occupations. The disease, which usually assumes a chronic character, is slow in its development and progress. As it is attended by the ordinary physical signs and symptoms observed in other forms of pneumoconiosis, the malady calls for no special description other than this, that in contradistinction to miners' phthisis, which occurs in men who work underground, stonemasons' phthisis is met with in men who are working in the open air, a circumstance which becomes a strong argument in favor of the dust origin of pneumoconiosis as against the bacillary. After a time the lung disease becomes tuberculous, hence the extraordinary fact of the death rate from pulmonary tuberculosis among stonemasons and marble cutters, who are following an outdoor occupation, being six times that of bankers and brokers, who are leading an indoor life. This want of harmony between occupation and mortality from pulmonary phthisis is observed in other outdoor occupations than stonecutting. It would appear, therefore, as if the predisposing causes of lung disease are often of greater importance than the exciting—in other words, that the soil is of as much, if not of greater, influence than the seed. The irritation of the lung caused by dust would seem in some instances, especially in the early stages of the disease, to

create a favorable soil for the implantation of the tubercle bacillus, while in the slowly developed forms of pneumoconiosis the hard and unyielding fibrous tissue does not offer the same attractions to the microorganism, and as a consequence it is in those parts of the lung where the structure is least fibrous that the tubercle bacilli exert their greatest power for harm.[1]

### EXPERIENCE OF THE OPERATIVE MASONS' SOCIETY OF LONDON.

The remarks of Oliver are fully sustained by the available statistical evidence. The secretary of the Operative Masons' Society of London, in his testimony before the committee on industrial diseases, produced the mortality record for Newcastle for the period of 1871 to 1896, including an account of 160 deaths of stonemasons, and of this number 71, or 44.4 per cent, had died from phthisis, at an average age of only 42.23 years. It was admitted, however, that conditions had improved, and more recent data resulted in a more favorable showing. Out of 253 deaths of stonemasons reported in 1905 by the same society, 79, or 31.2 per cent, were deaths from pulmonary tuberculosis. The same witness stated that the average age at death of those dying from phthisis during 1905 was 44 years, against 51 years for deaths from all causes.[2]

### DESCRIPTIVE ACCOUNT OF OCCUPATIONAL CONDITIONS.

Conditions are probably somewhat different in this country, due to the more general use of pneumatic tools, which generate considerable quantities of fine dust, the complete prevention of which is always difficult and often impossible. The degree of disease liability varies materially according to the specific occupation, and the risk is less in the case of paving-stone cutters and slate splitters than in the case of monument or custom work, which requires close attention in matters of minute detail and which is more often carried on indoors. Surfacing and carving and cutting with pneumatic tools are the most dangerous employments, the risk being less in polishing, grinding, sawing, and lathe work, most of which is carried on by the wet process. Large quantities of dust are stirred up, however, in the brushing off and cleaning up of the accumulated dust, and in the moving of materials, dropping of slabs, etc. There is, therefore, more or less dust exposure in all branches of the stone industry, but the results of exposure vary according to the kind of material, which includes a large variety of stones, chiefly, however, granite, marble, limestone, sandstone, bluestone, and slate.

The stonecutters' trade is one which requires both skill and arduous physical labor. The men as a rule work in the open air, and in very

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[1] Diseases of Occupation, London, 1908, p. 305.

[2] Minutes of Evidence, Departmental Committee on Compensation for Industrial Diseases, p. 322.

warm or wet weather under shelter; but all are liable to inhale the dust and small particles from the material upon which they operate. This on some kinds of stone is much more deleterious to health than on others, the stone containing the largest proportion of flints being much more injurious than that which has most lime in it. The returns show that the present age of stonecutters is three years less than that of carpenters or masons, while the average number of years at work exceeds that of either by nearly one year. But this is accounted for by reason of the difference in the ages at which they began to work, which for 63.9 per cent of stonecutters was under 15 years of age, while in the other two trades mentioned it was 13.8 per cent and 4 per cent, respectively. The explanation is that in England, Ireland, and Scotland, as well as in other European countries, seven years are the rule for apprenticeship of stonecutters, and a large proportion are taken when 12 years old, and quite a number under this age. Eighty-three and one-half per cent of the total number were foreign born and but 16.5 per cent American born; and of the latter but nine-tenths of 1 per cent began to work under 15 years of age; while 15.4 per cent of carpenters and 25.6 per cent of masons began to work at their respective trades after the age of 20 years and upward, none of the stonecutters had reached this age. This fully accounts for the differences above noted.[1]

In his discussion of the hygiene of this occupation Lloyd[2] makes the following observations:

Stonecutters and quarrymen suffer in various degrees from the inhalation of dust. The extent of the evil in their cases depends upon, first, the character of the dust, and, second, the circumstances amid which the work is pursued. The quality of the stone has much to do with the extent of pulmonary disease among stonecutters. Some stone is much more dusty than others. A sedimentary stone, for instance, that was formed originally simply by the deposit of earthy and siliceous particles under water is much more liable to give off a large quantity of dust than is a stone that was fused in early geological ages—the igneous stones, for instance, like granite. Although the particles from these latter stones are exceedingly hard, yet there is not much true dust, only the particles actually displaced by the contact with the tool being thrown off. These probably do not carry far in the air, and are mostly too large to gain access to the alveoli as dust. This was the explanation given by Hamilton, of Aberdeen (quoted by Arlidge), for the fact that the masons and polishers at the Aberdeen quarries do not suffer much, if any, with industrial phthisis.

## RESULTS OF OFFICIAL INVESTIGATION IN MASSACHUSETTS.

A brief abstract from a special report of the Massachusetts State Board of Health on dangerous occupations,[3] as suggestive evidence

[1] Fourteenth Annual Report of the Bureau of Statistics of Labor and Industries of New Jersey, 1891, pp. 176, 177.

[2] "The diseases of occupations," by James Hendrie Lloyd, M. D., published in Twentieth Century Practice of Modern Medical Science, New York, 1895, Vol. III, p. 420.

[3] Commonwealth of Massachusetts, Senate Document No. 250, Boston, March, 1907, pp. 78, 79.

particularly applicable to American conditions at the present time, is included here:

It is preeminently a dusty trade, and the workmen are therefore exposed to the danger of inhaling nonabsorbable and irritating particles of mineral matter. Accidents to the eyes from flying chips are also very common, but they are generally less serious than those due to fragments of steel from the tools employed. Of the various kinds of stone dust, granite is regarded as more injurious than marble, and soapstone the least of all; but different granites vary in this particular, some yielding a much finer dust than others, on account of differences in texture. The greatest amount of dust comes from the surfacing machines, which are operated with compressed air. The tool is either a large hammer or an instrument which presents four smaller separate faces. Sometimes a bushing hammer, made of thin, chisel-like blades bolted together, is used; this creates the finest dust of all. The men who operate the surfacing tools rarely wear masks, but many chew tobacco and spit, in the belief that the practice serves to protect them from the effects of the dust to which they are exposed. Some protect themselves from flying chips by means of wire screens placed about the hammer; some wear wire masks and some wear glasses. By a union regulation, surfacing is done in the open sheds in the yard. While the operation of smoothing can not be done by the wet process, on account of clogging of the tools with the pasty material which would thereby be produced, polishing is conducted with the application of water, which prevents the evolution of dust. The sawing of granite and marble into slabs is conducted ordinarily by the wet process, and is therefore unattended by dust; but soapstone sawing and cutting for joints is frequently done dry, and with the evolution of much fine dust. Turning in lathes is conducted in the wet way, and is dustless.

Of 343 deaths which occurred in the city of Quincy among stonecutters during a period of about 16 years, no fewer than 142 (41.4 per cent) were due to pulmonary tuberculosis, 41 (12 per cent) to other diseases of the lungs, 44 (12.8 per cent) to diseases of the heart, 24 (7 per cent) to violence, and 92 (26.8 per cent) to all other causes. Excluding accidents, the percentage due to tuberculosis was 44.5. These statistics show even more strikingly than those quoted in a report submitted two years ago the dangerous character of this occupation. Therein it appears that, of a total of 30,000 deaths among stonecutters, tuberculosis was the cause in 28.57 per cent. It must be said, however, that the average age at death of the victims of the disease in this industry, so far at least as the Quincy records show, is somewhat high (47.8 years), but it is to be borne in mind that the calling is one which is not open to the naturally weak, and that many of those who become incapacitated through infection drift into other lines of industry in which physical strength is not so essential, and hence at death are not returned as belonging to this class.

### URGENCY OF SPECIAL SCIENTIFIC INQUIRIES.

No very satisfactory data for this country are available to determine with accuracy the probable degree of difference in the health-injurious conditions resulting from the cutting or manipulation otherwise of the different kinds of stone, such as granite, sandstone, limestone, bluestone, slate, etc., except marble cutting, to be separately considered as a well-defined branch of the trade. The term "stonecutters" is, therefore, practically inclusive of workers in all branches of the industry and in all the different employments necessary in connection therewith. An observer of conditions in the sandstone industry states that "stonecutters who work on sandstone seldom live to be 50 years of age, and nearly all of them die of lung disease, due to the inhalation of mineral dust"; but how far this is sustained by actual experience in the regions where sandstone is quarried and cut can not be stated at present. A physician of long residence in the Bedford, Ind., limestone field, states that he has not observed very serious consequences to result from employment in that branch of the stone industry, but all such observations are subject to serious error in the absence of trustworthy statistical data for a period of years.

### DIFFERENTIAL EFFECTS OF DUST EXPOSURE.

These differences of qualified opinion regarding the relation of stone dust to health arise obviously out of the wide variations in the physical, mechanical, and chemical properties of the different kinds of stone subjected to modern processes of quarrying, dressing, etc., particularly in consequence of the extensive use of modern pneumatic tools used for stonecutting purposes. Among all branches of the dusty trades and occupations the stone industry is of the first order of scientific importance. Aside from the industry itself, as regards the production of stone for commercial purposes, practically the entire mining industry is in a measure a branch of the stone industry, in that all the metals and nonmetallic minerals obtained by mining methods are obtained by processes of extraction from rock material more or less identical with the substances which enter into the stones quarried and cut for commercial purposes. The most thorough and strictly scientific study of dust phthisis with special reference to the stone industries has been made by Dr. Edgar L. Collis, His Majesty's medical inspector of factories, presented in the Milroy Lectures of 1915. The differential effects of dust containing a large proportion of free silica (quartz) and dust relatively free therefrom are emphasized in the most concise and conclusive manner.

### LUNG DISEASES OF FLINT KNAPPERS AND BUHRSTONE DRESSERS.

The correlation of these conditions to the relative frequency of true phthisis or of lung fibrosis, with a subsequent tuberculous infection, is made clear on the basis of indisputable clinical evidence amplified by numerous Roentgen ray examinations. Stone dust containing but a relatively small proportion of free silica, such as limestone, is considered comparatively harmless, while the extreme seriousness of stone dust consisting chiefly of free silica (quartz) is illustrated by numerous concrete cases, of which the so-called flint knappers and French buhrstone dressers are the most striking and lamentable examples. Dr. Collis defines the term "pneumoconiosis" as one which should be restricted to "disturbances in health following upon changes induced in the lungs by inhalation of nonviable particles." And he remarks that "just as all germs are not pathogenic, so all kinds of nonviable particles do not give rise to pneumoconiosis." This extremely important conclusion in its particular application to the stone industry requires constant application to the more specialized consideration of its injurious results in employment in the different branches of the industry. Referring to the flint knappers of Brandon as the lineal occupational representatives of the oldest of all industries, that of the making of prehistoric stone tools and weapons, he states that they "suffer a terrible mortality from phthisis induced by flint dust generated in their work," and he recalls the results of earlier observations as regards the lamentable consequences produced among the population of Meusnes, France, by the introduction of the gun-flint industry, which, according to Chateauneuf, "slays those who follow it; it kills them before their time; for them there is no old age." He illustrates these observations by a most interesting analysis of the mortality from phthisis among flint knappers in the Brandon district, shown in Table 72.

TABLE 72.—MORTALITY FROM PHTHISIS OF FLINT KNAPPERS COMPARED WITH THAT OF CERTAIN OTHER CLASSES.

| Class. | Cause of death, stated as percentages from— | | | | Total number of deaths. | Average age at death. | Calculated death rate from phthisis per annum among 1,000 living. |
|---|---|---|---|---|---|---|---|
| | All causes. | Phthisis. | Respiratory diseases other than phthisis. | All other causes. | | | |
| Flint knappers [1] | 100.0 | 77.8 | 7.4 | 14.8 | 27 | 46 | 41.0 |
| Wives (2) and widows (11) of flint knappers. | 100.0 | ........ | 15.4 | 84.6 | 13 | 78 | .......... |
| Brandon rural district [2] | 100.0 | 6.5 | 11.7 | 81.8 | 63 | ........ | .8 |
| All males (England and Wales, 1900–1902) [3] | 100.0 | 11.2 | 17.6 | 71.2 | 509,567 | ([4]) | 1.6 |

[1] Average number employed for 25 years estimated at 16.5.
[2] Population about 5,150. The figures for this class, supplied by Dr. A. Harris, M. O. H., Thetford, Norfolk, are for all ages, 1901–1910.
[3] The figures for this class, calculated from the Supplement to the Sixty-fifth Annual Report of the Registrar-General, are for all males aged 15 years and upward, 1900–1902.
[4] Median age at death between 56 and 57.

## MIXED MINERAL AND METALLIC DUST EXPOSURE.

Next to the inhalation of steel dust the continuous and considerable inhalation of flint dust is one of the most serious industrial conditions predisposing to pulmonary tuberculosis. In the pottery industry (see pages 247 to 271), the employees who handle or employ flint dust in connection with production processes are known to be subject to an exceptionally high mortality from pulmonary tuberculosis; so much so that flint workers generally are considered uninsurable by all American life insurance companies.

### SECONDARY IMPORTANCE OF BACILLARY INFECTION.

The effects of stone dust in the mining industry are briefly set forth in the conclusions of the departmental committee appointed in 1902 to reinvestigate the causes of the persistently high phthisis mortality among Cornish tin miners, which, excluding all other contributory circumstances, except dust inhalation, decided that—

So far as the Cornish miners are concerned it seems evident enough that stone dust which they inhale produces permanent injury of the lungs—gradually in the case of ordinary miners and rapidly in the case of machine-drill men—and that this injury, while it is apparently capable of gradually producing by itself great impairment of the respiratory functions, and indirectly of the general health, also predisposes enormously to tuberculosis of the lungs, so that a large proportion of miners die from tubercular phthisis. That the primary injury to the lungs is due solely to inhalation of stone dust would seem to be practically certain.

In other words, the more generally recognized menace of bacillary infection in tuberculosis was considered of secondary importance as a causative factor in the production of so-called miners' phthisis, more directly and specifically attributable to the continuous and considerable inhalation of silica dust. A descriptive account of the different varieties of dust, based on the microscopical examination of their physical and mechanical properties, is, therefore, a prerequisite for a thorough understanding of the pathological consequences of dust inhalation in the different branches of the stone industry. It is pointed out by Collis that all classifications in general use are inadequate to the purpose and that in the main it seems best to ascertain, first, the relation of each of the main respiratory diseases to dusts, and then from that standpoint to examine the properties of the dusts which are associated with an undue prevalence of each of these diseases. This, of course, implies a much broader plan and scope than the present investigation, which for practical purposes is limited chiefly to pulmonary tuberculosis. The chemical properties of dusts are occasionally of major importance on account of the solubility of certain kinds of dust, best illustrated in the case of the cement industry. As observed by Collis—

Only particles which are insoluble in the fluids of the body when carried into the air passages remain as foreign bodies either to stimulate the ciliated epithelium to overaction for their expulsion, or, if they gain access to the lymph channels, to give rise to a proliferation of the connective tissue; thus dusts of ivory, horn, bone, and other animal structures, and of calcium sulphate (plaster of Paris and alabaster), of limestone, and of oxide of iron are not associated with pneumoconiosis in the way that dusts of vegetable husks, emery, glass, sandstone, and flint are.

He adds to this extremely important practical conclusion the observation that, "generally speaking, dusts are more injurious as their chemical composition differs from that of the human body, or from the elements of which the body is normally composed."

## MORBIDITY AND MORTALITY OF THE STONE WORKERS OF DERBYSHIRE.

The most useful application of the theory and conclusions of Dr. Collis is to be found in the extended study which has been made of the different branches of the stone industry of Derbyshire by Dr. Sidney Barwise, in a report to the county council of Derbyshire, on the basis of a careful study of the relation of phthisis incidence to the surface geological formation. Dr. Barwise ascertained that there was an excessive frequency of pulmonary tuberculosis on areas showing millstone grit, and a preliminary investigation indicated that "the key to the higher phthisis mortality in the gritstone area was to be found in the occupations of the males." A subsequent analysis of the mortality record for a period of 10 years proved conclusively that the gritstone quarries experienced an exceptional mortality from phthisis. It was found that of the deaths of quarrymen 29 per cent was from phthisis, while only 4.6 per cent of the deaths of agriculturists was attributed to this cause. On the basis of the calculated death rate, without reference, however, to the age distribution of the employees, it was shown that the death rate from phthisis among the agricultural group of the county was 0.72 per 1,000, while among the quarrymen and masons (stonecutters, dressers, etc.) it was 5, or seven times as great. Subjecting the data to a thoroughly specialized and qualified analysis, it was then ascertained that "among the limestone workers there was not an excessive mortality from phthisis, so that the mortality of gritstone workers separately considered was even higher than indicated by the combined mortality rate for all quarrymen and stone workers in the section under consideration. The results of this exceptionally valuable, and, broadly speaking, scientific investigation, are set forth in Table 73, derived from the "Report on the Prevalence of Phthisis among Quarry Workers and Miners," made by Dr. Sidney Barwise to the Derbyshire county council, February 6, 1913.

TABLE 73.—DEATHS FROM PHTHISIS OF MALES OVER 15, AND NUMBER OF MALES OVER 10 ENGAGED IN CERTAIN OCCUPATIONS, WITH DEATH RATES FROM PHTHISIS PER 1,000 MALES OVER 10 ENGAGED IN SUCH OCCUPATIONS, 1901 TO 1910.

| District. | Stone-workers' group. | | | Agriculture. | | |
|---|---|---|---|---|---|---|
| | Workers. | Phthisis deaths. | Rate per 1,000. | Workers. | Phthisis deaths. | Rate per 1,000. |
| Matlock registration subdistrict (chiefly gritstone): | | | | | | |
| The two Matlocks and the two Darleys | 426 | 31 | 7.3 | 473 | 2 | 0.4 |
| Certain rural parishes | 233 | 15 | 6.4 | 245 | 3 | 1.2 |
| Total, Matlock registration subdistrict | 659 | 46 | 7.0 | 718 | 5 | .7 |
| Bakewell registration subdistrict (gritstone and limestone): | | | | | | |
| Bakewell, Baslow, and certain rural parishes in Bakewell registration subdistrict | 530 | 20 | 3.8 | 1,079 | 10 | .9 |
| Tideswell registration subdistrict (chiefly limestone): | | | | | | |
| Certain rural parishes in Tideswell registration subdistrict | 339 | 10 | 2.9 | 579 | 2 | .34 |
| Total, Bakewell registration district | 1,528 | 76 | 5.0 | 2,376 | 17 | .72 |

COMPARATIVE PHTHISIS DEATH RATES ACCORDING TO DUST EXPOSURE.

According to this table the gritstone workers, who predominate in the Matlock subdistrict, show a phthisis rate of 7 per 1,000, or ten times greater than the agricultural group, whereas in the Bakewell subdistrict, where both limestone and gritstone deposits are worked, the rate is only 3.8, and in the Tideswell subdistrict, in which the proportion of gritstone workers is still less, the rate is only 2.9. Subjecting the returns for the Matlock and the Tideswell subdistricts to further analysis, it is shown that the phthisis mortality during the period 1901–1910, limited strictly to the workers themselves, is 13.7 per 1,000 for gritstone workers (chiefly exposed to insoluble pure silica dust); whereas in the case of limestone workers, chiefly exposed to a dust more or less soluble, the rate is only 1.2. In other words, the phthisis mortality of gritstone workers is more than ten times the corresponding mortality of limestone workers. It should be said in this connection that the number of men exposed to risk was 124 in the case of gritstone workers, with 17 deaths from phthisis, and 170 in the case of limestone workers, with 2 deaths from phthisis during the 10-year period. The results of the investigation are summarized in a convenient form in Table 74.

TABLE 74.—COMPARATIVE PHTHISIS DEATHRATE IN DERBYSHIRE COUNTY, ENGLAND, 1901 TO 1910.

| | Persons. | Rate per 1,000. |
|---|---|---|
| Gritstone workers | 124 | 13.7 |
| The two Matlocks and the two Darleys, stoneworkers (some in limestone) | 426 | 7.0 |
| Bakewell registration district, gritstone and limestone works | 1,528 | 5.0 |
| Persons employed in and about limestone quarries and works | 1,282 | 1.71 |
| Limestone workers | 262 | 1.52 |
| Persons employed in and about coal mines | 1,757 | .68 |
| Persons employed in agriculture | 3,615 | .66 |
| Standard phthisis death rate | 15,152 | .77 |

In addition it was found that among those employed in gritstone working, the proportionate mortality from phthisis was 45 per cent, and among quarrymen and miners in the same district and working on the same material 36.6 per cent, in contrast to a proportionate mortality of 12.3 per cent for men employed as quarrymen and miners in the limestone area, and 7.4 per cent among the men employed in coal mining. The highest proportionate mortality among agricultural workers in the same district in which the proportionate mortality of gritstone workers was 45 per cent was only 7.9 per cent. The extremely injurious nature of gritstone dust, which is largely pure silica in a crystalline form, with special reference to pulmonary tuberculosis, is, therefore, conclusively established by these investigations.

## AMERICAN MORTALITY STATISTICS.

The Vermont State board of health has reported the mortality by occupations during the six years ending with 1905, and during that time there were 204 deaths from all causes among the granite and other stone workers in that State. Of these deaths, 80, or 39.2 per cent, were from pulmonary tuberculosis, and 27, or 13.2 per cent, from other respiratory diseases. Of the deaths from all causes among stone workers in Vermont, 52.4 per cent were attributed either to pulmonary tuberculosis or to other respiratory diseases.

The census mortality statistics for 1900 combine marble and stone cutters into one group, including 26,141 males aged 15 years and over in the registration States. Of the number stated, 659, or 2.5 per cent, had attained to 65 years of age or over, which compares with 3.9 per cent for men in mechanical and manufacturing industries generally. In the mortality from all causes the death rate is comparatively low at ages under 25, but high at ages 25 and over, as shown in detail in Table 75. The census mortality statistics, however, are subject to the criticism that in all probability the facts are understated on account of defective enumeration.

TABLE 75.—MORTALITY FROM ALL CAUSES AMONG MARBLE AND STONE CUTTERS, 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— | | |
|---|---|---|---|
| | Marble and stone cutters. | The manufacturing and mechanical class. | The mercantile and trading class. |
| 15 to 24 years | 3.35 | 4.43 | 2.60 |
| 25 to 44 years | 9.32 | 8.35 | 6.72 |
| 45 to 64 years | 24.72 | 20.16 | 19.91 |
| 65 years and over | 122.91 | 105.43 | 93.79 |

A further difficulty in connection with the vital statistics of stone and marble cutters results from the fact that men in this trade are a very mobile element, frequently moving from one place to another in response to better trade conditions, higher wages, etc., in other fields. The most suggestive result of the census mortality investigation is the extraordinarily high death rate from pulmonary tuberculosis, which is returned at 5.41 per 1,000, compared with 2.62 for the mechanical and manufacturing class, and 1.66 for the mercantile and trading class.

### ENGLISH OCCUPATIONAL MORTALITY INVESTIGATIONS.

For unknown reasons the Report of the Registrar-General for England and Wales does not specifically consider stonecutters, but combines them with quarrymen in stone and slate, which, of course, precludes the utility of the resulting averages in an effort to determine the relative degree of pulmonary tuberculosis frequency in a well-defined specific occupation such as the stonecutters' trade. Even when considered as a group, however, quarrymen and stonecutters combined, according to English statistics, show an excessive mortality from pulmonary tuberculosis and other respiratory diseases, but it is a matter of regret that the data should not be separately available for men employed in the more important branches of the stone industry.

The health and mortality of men employed in granite, marble, and stone quarrying, including stonecutters and polishers, has been reported upon at length by Arlidge, who observes, in part, that—

All employed on these mineral substances suffer in various degrees with respiratory disorders, and, on the whole, more so than coal miners. The quality of the stone, in regard to its petrological characters, determines its severity of action; but observations have hitherto not been sufficiently numerous to establish the fixed relations between the character of the stone and the mischief caused by its dust. Speaking generally, sedimentary rocks composed of siliceous and readily detached particles do more harm on inhalation than primary rocks in which a fusion of their constituents has taken place. Other modifying characters are exhibited in the chemical composition and in the miscibility of the mineral dust with fluid.

### MORTALITY OF THE GRANITE CUTTERS OF ABERDEEN.

With special reference to granite cutting in the district of Aberdeen, Scotland, it is stated that men employed in the cutting, dressing, and polishing of granite are seldom victims of pulmonary lesions attributable to their occupation. Arlidge considers this a surprising fact, possibly explained by the density of granite and its lithological elements. He quotes Prof. Hamilton, of Aberdeen University, to the effect that the explanation may be found in the igneous character of the rock, which opposes itself to the throwing off of dust, because its particles, unlike those of stratified rocks, do not exist in granite ready formed, but must be made by the chisel of the workman. Prof. Hamilton concludes that—

The dust in granite working would in all likelihood be coarser than in chiseling stratified rock, and would be caught in the superior respiratory passages without gaining entrance to the air vesicles where alone it seems to make its way into the pulmonary lymphatics.

Whether this explanation is accepted or not, it is a fact of considerable importance that the men employed in the granite-cutting industries suffer considerably from chronic bronchitis, but the severe lesions indicative of fibrosis and industrial phthisis are practically unknown among them.

According to the report of the chief inspector of factories for 1880 (p. 81)—

It seems that a like immunity is enjoyed by the laborers in the Purbeck and Portland quarries. Here the material is a limestone of close, compact grain, and not a mass of imperfectly coherent particles of sand; in short, a marble—a substance recognized by those who work it as but slightly detrimental to the respiratory organs.

In marked contrast, Arlidge directs attention to the extremely high fatality rate among men employed in the Edinburgh stone quarries, but no conclusive statistical information has been made public concerning this. According to Dr. R. W. Philip, of Edinburgh, in a statement to Dr. Arlidge, "A large number of cases of stonemasons suffering from phthisis seek relief at the local dispensary, and the average age at which they come under observation is only about 35 years. As a rule, the cases run a very chronic course, passing from recurrent to persistent attacks of bronchitis." Reference is made to a much earlier observation by Prof. Alison in 1824, according to which there was reason to believe "that there was hardly an instance of a mason regularly employed in hewing stones in Edinburgh being free from phthisical symptoms to the age of 50."

## COMPARATIVE OCCUPATIONAL MORTALITY OF THE STONE WORKERS OF ABERDEEN.

It is self-evident that these conflicting conclusions are more or less attributable to important variations in the nature of the stone quarried as well as to differences in the method of work. Modern pneumatic processes, for illustration, have practically revolutionized the stone-cutting industry, and the dust menace has been very materially increased in consequence. The mortality of stone workers in the Aberdeen district has been reported upon with admirable thoroughness by Dr. Matthew Hay in an appendix to his annual report as medical officer of health for the year 1909. He points out that—

A workman who has contracted phthisis in one occupation may change his occupation some months or years before death, and his relatives on registering his death may or may not give his original occupation as his ordinary occupation. Much depends upon the length and nature of the last occupation, whether it is presumed to be inferior or not, and on the person to whom it may fall to supply the information required by the registrar. Even the registrars themselves act differently in such cases of changed occupation.

Other difficulties are the probable incompleteness of returns regarding the number of persons employed, which by inference suggests the possibly greater practical utility and scientific conclusiveness of proportionate mortality data. Hay points out that—

Considerable interest attaches in Aberdeen to the incidence of phthisis among stonecutters and masons, owing to their considerable number and to the danger to which they are exposed from the inhalation of granite dust. All masons are not, however, so exposed, as a proportion of them, varying with the character of the building, are employed solely in building, and are known within the trade as "wallers," while the remainder are engaged in hewing and dressing stones. Wallers are not so distinguished in the death registers. Nor is any distinction made in the registers between masons, whether hewers or wallers, employed in connection with buildings and stonecutters employed in the numerous monumental yards. As a rule, a hewer working in the latter is known as a stonecutter, but he is not infrequently designated as a mason.

The results of the investigation are summarized in Table 76.

TABLE 76.—AVERAGE ANNUAL DEATH RATE OF PERSONS 21 YEARS OF AGE AND OVER (EXCLUDING EMPLOYERS) IN ABERDEEN, 1900 TO 1909, BY OCCUPATIONS.

| Occupation. | Estimated average annual number of persons over 21 years of age employed. | Annual number of deaths per 1,000 persons due to— | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Phthisis. | Lung diseases. | | Circulatory and nervous diseases. | Other diseases. | All causes. | Tuberculosis. | |
| | | | Excluding phthisis. | Including phthisis. | | | | Wives and widows. | Unmarried children. |
| **MALES.** | | | | | | | | | |
| Stonecutters and masons | 1,750 | 5.7 | 2.5 | 8.2 | 4.6 | 5.4 | 18.1 | 1.8 | 4.7 |
| Stone polishers | 420 | 2.5 | 4.8 | 7.3 | 4.8 | 5.2 | 17.3 | 1.6 | 5.5 |
| Joiners, etc | 1,420 | 1.8 | 3.4 | 5.2 | 7.0 | 8.6 | 20.8 | 1.8 | 3.7 |
| Painters | 420 | 2.1 | 4.0 | 6.1 | 9.3 | 5.2 | 20.7 | 1.7 | 4.5 |
| Tailors | 620 | 3.2 | 5.6 | 8.8 | 9.0 | 8.5 | 26.5 | 1.6 | 2.7 |
| Bakers | 360 | 1.4 | 4.4 | 5.8 | 6.4 | 8.3 | 20.6 | 1.9 | 4.4 |
| Engineers, etc | 2,600 | 1.8 | 2.3 | 4.1 | 5.2 | 4.8 | 14.1 | 1.6 | 3.9 |
| Printers, etc | 380 | 4.5 | 1.1 | 5.6 | 4.5 | 3.7 | 13.7 | 1.1 | 1.6 |
| Comb makers | 345 | 4.3 | 4.3 | 8.6 | 7.2 | 6.7 | 22.5 | 2.0 | 3.2 |
| Carters | 1,450 | 1.1 | 3.1 | 4.2 | 3.0 | 5.0 | 12.2 | 1.8 | 4.7 |
| Laborers | 3,600 | 2.3 | 5.6 | 7.9 | 8.3 | 9.8 | 26.0 | 2.1 | 4.4 |
| Clerks | 1,220 | 3.8 | 1.5 | 5.3 | 3.9 | 5.4 | 14.6 | 1.1 | .7 |
| **FEMALES.** | | | | | | | | | |
| Dressmakers and milliners | 1,750 | 1.9 | 1.5 | 3.4 | 2.7 | 3.3 | 9.4 | ........ | ........ |
| Domestic servants | 3,500 | 2.1 | 3.3 | 5.4 | 6.8 | 8.8 | 21.1 | ........ | ........ |
| All males 21 years and over | ........ | 1.9 | 3.3 | 5.2 | 5.6 | 8.0 | 18.8 | ........ | ........ |
| All females 21 years and over | ........ | 1.7 | 2.7 | 4.4 | 5.1 | 8.3 | 17.8 | ........ | ........ |

This table is of additional interest in that it includes a number of other important occupations with more or less exposure to industrial dust. The table shows that stonecutters and masons rank above all other employments considered, with a death rate of 5.7 per 1,000 from phthisis, which is three times as high as the average of 1.9 for males above 21 years of age. Making allowance for persons not directly employed in the cutting and hewing of granite, it is quite probable that the true phthisis death rate of this class is 6.2 per 1,000. Next to stone workers, according to the table, come printers and lithographers, with a phthisis mortality of 4.5 per 1,000, which is slightly less than two and one-half times the average. In further explanation of the table it is said that—

As a rule, occupations with a high mortality from phthisis have also an increased mortality from other lung diseases. This is not the case with stonecutters and masons in Aberdeen, or with printers and lithographers, or with clerks. In all three occupations, the mortality from other lung diseases is under the average. Tailors and comb makers, however, follow the usual rule, having a somewhat high mortality from other lung diseases. The result is that, if the rates for phthisis and other lung diseases are combined, tailors and comb makers, with 8.8 and 8.6 per 1,000, respectively, take precedence of stonecutters and printers, with 8.2 and 5.6, respectively. For clerks it is 5.3. Indeed, the total death rate from lung diseases (including phthisis) among clerks and printers is only very slightly beyond the average (5.2) for all male persons above 21 years of age. Some of these differences in the incidence of phthisis and of other lung diseases are probably in some measure more apparent than real, being dependent upon the fact that the death rate from phthisis decreases after the age of 55 to 60, while the death rate from other lung diseases rapidly increases with advancing age. Occupations with a large proportion of old men have accordingly a lower death rate from phthisis and a higher death rate from other lung diseases than occupations with a smaller proportion of old men.

Attention is directed to the exceptionally large number of deaths from phthisis among stonecutters after the age of 55, which is a relatively rare occurrence in other occupations. The rather involved terminology of English occupational terms precludes an accurate comparison with corresponding statistics for this country. Two occupations which show high death rates from phthisis in the Aberdeen experience, namely, stonecutting and comb making, are both referred to as dusty occupations, and there are grounds for believing, not only from available statistics but from results of similar investigations elsewhere, that the dust was the slow but ultimate cause of death in many cases.

#### PHTHISIS, AND PNEUMATIC TOOLS.

The subject of stonecutters' mortality in relation to the use of pneumatic tools is considered briefly by Hay, who points out that—

In regard to the mortality from phthisis among stonecutters and masons, the question has been raised as to whether the introduction of pneumatically driven tools, which produce more fine dust than the old hand chisels, has increased the amount of phthisis and lung disease. I am informed that previous to 1900 very few pneumatic tools were in use in Aberdeen. Between 1900 and 1905, and especially after 1902, their use rapidly extended, so that by 1905 they had come into full use in practically all stonecutting yards.

The following table gives the number of deaths among stonecutters and masons combined for each of the 15 years ending with 1909. The first five years, 1895–1899, represent a period in which pneumatic tools were coming into use; and the third five years, 1905–1909, a period in which the tools were in full use. Only deaths at ages of 21 years and upward are included.

TABLE 77.—NUMBER OF DEATHS FROM PHTHISIS AND FROM OTHER LUNG DISEASES AMONG STONECUTTERS AND MASONS OF ABERDEEN, 1895 TO 1909.

| Year and period. | Cause of death. | | Year and period. | Cause of death. | |
|---|---|---|---|---|---|
| | Phthisis. | Other lung diseases. | | Phthisis. | Other lung diseases. |
| First period: | | | Second period—concluded. | | |
| 1895 | 6 | 5 | 1904 | 9 | 8 |
| 1896 | 9 | 1 | Total | 50 | 31 |
| 1897 | 12 | 5 | Third period: | | |
| 1898 | 7 | 9 | 1905 | 11 | 2 |
| 1899 | 13 | 8 | 1906 | 10 | 3 |
| Total | 47 | 28 | 1907 | 9 | 3 |
| Second period: | | | 1908 | 11 | 1 |
| 1900 | 10 | 6 | 1909 | 8 | 3 |
| 1901 | 6 | 10 | Total | 49 | 12 |
| 1902 | 13 | 5 | | | |
| 1903 | 12 | 2 | | | |

The numbers for 1900–1904 are slightly above those for 1895–1899 in respect both of phthisis and of other lung diseases. The total number for 1905–1909 is, however, considerably down; but the fall is practically confined to deaths from lung diseases other than phthisis.

The first two periods are fairly comparable, except that allowance should be made for an increase of, perhaps, 10 per cent in the number of persons employed as between the first and second periods, and for the fact that during the two periods the mortality from phthisis in the community as a whole was falling. As probably the effect of the latter influence did rather more than equalize the effect of the former, a comparison of the first two periods would appear to show that the introduction of pneumatic tools had produced some increase, although not a large increase, in the death rate from phthisis and other lung diseases.

As regards the third period (1905–1909), while the number of stonecutters and masons employed in monumental yards has not fallen off, but rather increased, there has been a great decline in the number of building masons in employment, due to unusual depression in the building trade. Some of these out of employment as mason hewers have, I believe, found employment as stonecutters in monumental yards, and thus checked in some measure the advancement of apprentices to the status of journeyman. Some have emigrated to America. Some have drifted into laboring, but not improbably in the event of death within two or three years of leaving their trade, their deaths have been registered by their relatives as the deaths of masons. It is difficult to know to what extent to make allowance for these disturbing factors. Probably, any reasonable allowance would not raise the total number of deaths from phthisis and other lung diseases combined above or even up to the number for each of the preceding two quinquennial periods, but it would raise the number of deaths from phthisis above the numbers for these periods.

After a brief discussion of possible errors attributable to the erroneous use of apparently equivalent occupational terms, it is said with further reference to the use of pneumatic tools, that—

About the time of the introduction of pneumatic tools for granite cutting, but not altogether as a consequence of it, the sheds, which had usually been entirely open along the front, as in the case of an ordinary builder's shed, began to be closed. The closure, while increasing the liability to the inhalation of dust, must at the same time have afforded some protection against cold and possible chills. This may possibly account in part for the diminution during the past five years in the number of lung diseases other than phthisis. But the numbers dealt with are small, and allowance must be made for mere chance variations.

### COMPARATIVE FREQUENCY OF LUNG DISEASES IN ABERDEEN AND IN EDINBURGH.

In view of the foregoing, the final conclusion is advanced that " the unusual combination, in the case of workers in stone, of a high mortality from phthisis, with a low mortality from lung diseases other than phthisis, may serve to bear out the statement made by the late Prof. Hamilton, professor of pathology in Aberdeen, that a definite development of so-called lithosis, or a fibroid affection of the lungs due to stone dust, is rare among granite workers, although common among firestone workers in Edinburgh." In part, this conclusion would seem to be sustained by the examination of a relatively small number of autopsy records. The strictly medical question, therefore, whether the form of tuberculosis met with among the granite workers of Aberdeen was to be considered industrial fibrosis with a superinduced tuberculosis, or strictly pulmonary tuberculosis in the more limited sense of the term, can not be considered finally decided by the information at present available. The investigation reemphasizes earlier conclusions regarding the importance of minute attention to the character of the dust inhaled in the different branches of the stone industry; certain forms of stone dust are obviously much more injurious than others, and a general grouping of stone workers for purposes of mortality analysis is therefore quite likely to yield inconclusive results.

## PHYSIQUE OF STONE WORKERS.

Not only is it necessary to take into acoount the kind and nature of the dust inhaled, particularly whether of granite trap rock, sandstone, or limestone, but the different employments also require special consideration. Some occupations are unquestionably very much more exposed than others. Additional attention is necessary as regards the conditions of employment, whether outdoors or indoors, and finally, there is the important relation of physique to disease resistance. Table 78 shows the average chest expansion of males in certain occupations, including the Aberdeen granite trade, and has been derived from the discussion on industrial pneumoconiosis, by E. L. Collis, London, 1915, in the Milroy Lectures.

TABLE 78.—AVERAGE CHEST EXPANSION IN INCHES OF MALES IN CERTAIN CLASSES, AT VARIOUS AGE PERIODS.

| Age period. | Leisured class. | Factory operatives not exposed to dust. | Aberdeen granite trade. | | | Sheffield cutlery trade. | | | Strippers of cotton carding machines. |
|---|---|---|---|---|---|---|---|---|---|
| | | | Polishers, etc., very slightly exposed to dust. | Cutters in open sheds. | Cutters in closed sheds. | Cutters. | Light grinders. | Heavy grinders. | |
| 14 | 2.31 | ........ | 2.58 | 2.14 | 2.40 | 2.43 | 2.54 | 2.67 | 3.33 |
| 17 | 2.45 | ........ | 2.57 | 2.64 | 2.60 | 2.27 | 2.37 | 2.49 | |
| 20 | 2.79 | 2.84 | 2.58 | 2.43 | 2.44 | 2.24 | 2.45 | 2.19 | 2.75 |
| 25 | 2.90 | 2.33 | 2.21 | 2.51 | 2.11 | 1.96 | 2.40 | 2.19 | 2.45 |
| 30 | 2.87 | 2.13 | 2.14 | 2.19 | 1.93 | 2.09 | 2.14 | 2.04 | |
| 35 | 2.64 | 2.20 | 2.04 | 2.13 | 1.80 | 1.92 | 2.07 | 1.89 | 1.86 |
| 40 | 2.35 | 2.15 | 2.07 | 2.16 | 1.67 | 1.73 | 1.75 | 1.52 | |
| 45 | 2.39 | 2.24 | 1.98 | 1.92 | 1.84 | 1.56 | 1.58 | 1.55 | 1.69 |
| 50 | 2.24 | 1.64 | 2.04 | 1.73 | 1.44 | 1.49 | 1.58 | 1.51 | |
| 55 | 2.12 | ........ | 1.80 | ........ | 1.56 | 1.50 | 1.53 | 1.45 | 1.72 |
| 65 and over | 1.87 | ........ | ........ | ........ | ........ | 1.13 | ........ | ........ | |

In connection with the table Dr. Collis points out that—

Inhalation of silica dust takes several years, varying with the intensity of the exposure, in producing any obvious effect, but gradually the affected person notices that on exertion his breathing capacity has become limited, and that a cough, slight at first, has become persistent, though seldom accompanied by much expectoration; otherwise he may look robust and feel well. This limitation in the breathing capacity which has been noted by nearly every authority from Hippocrates to the South African Miners' Phthisis Commission of 1912 has been described as pathognomic of the disease and may at first be the only objective sign present. In several inquiries in which some thousands of operatives have been examined, I have collected physical data which demonstrate this limitation, and the results are stated in the table; but as Dr. Cumpston points out, "the actual amount of expansion in inches is not of so much importance as the manner in which the chest wall behaves when an attempt at expansion is made." This diminution in chest expansion must, however, not be relied on as an indication of exposure to silica dust, as it is present, though not so markedly, among workers exposed to other dusts.

In further explanation, it is said that should the condition progress until the age of 45 to 50 years, a definite clinical picture is presented, briefly described as follows:

Such a man is usually somewhat below the average height for his class, for exposure to dust inhalation during the growing period of life appears to inhibit the normal growth; he looks well, but if he has just ascended stairs or has hurried, he is out of breath for a few minutes; and on being questioned, though unable to count 20 without taking a breath, he speaks of himself as fit, and may even boast of being a credit to his trade; but he owns to frequent colds, especially in winter, and a troublesome cough; he expectorates but little sputum, and what there is is rejected with difficulty and is colored by the dust produced in his work; in some industries, particularly in tin mining and gold mining, he is stated to be subject to distinctive attacks of dyspnœa, but this symptom is not prevalent among metal grinders or granite cutters. When he is stripped he is found to be well nourished, but respiration is seen to be carried on nearly entirely by diaphragmatic action, and even though urged he seems incapable of inducing his intercostal muscles to lift his ribs.

## PRACTICAL VALUE OF PHYSICAL EXAMINATIONS.

These observations, arrived at after an exceedingly careful and conservative study of the subject, emphasize strongly the great practical value of physical examinations, and reexaminations at least once a year. The necessity for such an examination, including a radiological photograph of the chest, becomes of supreme importance in the case of men exposed to the risk of silica or quartz dust inhalation, particularly in confined spaces, such as stopes of deep mines, etc., for, as previously intimated, the general appearance and general indications of health and strength may be very deceptive, since the progress of the disease is often extremely chronic, lasting in some cases, according to Wheatley, "upwards of 20 years." Knowledge of the exact occupation followed is, therefore, of equal importance and general conclusions, based upon groups of men in different specific employments, though following the same trade, can not be relied on as trustworthy. According to Collis—

Silica dust is generated in the following among other industries: Gold mining, tin mining, and lead mining; quarrying and dressing sandstone and granite; flint knapping, making honing stones for scythes; building millstones, which are used and require dressing in such diverse industries as the milling of flour, rice, cocoa, cement (occasionally), and white lead; the manufacture of grindstones, which are used and require racing, trueing, and surfacing in the grinding of metal articles, mother-of-pearl, bone, horn, and other materials; sand blasting to clean castings and to etch glass; crushing flints and quartz to make silica flour used in the manufacture of pottery, certain abrasive soaps, sandpapers, chicken food, disinfecting powders, and silica paints; the mining and quarrying of ganister and silica stone; and the manufacture of silica bricks.

### DESCRIPTIVE ACCOUNT OF SILICA OR QUARTZ.

Pure silica, or the oxide of silicon, is the substance commonly known as quartz, which is one of the most abundant of mineral substances. According to Frank J. Katz, in a report on "The Production of Silica in 1913," to the United States Geological Survey—

> Its occurrences of commercial importance are in a great many different forms, such as vein quartz; as a constituent of pegmatites; as sand, sandstone, quartzite, or flint; as tripoli; and as diatomaceous (infusorial) earth. In some forms, such as rose, smoky, and amethystine quartz, it has a gem value. This chapter deals with silica from all sources exclusive of gem quartz, of all forms of silica used for making glass, and also of all silica used in the form of sand, gravel, and crushed material for building, for concrete and mortar, for foundry and furnace work, and for cutting and grinding stone.

As regards the principal uses of silica, it may be said, in the words of the same authority, that silica is employed in the manufacture of pottery, paints, scouring soaps, as a wood filler, and as a polisher. In pottery the use of silica, generally called flint in the pottery industry, diminishes the shrinkage in the body of the ware; it is also used in many glazes. Silica for use in pottery should contain less than 0.5 per cent of iron-bearing minerals. Considerable quantities of very finely ground silica are used in the manufacture of paint. In all of these processes it is self-evident that exposure to the inhalation of silica or quartz dust must directly or indirectly result in serious disease complications. The exact proportion of pure silica in the dust inhaled should be ascertained in all cases where an effort is made to establish with accuracy the health-injurious conditions of an occupation with exposure to mineral dust.

### SUGGESTIONS FOR PROTECTIVE PRECAUTIONS.

It is regrettable that no very extensive investigations should have been made into the health-injurious conditions of the more important branches of the American stone industry. Hanson, in his report on "Methods of Protection from Dusts and Fumes," illustrates the process of stonecutting and observes that—

> The strong blast of air keeps the granite clean, but gives rise to a great amount of dust. The surfacing tool is either a large hammer or an instrument which presents four smaller separate faces. Sometimes a bushing hammer made of thin, chisel-like blades bolted together is used; this creates the finest dust of all. The men who operate the surfacing tools rarely wear masks. Some protect themselves from flying chips by means of wire screens placed about the hammer, some wear wire masks, and some wear glasses.

This is an admirable description of modern processes which, on account of the extensive use of pneumatic tools, have become extremely injurious in numerous individual cases. Only superficial precautions, as a rule, are adopted. The regulations of the Barre branch of the Granite Manufacturers' Association, for illustration, provide:

Article 6. Cutters must provide themselves with broom, and no air power to be used to remove dust.

Article 7. Turning down grindstones to be done outside of working hours, unless said stones are thoroughly boxed in. This agreement is made for the purpose of eliminating the dust from grindstones.

Article 8. No surface-cutting machine to be worked in cutting shed during working hours, unless properly equipped with effective air suction or other device to remove dust. Hand surfacers shall not weigh more than 12 pounds. Workmen to be amply protected at all times from dust from said machines, whether in the sheds or outside. This article not to apply to pneumatic tools weighing less than 7 pounds.

As a matter of fact, however, there is only inadequate protection from dust at most of the machines and in most of the sheds which have been investigated and reported upon, including the Barre district of Vermont.

## INJURIOUS OCCUPATIONAL CONDITIONS.

The occupation is also briefly referred to in a recent discussion by Baker,[1] in part as follows:

Much of the stonecutting is outdoors or in large, airy sheds. It consists of shaping, smoothing, and cutting the stones into smaller pieces, as for paving blocks. Formerly much of the work was done by hand, but now pneumatic tools are used considerably. These produce a finer dust and tend to increase the hazard. It is held by some that the dangers are greater in sedimentary stones than the harder stones, like granite, but no definite figures on this point could be obtained. Dust is also stirred up in sweeping and moving the stones about. Thirty-seven stonecutters were medically and physically examined, and of this number 12 patients showed respiratory disease, 9 being ill with chronic and 3 with acute diseases. Three workers had pulmonary tuberculosis, three emphysema, and one each chronic bronchitis, chronic pharyngitis, chalicosis, acute bronchitis, acute pharyngitis, and acute laryngitis. Although only one case of chalicosis is recorded, a greater number would probably have been noted if other factors were studied as closely as physical signs.

In view of the fact that 21 of the stonecutters were over 40 years of age, the number ascertained to be affected with pulmonary tuberculosis is relatively small, but the number affected with respiratory diseases more or less predisposing to a terminal tuberculosis must be considered very large. There is no information as to the kind of

[1] Journal American Medical Association, May 6, 1916.

dust inhaled or the nature of the stone cut. The sanitary conditions of the shed were obviously far from what they should have been.

### URGENCY OF DRASTIC REGULATIONS.

The importance and necessity of drastic regulations in stonecutting, polishing, etc., have not been recognized in the factory legislation of this country. In the Edinburgh and Aberdeen districts of Scotland the local inspectors, according to the annual report of the chief inspector of factories and workshops for 1910—

have been pressing upon the granite cutters the question of local exhaust. The pneumatic tools which are now universally used have largely increased the amount of fine dust breathed by the workers. Mr. Buchan says some idea of the action of granite dust can be gathered from the fact that the glasses of the workers' goggles become so dim by the constant impact of the fine particles of granite that monthly renewal is essential. Mr. Kirkwood says experiment has led to the successful removal of dust at the point of the tool by the induced draft, but he fears that the extra fitting with a pipe attached on the side of the tool may cause difficulties in the manipulation at fine work. One occupier has, however, undertaken to give the arrangement a fair trial, and the workers seem anxious that something should be done.

### PRACTICAL POSSIBILITIES OF DUST PREVENTION.

There are abundant reasons for believing that much more could be done to control the dust menace in the stonecutting industry than is at present being done in practically all American stonecutting districts. W. Gilman Thompson refers to the statistics of the Quincy, Mass., district for the year 1907, according to which 41 per cent of the deaths of stonecutters were from pulmonary tuberculosis, and including all forms of pulmonary disease the proportion was 53 per cent. According to the same investigation, the tuberculosis mortality among stone and marble cutters and carvers was found to be five times greater than among farmers or lumbermen. The usual processes are explained and admirably illustrated in the work of W. Gilman Thompson, who observes, in part, as follows:

The drilling of rocks and coal or mineral veins for blasting is almost universally accomplished by machine drill hammers, operated by compressed air or steam, which have replaced the slow method with the crowbar and hand-wielded sledge hammer. When this process is conducted by machines in mines, tunnel boring, or any kind of hard dry stone without the use of a water spray to moisten the dust, it is one of the most dangerous of all the trades which produce chronic disease. When the drilling is done overhead, so that the dust falls back toward the face of the machine operator, the hazard is at its worst.

These observations apply in a large measure to rock drilling in mines, tunnels, etc. In coal mining where the overlying strata are usually of limestone, the dust menace is, of course, much less than in deep mining where the quartz rock consists frequently of almost pure silica. According to W. Gilman Thompson—

> To lessen the dust hazard from the drill holes various expedients have been devised. The simplest of these is the placing of wet cloths around the drill hole to catch the dust and mopping up the dust, procedures which are troublesome and time consuming. A recent invention consists of a pipe attached to the drill at the mouth of the bore through which a fine jet of water is forced under pressure into the drill hole, where it unites with the compression air stream in mixing the dust into a harmless paste which flows back out of the hole. Another invention by Korfmann employs an exhaust pipe connected with the drill, by means of which the dust is drawn out of the hole, after the manner of a vacuum cleaner, and discharged into a vessel of water or a moist bag. These inventions have the advantage that they operate independently of the workmen and do not require precautions, which such workmen are notoriously reluctant to observe.

Actual experience has unfortunately shown many of these devices to be rather impracticable in that they cause too much interference with the work and consequently bring about a diminution in earnings. The use of dust-spraying devices, etc., as well as respirators in connection with exceptionally dusty processes where the dust consists largely of pure silica, should be made obligatory upon the employees as well as upon employers.

Although not directly pertinent to the present discussion, the following interesting reference to a case of Raynaud's disease[1] in a stonecutter using pneumatic tools has been reported by Dr. Charles H. Cargile, of Bentonville, Ark.:

> D. E. F., aged 26, married, with good family and personal history, except that he was neurotic, found that frequently and only when cutting stone with a pneumatic tool the index and middle fingers of his right hand would become white, cold, and numb. This instrument, which oscillates from 900 to 1,600 times per minute, transmits strong vibrations to the hand of the operator. The patient told me of a fellow laborer who was similarly affected by using the same kind of tool.

Whether there is a well-defined occupational relation between stone cutting and the occurrence of Raynaud's disease has not been sufficiently investigated to justify definite conclusions at the present time.

[1] Raynaud's disease is defined by Gould and Pyle as: "A vascular disorder characterized by three grades of intensity: (*a*) *Local syncope,* observed most frequently in the extremities, and producing the condition known as dead fingers or dead toes; it is analogous to that produced by intense cold. (*b*) *Local asphyxia,* which usually follows local syncope, but may develop independently. Chilblains are the mildest manifestation of this condition. The fingers and toes and the ears are the parts usually affected. In the most extreme degree the parts are swollen, stiff and livid, and the capillary circulation is almost stagnant. (*c*) *Local symmetric gangrene,* the mildest form of which follows local asphyxia."

## MORTALITY OF MARBLE AND STONE CUTTERS—UNITED STATES REGISTRATION AREA.

Most of the preceding observations have been derived from foreign sources. The census statistics for 1900 can hardly be considered applicable to present conditions, nor are they conclusive regarding the different branches of the stone industry and the more specific occupations followed.

The mortality of marble and stone cutters has 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 limited to the two years referred to. According to the census report, out of 1,657 deaths of marble and stone cutters from all causes, 509, or 30.7 per cent, were from pulmonary tuberculosis. The details of the mortality by divisional periods of life are shown in Table 79.

TABLE 79.—PROPORTIONATE MORTALITY OF MARBLE AND STONE CUTTERS FROM PULMONARY TUBERCULOSIS, UNITED STATES REGISTRATION AREA, 1908 AND 1909.

| Age at death. | Deaths from all causes. | Deaths from pulmonary tuberculosis. | |
|---|---|---|---|
| | | Number. | Per cent of deaths from all causes. |
| 15 to 24 years | 61 | 16 | 26.2 |
| 25 to 34 years | 170 | 74 | 43.5 |
| 35 to 44 years | 299 | 132 | 44.1 |
| 45 to 54 years | 401 | 167 | 41.6 |
| 55 to 64 years | 407 | 95 | 23.3 |
| 65 years and over | 316 | 25 | 7.9 |
| Age unknown | 3 | | |
| Total, 15 years and over | 1,657 | 509 | 30.7 |

TABLE 80.—PROPORTIONATE MORTALITY OF MARBLE AND STONE CUTTERS FROM NONTUBERCULOUS RESPIRATORY DISEASES, UNITED STATES REGISTRATION AREA, 1908 AND 1909.

| Cause of death. | Number of deaths. | Per cent of deaths from all causes. |
|---|---|---|
| Asthma | 9 | 0.5 |
| Bronchitis | 29 | 1.8 |
| Pneumonia | 131 | 7.9 |
| Other nontuberculous respiratory diseases | 33 | 2.0 |
| Total | 202 | 12.2 |

## TUBERCULOUS AND NONTUBERCULOUS LUNG DISEASES.

Tables 79 and 80 are of exceptional interest and value in that they may be considered representative for the American stone industry at the present time. There are no reasons for believing that material changes have occurred in the mortality during recent years. The data conclusively indicate an excessive proportionate mortality from pulmonary tuberculosis among marble and stone cutters at every divisional period of life. Commencing with ages 15 to 24 the proportion of deaths, 26.2 per cent, is not exceptionally high in comparison with other trades or occupations with continuous and considerable exposure to metallic or mineral dust. Among plasterers, for illustration, the corresponding proportion, according to data derived from the same official American sources, was 25 per cent, and for potters, 46.2 per cent, and for glassworkers, 47.2 per cent. At ages 25 to 34, however, the proportionate mortality from pulmonary tuberculosis among marble and stone cutters was 43.5 per cent, which compares with 31.5 per cent for plasterers, 44.4 per cent for potters, and 42.6 per cent for glassworkers. The proportion continues high throughout the remainder of life; for illustration, at ages 65 and over, among marble and stone cutters, 7.9 per cent are from pulmonary tuberculosis, compared with 3.8 per cent for potters, 4 per cent for glassworkers, and 3.6 per cent for plasterers. Aside from an excessive mortality from pulmonary tuberculosis the mortality from nontuberculous respiratory diseases among marble and stone cutters is extremely high, or 12.2 per cent for respiratory diseases considered as a group, or, respectively, 0.5 per cent for asthma, 1.8 per cent for bronchitis, 7.9 per cent for pneumonia, and 2.0 per cent for other respiratory diseases.

### COMPARATIVE MORTALITY FROM NONTUBERCULOUS RESPIRATORY DISEASE—UNITED STATES REGISTRATION AREA.

On account of the exceptional importance of nontuberculous respiratory diseases among certain groups of occupations with continuous and considerable exposure to mineral dust the following comparison is included in the present discussion:

TABLE 81.—COMPARATIVE PROPORTIONATE MORTALITY FROM NONTUBERCULOUS RESPIRATORY DISEASES IN SPECIFIED OCCUPATIONS EXPOSED TO MINERAL DUST, UNITED STATES REGISTRATION AREA, 1908 AND 1909.

| Cause of death. | Per cent of deaths due to each specific cause among— | | | |
|---|---|---|---|---|
| | Marble and stone cutters. | Potters. | Glassworkers. | Plasterers. |
| Asthma | 0.5 | 0.7 | 0.2 | 0.3 |
| Bronchitis | 1.8 | .7 | .6 | 1.1 |
| Pneumonia | 7.9 | 6.7 | 7.7 | 8.1 |
| Other nontuberculous respiratory diseases | 2.0 | 4.4 | .7 | 1.1 |
| Total | 12.2 | 12.5 | 9.2 | 10.6 |
| All other causes | 87.8 | 87.5 | 90.8 | 89.4 |
| Total, all causes | 100.0 | 100.0 | 100.0 | 100.0 |

Table 81 brings out the interesting fact that the proportionate mortality from bronchitis is particularly excessive among marble and stone cutters in comparison with other occupations with exposure to mineral dust, and with the exception of potters the conclusion applies equally to asthma and other respiratory diseases, excepting pneumonia. The data are not sufficient for final conclusions, but they suggest the practical value of thoroughly specialized investigations into the occurrence of nontuberculous respiratory diseases among marble and stone workers, particularly asthma and bronchitis. The data are derived from official American vital statistics and are quite generally confirmed by corresponding statistics derived from insurance experience or foreign sources.

## MORTALITY OF JOURNEYMEN STONECUTTERS—MEDICO-ACTUARIAL EXPERIENCE.

In the medico-actuarial investigation journeymen stonecutters were fortunately considered separately, and the results, based upon a fairly extensive experience, indicate a truly lamentable condition. In the interpretation of Table 82 it should be taken into consideration that only the better class of stonecutters would be accepted for ordinary life insurance, since in former years at least quite generally the practice was to decline stone workers entirely.

TABLE 82.—MORTALITY FROM ALL CAUSES AMONG JOURNEYMEN STONECUTTERS, BY AGE GROUPS—MEDICO-ACTUARIAL INVESTIGATION.

| Age at death. | Number exposed to risk 1 year. | Actual deaths. | Expected deaths. | Per cent actual are of expected deaths. |
|---|---|---|---|---|
| 15 to 29 years | 2,579 | 17 | 11.96 | 142 |
| 30 to 39 years | 2,289 | 32 | 13.44 | 238 |
| 40 to 49 years | 681 | 22 | 6.75 | 326 |
| 50 to 59 years | 138 | 5 | 3.20 | 156 |
| 60 years and over | 3 | ............ | .10 | ............ |
| Total, 15 years and over | 5,690 | 76 | 35.45 | 214 |

According to this table the actual mortality of journeymen stonecutters in the combined experience of American life insurance companies is 214 per cent of the expected, increasing rapidly with age to a maximum of 326 per cent at ages 40 to 49. The table, of course, includes all causes, and does not refer to pulmonary tuberculosis, but, as subsequently to be shown, the excess in the mortality is chiefly attributable to this disease. Out of 76 deaths at all ages of journeymen stonecutters not a single death occurred at ages 60 and over. This, of course, in part may possibly be the result of the limited extent of the experience under consideration.

## MORTALITY OF MARBLE AND STONE WORKERS—INDUSTRIAL INSURANCE EXPERIENCE.

According to Table 83, the industrial mortality experience of the Prudential Co. with reference to marble and stone workers for the period 1897 to 1914 includes 2,052 deaths from all causes, of which 690, or 33.6 per cent, are from pulmonary tuberculosis.

TABLE 83.—PROPORTIONATE MORTALITY FROM PULMONARY TUBERCULOSIS AMONG MARBLE AND STONE WORKERS, 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 marble and stone workers, 1897 to 1914, from— | | Per cent of deaths from pulmonary tuberculosis among— | |
|---|---|---|---|---|
| | All causes. | Pulmonary tuberculosis. | Marble and stone workers. | Males in registration area, 1900 to 1913. |
| 15 to 24 years | 60 | 23 | 38.3 | 27.0 |
| 25 to 34 years | 228 | 121 | 53.1 | 30.5 |
| 35 to 44 years | 403 | 179 | 44.4 | 23.4 |
| 45 to 54 years | 513 | 200 | 39.0 | 14.7 |
| 55 to 64 years | 506 | 135 | 26.7 | 7.9 |
| 65 years and over | 342 | 32 | 9.4 | 2.6 |
| Total, 15 years and over | 2,052 | 690 | 33.6 | 13.9 |

The proportionate mortality from pulmonary tuberculosis is extremely high at all ages, but particularly so at ages 25 to 34, at which out of the mortality from all causes 53.1 per cent was from pulmonary tuberculosis, against 30.5 per cent among males in the registration area. If it had been possible to separate this experience according to the different branches of the stone industry and the more important occupations with dust exposure, there are the most convincing reasons for believing that the results of this analysis would have been decidedly more suggestive of the seriously health-injurious consequences of exposure to silica or quartz dust.

## GENERAL CONCLUSIONS.

Inconclusive as these observations are with reference to the several branches of the stone industry and the more important specific occupations with dust exposure, the data are fully sufficient, for the present purpose, to emphasize the extremely dangerous nature of dust exposure in connection with practically all processes of stone quarrying, cutting, polishing, etc. This conclusion applies also and perhaps even more specifically to men employed in connection with stone-crushing operations, which during recent years have assumed very considerable proportions throughout the country. In practically all of these rock-crushing processes no protective devices whatsoever are employed. Most of the men, it is true, work often only for a portion of the year, and much of the labor is of an itinerant nature, so that the serious damage done to the lungs must frequently escape observation. On account of the extreme hardness of trap rock, virtually the equivalent of flint, it is a practical certainty that dust exposure in trap-rock crushing is very serious. The entire stone industry must be more thoroughly investigated for the purpose of ascertaining the most health-injurious processes as well as such branches as include work on limestone and similar mineral substances apparently much less injurious than the so-called gritstone or granites, etc. In view, however, of the universal use of pneumatic tools in the stonecutting industry this aspect demands particular consideration for the ascertainment of the required methods and means by which the dust menace may be reduced to a minimum.[1]

The most recent medical observations on the mortality of stonecutters and marble workers are by Kober and Hanson in their treatise on Diseases of Occupation and Vocational Hygiene, where it is said, in part, that—

We know now that the inhalation of mineral dust develops sooner or later pneumoconiosis which may eventuate in pulmonary tuberculosis. It is generally held that the liability to diseases of the respiratory passages is less in the case of paving stonecutters and slate splitters, and in the sawing, grinding, polishing, and lathe work which can be conducted by the wet process, than in the case of monument or custom work, and particularly in the surfacing, carving, and cutting with pneumatic tools. The greatest amount of dust is evolved by the surfacing machines which are operated with compressed air. Of the various tools employed the bushing hammer creates the finest dust. Unfortunately, work with pneumatic tools can not be done by the wet process, as the pasty material created by a mixture of water and dust clogs up the tools. This work is usually done in large open sheds or in the yards, but even under such conditions the men are exposed to clouds of dust. The sawing of granite and marble into slabs, turning in lathes, and the final polishing can be conducted by the wet process; soapstone sawing and cutting for joints is frequently done dry and is attended with exposure to considerable dust.

Kober also refers to the fact that experience has shown that the mortality from pulmonary tuberculosis is generally excessive among workers in sandstone and relatively low among workers in limestone. No additional evidence, however, has been forthcoming in support of this point of view, which for practical reasons is one of considerable importance. The suggestions concerning the prevention of dust exposure in the stone industry as advanced by Kober are also quite

[1] A useful treatise on the subject of rock excavation, including observations on rocks and their properties, methods of hand and machine drilling, quarrying, open-cut excavating, tunneling, etc., is Rock Excavation, by H. P. Gillette, New York, 1907. Of more general value is a recent treatise on the Elements of Mining, by Geo. J. Young (New York, 1916), which includes observations in detail on rock breaking, but not with special reference to rock crushing for road-making purposes, which is the branch of the industry probably most injurious to health.

inadequate for the purpose of the effective sanitary control of an industry which is so obviously injurious to health and life and with regard to which the evidence of a decided predisposition to pulmonary tuberculosis is incontrovertible and conclusive.

## MARBLE WORKERS.

Marble workers constitute a distinctive and well-defined group of the stone industry, which it has seemed best to consider separately, though most of the general statistics appertaining to the occupation are included in the stone industry considered as a whole. The American marble industry is centered chiefly in Vermont, where about 60 per cent of all the marble produced in the United States is quarried, and most of it is cut and dressed, sawed, or polished, as the case may be, in the locality where quarried. The Vermont State board of health for some six years (1900 to 1905, inclusive) reported the mortality by occupations, and of the 42 deaths of marble workers from all causes reported in that State only 5 were from pulmonary tuberculosis and 5 from other respiratory diseases. The fact that Vermont is an otherwise exceptionally healthful State goes far to mitigate the intrinsic dangers of the occupation resulting from continuous exposure to the inhalation of stone dust.

Bertillon, in his observations on morbidity and mortality, refers to stonecutters and workers in marble in Switzerland as being subject to a considerable mortality, principally from phthisis, which rapidly increases with age. Under 20 years of age, according to this authority, the mortality is lower than among the mass of the population. From 20 to 29 the death rate equals the average, from 30 to 39 it is twice, from 40 to 49 it is thrice, and from 50 to 59 it is four times the average rate of the Swiss as a nation. He also refers to Italian statistics, which are significant on account of the remarkable development of the marble industry at Carrara, stating that stonecutters and pavers average fewer days of sickness than the whole population up to 45 years, but considerably more above that age. In Paris the workers in marble are subject to a high death rate at all ages.

A very instructive descriptive account of the machine process as generally employed in the marble industry was included in the report on the stone industry for 1908, by Mr. W. C. Day, of the United States Geological Survey, from which the following extract is made as emphasizing the more or less health-injurious circumstances of employment in marble manufacture:

After being sawed the slabs are placed on a "rubbing bed," which consists of a circular cast-iron plate, from 8 to 15 feet in diameter, the older forms having a circular opening from 1 foot to 18 inches in diameter in the center. The plate is planed to a smooth surface and is mounted upon running gear so that it may revolve in a horizontal plane. Fixed arms, usually four in number, are sustained radially about one-fourth of an inch above the plate, either by an upright passing through the central opening or by a framework overhead (in the case of the newer solid forms of bed). The slabs of stone to be polished are placed upon the bed in front of the arms, and the bed is revolved slowly beneath them in such a direction as to hold them firmly against the arms. An abrading material, such as sand, sometimes mixed with "chilled shot," or crushed steel, with a constant supply of water, is fed upon the plate. If necessary, the stones are weighted to increase the friction. From this rubbing bed the slabs are removed to the emery bed, which is similar to the former, fine emery being used for abrasion. They are then rubbed down by hand with a fine, evenly grained sandstone, commonly called a "Scotch hone," with a sufficient supply of water, and smoothed off with pumice stone and water. The final polish is put on by rubbing the slabs upon a buffing bed, similar in form to the rubbing bed, but covered with a thick, specially prepared felt, upon which a small amount of "putty powder" (oxide of tin) is fed, to give a high gloss. The hand process consists in grinding on the rubbing bed as before, and then rubbing down by hand successively with Nova Scotia "blue stone," "red stone," "Scotch hone," and pumice stone, after which it is glossed with putty powder, or, in case of cheaper "onyxes" and common marbles, with a mixture of two parts of oxalic acid and one part of tin oxide.

In marble-cutting, as in the stone industry generally, the introduction of pneumatic tools operated by compressed air has brought in a new and decidedly health-injurious factor, since the amount of very fine dust generated by this process is much greater than when the work is done entirely by hand with the ordinary chisel and mallet. Portable stone-dressing machines have been invented and quite widely adopted, since in part the quality of the work done by these machines is superior to handwork, while the productive capacity is claimed to be from eight to fifteen times as much as when the work is done entirely by hand. Exhaust air is employed to keep the stone clean at the point of impact of the cutting tool, but the clouds of dust raised by this apparatus are considerable, even though the work is usually done outside of the shed. Aside from the dust generated in either machine or hand cutting, a vast additional amount of dust is produced during cleaning-up operations, and while labor organizations have, in part, provided against this risk by special regulations, the generation of much dust is practically unavoidable under the existing methods by which the work is carried on.

The United States census mortality statistics combine marble and stone cutters, so that it is impossible to separately consider statistically the mortality of this employment. As has been previously pointed out in discussing stonecutters generally, the evidence is entirely conclusive that the mortality from pulmonary tuberculosis and other respiratory diseases among this class is decidedly excessive. It is observed in a discussion of the mortality in the manufacturing and mechanical industries in the Report on Vital Statistics of the Census of 1890 (Part I, p. 144) that "it will be seen * * * that among marble and stone cutters in the United States the greatest proportion of deaths was due to pulmonary tuberculosis, being much greater than the average proportion due to this cause in this class. The proportion of deaths * * * due to diseases of the respiratory system was [also] greater." The respective death rates per 1,000 living were 3.15 for pulmonary tuberculosis for marble and stone cutters, against an average of 2.11 among occupied males in manufacturing and mechanical industries generally, and 1.91 for other respiratory diseases for marble and stone cutters against an average of 1.54.

The more general aspects of marble dust in relation to health, and with special reference to pulmonary tuberculosis, are considered in the discussion of the several branches of the mineral industries. The available data are unfortunately far from conclusive, but in a general way it would seem that marble dust is distinctly more injurious to health than the dust of limestone and slate. The difficulty of arriving at definite conclusions is chiefly due to the defective and even misleading character of the occupation mortality returns in which marble cutters and polishers are combined with other stone workers, and even quarrymen. All of the available statistics, however, emphasize the lamentable fact that the proportionate mortality from pulmonary tuberculosis is exceedingly high among marble cutters and polishers, and there can be no question as regards an increased liability to the disease in consequence of the almost universal use of pneumatic tools for marble and stone cutting purposes.

No final conclusions, however, can be arrived at until the entire subject of stone workers' mortality has been subjected to a thoroughly critical and qualified analysis with a due regard to the chemical and mechanical properties and especially the degree of fineness of the different varieties of stone dust and their relation to tuberculosis and nontuberculous lung diseases.

## SLATE WORKERS.

The slate industry is of practical importance in only two States—Pennsylvania and Vermont. Of the aggregate value of the product sold in 1915, $4,958,000, these States are credited with $4,200,000, or 84.7 per cent of the total. The reduction in output during the last few years is attributed to the increasing use of artificial roofing materials as well as to the larger proportion of new buildings with flat roofs. The industry, with observations on the chemical and microscopical analyses of slates and methods of production, has been reported upon in considerable detail by T. Nelson Dale and others of the United States Geological Survey.[1]

## HYGIENE OF THE SLATE INDUSTRY.

The hygienic aspects of the slate industry have been briefly described by Arlidge, with special reference, of course, to English conditions, which, however, do not very materially differ from those common to the centers of slate production in this country. According to Arlidge, " The dust examined microscopically appears made up of irregular but sharply angular particles, often serrated," but he quotes Dr. Roberts to the effect that " It is wonderful how little the quarrymen complain of any irritation or direct inconvenience from inhaling the dust. They soon become accustomed to their condition in life, and the only two discomforts which they generally seem to suffer are lassitude and thirst," and these appear to be due to fatigue rather than to any other cause. In the actual processes of slate sawing and dressing, Arlidge states that, this being done in closed shops, the workmen employed can not escape breathing the copious dust given off. In this country, however, much if not most of the slate splitting is done outdoors so that the dust hazard is materially reduced. Arlidge quotes Roberts in a statement that, taking all the circumstances into consideration, slate workers are subjected to conditions highly calculated to produce respiratory diseases.

## MORTALITY OF SLATE-PENCIL MAKERS.

The most thoroughly scientific study of the sanitary aspects of the industry in Germany has been made by Sommerfeld, chiefly, however, with reference to the manufacture of slate pencils and school slates. The investigation emphasizes the unsatisfactory workshop conditions common to the industry and more or less subject to material improvements. When carried on indoors the work is considered decidedly injurious to health, particularly because of the unsatisfactory economic conditions of the laborers. Tuberculosis is of frequent occurrence, but in all probability the underlying causes are social and economic rather than directly attributable to the risk of slate-dust inhalation. Out of 260 deaths from all causes among slate-pencil makers in two typical communities, 167, or 64.2 per cent, were attributed to pulmonary tuberculosis and 25 to other diseases of the respiratory organs. At certain ages the disease attained extraordinary proportions, reaching 80 per cent of the mortality from all causes at 40 to 45. Comparing the proportionate mortality with certain other occupations in the same district, it is shown that among woodworkers 50.6 per cent died of pulmonary tuberculosis, and

[1] " Slate in the United States," by T. Nelson Dale and others, U. S. Geological Survey, Bulletin No. 586, Washington, 1914.

among all other occupations, excluding slate workers, the proportion was 45.9 per cent. The percentages for all occupations indicate that the general health of the district was exceptionally bad and that the predisposing causes of the high mortality from pulmonary tuberculosis were induced more by social and economic conditions than by the liability to slate-dust inhalation. The average age at death for slate-pencil makers was 45.7 years and for woodworkers 55.2 years. But the former industry, in all probability, employs a larger proportion of young persons. An analysis of a slate workers' sick fund experience, including, however, only 189 employees, shows that nearly one-third had commenced to work at the industry below the age of 14, and some had been at work from the seventh year of life. Under such conditions, irrespective of the dust danger, it would naturally be expected that the liability to pulmonary tuberculosis would be exceptionally high. Upon physical examination it was found that 34 per cent were of an inferior constitution and 34.4 per cent exhibited some degree of lung impairment. The results of this investigation can not be considered conclusive or applicable to the American slate industry, which is carried on under decidedly better social economic conditions. The investigation by Sommerfeld of this particular trade is, however, one of exceptional importance and suggestive of the methods to be followed in corresponding investigations in this country.[1]

### ENGLISH SANITARY INVESTIGATIONS.

The slate industry was quite carefully inquired into in 1907 by the English Departmental Committee on Industrial Diseases. Quite a number of witnesses with practical experience, both medical and otherwise, were examined, but the evidence obtained was far from conclusive. In the main, however, the experience seemed to prove that continuous and considerable inhalation of slate dust, according to the work followed, was distinctly injurious and a causative factor in the development of pulmonary tuberculosis. The evidence seemed to show in many cases a preceding fibrosis, often of long duration, suggestive of a considerable degree of similarity in the mechanical properties of slate and quartz dust. The opinion seemed to prevail that working in the quarries was distinctly less injurious than working in the mills, where, of course, the dust hazard would be much greater. It was made quite clear, however, that pure slate dust was rarely met with, but that as a rule the dust inhaled included a considerable proportion of minute particles of adherent quartz. An exceptionally interesting and valuable post-mortem report was pre-

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[1] Handbuch der Gewerbe-Krankheiten, by Theodor Sommerfeld, M. D., Berlin, 1898, p. 225 et seq.

sented by Dr. Robert Owen, who, quoting from his notes, stated as follows:

Report of the post-mortem R. R., 48 years, slate quarrier, working in a quarry for 25 years. Permission only was given to open and examine the chest. The body was that of a man over 6 feet, very emaciated, and looked 10 years older than his age. Frequent attacks of bronchitis during the last 20 years. Three years before he died he began to lose flesh and was short of breath. Bronchitis, followed by a good deal of expectoration, which was muco purulent; when his complaint was far advanced he was told that he was suffering from tubercular consumption, but when his sputum was examined, which was done repeatedly, no tubercle bacilli were present. Then the thought occurred to us that the patient was suffering from non-tubercular disease of the lung—that is, fibrosis. He became weaker; Bright's disease followed, and he soon died. That is the history of the case. On examination the right lung was adherent to the chest wall. The adhesions were so thick and firm that they had to be cut with a knife. The pleura was adherent. The lung did not collapse when removed from the body. The left lung was not adherent to the chest wall. In the right lung the pleura was very thick. The bronchi of both lungs were greatly thickened and surrounded by dense bands of fibrous tissue. Both lungs were diminished in size; they were hard and dense, almost like cartilage. Both lungs were somewhat of a buff color, but there was no distinct pigment observed. The bronchi contained much mucus and pus. On microscopical examination of the lung it was found to be a real specimen of fibrotic lung tissue. This is partly a report I had from Glasgow, where I sent a tissue to be examined. The walls of the air cells were thickened; also the walls of the minute arteries were in the same condition. The bronchial glands were enlarged (that is my own observation) and of a peculiar color. They were nothing like the glands you find in a coal miner. In this case no tubercular cavities were found; there was no breaking down of the lung. The second case is not so important, as tubercular disease supervened, but the general condition of the lung was the same. I made no microscopical examination in that case.

It would seem from this examination that the conditions observed were quite typical of fibroid phthisis, more or less directly related to slate dust; but in the case of a slate quarryman the physical condition of the lungs would, of course, be less seriously impaired than in the case of a mill worker exposed more continuously and more considerably to the fine dust inhaled. In the mill also the dust particles would be much more minute than in the quarry and the favorable outdoor conditions would be absent.

### SOCIAL AND SANITARY CONDITIONS IN THE AMERICAN SLATE INDUSTRY.

In the United States, particularly in the Bangor slate district of Pennsylvania, somewhat similar conditions have been observed. The economic condition of the slate workers in this country is, however, so much superior to that of slate workers abroad that this factor by itself unquestionably operates distinctly in the direction of a lower death rate from pulmonary tuberculosis. The hours of labor are reasonable, the wages are fairly high, the proportion of home owners is relatively large, and the moral conditions, particularly as regards temperance, are distinctly good Slate work is frequently a family trade and is, as a rule, commenced rather early in life. Boys are often employed on school-slate work, which by itself is one of the obviously unhealthy branches of the industry. The specific occupations are quite numerous, but most of the employed are returned as "slaters," millmen, hole men (quarry drillers), and quarrymen. Employments such as slate cutters and slate dressers are more generally covered by the term "slaters" or "millmen." Work at the quarries, which is all by the open or pit method, is considered dangerous, but not distinctly injurious, to health. The dust exposure is apparently not serious, but the ladder-climbing in and out of the quarry involves occasionally a heavy physical strain. Work at the channeling machines is also relatively free from dust, and no evidence is available to show that either quarrymen or those occupied in related occupations suffer above the average from pulmonary tuberculosis. After the slate has been quarried in good-sized blocks it is hoisted out of the pit to the banks where the shanties or huts of the "splitters" or "dressers" are located in large numbers. These are among the principal occupations in connection with slate dressing, and, while there is a reasonable amount of dust exposure, the fact that most of the work is done out of doors reduces the liability to dust inhalation considerably.

In connection with the work of the blocker, who performs the first operation which somewhat resembles the work of paving-stone cutting, the work is all done in the open air, and whatever dust is created by the process is rather heavy and falls readily to the ground before it has a chance to rise. The blocks are first wetted down by a swab or mop, which is essential for good cleavage, and which also tends to reduce the dust menace. The work is not considered seriously to predispose to pulmonary tuberculosis. The men observed in this and related occupations in the slate industry present a favorable, robust, and healthy appearance. From the block maker or bank men the block or slab of slate goes to the splitter, who usually sits on a cushion or wooden seat on the ground, his legs being covered with rugs or an old blanket to guard against injury to the slabs of slate and to protect himself from cold and dampness. This constrained position must in time have some effect upon health, particularly as regards circulatory and digestive disturbances. The dust at this stage of the operation is not very serious, except that on account of the splitter's peculiar position near to the ground it is more readily inhaled. The dust danger, although present in this employment, is not considered sufficient to produce an increased liability to pulmonary tuberculosis. The next operation is that of the dresser, who by means of a cutting machine trims the edge of the slate to the required size. The machine is operated by foot power, and the steady up-and-down movement of the right leg may in time have some health-injurious results, which, however, have not become a matter of official record. The power required to run the machine is quite considerable. Much dust is at times created by this process, according to the character of the slate. As a rule, however, the dust is heavy and falls at once to the ground. Most of the men in this employment have been at work for many years, and they give the personal impression of a healthy, robust, sober type. The very fine dust is not considered excessive, and no evidence is available to prove an abnormal frequency of pulmonary tuberculosis among this class of employees.

### OCCUPATIONAL HAZARDS IN SLATE MILLS.

The remaining occupations are generally comprehended under the term "millwork," and it is in these that most of the dust injury occurs. Millmen and others employed in this group of occupations of the slate industry constitute about one-fifth of the whole. The work includes the making of marbleized slate, which involves an additional dust problem. A brief description is difficult, but the existing situation in the Bangor and similar slate districts may be summed up in the statement that the dust menace is fairly well recognized and that no material conflict of opinion prevails concerning the relation of certain mill processes to pulmonary tuberculosis. How far it would be possible to control the dust problem in this branch of the industry has not been ascertained by qualified inquiry. The question was raised in the investigation made by the Departmental Committee on Industrial Diseases and the conclusion arrived at was essentially that effective ventilation would be quite difficult, but that more spraying might be employed to advantage.

Concerning the control of the dust menace in the finishing processes in the manufacture of writing-slates it is stated in the report of the chief inspector of factories and workshops for 1910 that while a considerable amount of dust is given off in this process, a certain amount or proportion of the same can not be exhausted by ventilating devices such as hoods and exhaust fans, on account of the weight of the dust, which by gravity falls to the ground. Mr. J. L. Edwards, of Wrexham, suggested a perforated worktable with a water trough underneath, which in actual practice was found to give good results.

It is regrettable that the available information regarding this important branch of the mineral industry should be so limited and, partly at least, inconclusive. The decline in production during the last few years no doubt accounts, in a measure, for this neglect, which is so much the more regrettable since, aside from humanitarian and economic considerations, the scientific aspects of the slate-dust problem are of special importance. There are as yet no trustworthy official vital statistics for this country, although an analysis of the mortality in slate-producing centers would unquestionably yield useful results. In the subsequent discussion of the mineral industries slate workers are again briefly referred to, chiefly with reference to slate quarrying. In a general way the data sustain the conclusion that the inhalation of slate dust is relatively less serious in its effects on the lungs than the inhalation of more irritating forms of mineral and metallic dust.

In the industrial insurance experience of the Prudential Co. during the period 1907 to 1914 there were 93 deaths of slaters, of which 12, or 12.9 per cent, were from pulmonary tuberculosis. In addition, there were 10 deaths from nontuberculous respiratory diseases, equivalent to 10.8 per cent of the mortality from all causes. There were also 7 deaths of slate makers, with 2 deaths from pulmonary tuberculosis. The statistical evidence, although entirely too limited for final conclusions, apparently sustains the point of view that exposure to slate dust is less serious in its effects than continued and considerable exposure to more irritating forms of mineral and metallic dust.

## LIME WORKERS.

The lime and cement industries are so closely related to each other that for practical purposes it has been found difficult to give separate consideration to the mortality returns for each group of these employments, which have therefore been combined to provide a more substantial statistical basis in support of the conclusions advanced. Cement and lime, of course, have different properties, dependent upon their chemical composition and the methods of manufacture, and are generally classified either according to the chemical reaction involved in setting or according to the conditions under which they will harden. Chemically pure lime is the oxide of calcium, which, as shown in the description of the cement industry, constitutes the major portion of the cement product. Lime is a strong caustic alkali which unites readily with many substances and is readily soluble in water at ordinary temperature. On this account it is claimed that the inhalation of lime dust is noninjurious, and some authorities go so far as to ascribe beneficial results to lime-dust exposure as a precautionary measure against a risk of tuberculosis.[1] There are, of course, numerous varieties of limestone which may vary in their effects and unquestionably do so where there is a considerable degree of intermixture with shell, chalky, cherty,

[1] "The Influence of Calcium," Appendix II, The Cancer Problem, by C. E. Green, F. R. S. E., Edinburgh, 1917.

or other substances. The general processes of manufacture, without reference, however, to sanitary conditions or dust exposure, have been described in a report of the Missouri Bureau of Geology and Mines on lime and cement resources (Jefferson City, Mo., 1907) and in part 2 of the Mineral Resources of the United States for the calendar year 1913, by Burchard and Emley, on "The sources, manufacture, and use of lime." The annual reports of the United States Geological Survey emphasize the magnitude of the lime industry, but no satisfactory statistics are available concerning the health of this class of employees with special reference to tuberculosis other than the data elsewhere included in the discussion. Hayhurst in his report on health hazards in Ohio reports upon conditions observed in seven establishments employing, however, only 188 persons. A brief reference is made to dust exposure in the drawing or unloading of the kilns in connection with which no protective devices were employed. As regards grinding and packing, it is said that this is done in all plants but is practically a side practice or process of lime manufacture. It is explained that the lumps of lime after cooling on the floor space are taken to the mill and ground to powder and then sacked by machinery. The health hazard is referred to as "very bad." The air is dense on account of the dust in some places, and in only one was there an efficient suction system, in connection with which it is pointed out "the saving of lime collected paid a very good interest on the money invested in the blower system." Skin irritation, especially in summer, is referred to as frequent, and eye inflammations were complained of, but there is no mention of a specific liability to pulmonary tuberculosis. The idea seemed to prevail that the inhalation of lime dust was beneficial and in some communities medical evidence to this effect was quoted. Some of the men observed, however, were decidedly pale and a few were short of breath, an impairment acquired since entering the plant.

## LIME DUST AND PULMONARY TUBERCULOSIS.

The relation of lime-dust inhalation and pulmonary tuberculosis was investigated by Reckzeh, who, according to a brief statement in the Medical Record for December 5, 1903, concluded that—

The statistics in lime-producing districts show that pulmonary tuberculosis is rare, and that sometimes when present its course is favorably affected. Various authors ascribe this beneficial effect to different features attending the occupation of lime burning. Such are, an effect of the inhaled lime dust in facilitating calcification of the suppurating foci, the dryness of the inhaled air, and the deeper respiration it makes necessary, the warmth of the inspired air which contains no tubercle bacilli, and the more active metabolism it causes. In order to determine the effect of the lime dust suspended in the air the author caused eight tuberculous patients to inhale air charged with the dust by striking suspended bags filled with powdered lime. At first the inhalations were carried on for five minutes daily, but the time and frequency were gradually increased. The results were without encouragement, no improvement in the pulmonary condition was noted, while there were marked undesirable secondary effects, such as headache, loss of appetite, and nausea.

### RELATIVE INFREQUENCY OF RESPIRATORY DISEASES.

Selkirk subsequently investigated the same problem by personal inquiry among lime workers with special reference to the prevailing opinion that as a class they were exceptionally free from bronchitis and pulmonary tuberculosis. According to the Journal of the American Medical Association, for December 12, 1908—

He was unable to find an instance of phthisis among them, nor could he learn on inquiry of any worker in limekilns having died from tuberculosis. He asks whether those who inhale and swallow much lime are abnormally free from tuberculosis of the lungs. He discusses what is known of the therapeutics of calcium salts, and says it appears that the continued absorption of calcium from the lungs and intestines might maintain an abnormally high percentage of it in the blood. He suggests that the workingman predisposed to tuberculosis might turn his attention to lime and cement working as an occupation, and even hints at the organization of lime works as a curative tuberculosis colony. A rapid increase of weight is commonly observed in new workers at the Warren Cement Works, at Hartlepool.

### GENERAL CONCLUSIONS.

The same authority is also quoted, but in another statement, that he found the health of workers in limekilns above the average, and that there seemed to be far less than the normal amount of pulmonary tuberculosis and bronchitis. He therefore concluded that—

It is believed that the lime inhaled is dissolved by the carbonic acid in the lungs and absorbed. Calcium in the intestinal canal prevents fermentation. Lime-dust particles may, however, be deposited in the lungs. It may be that continual absorption of calcium from the lungs and intestine may maintain an abnormally high percentage of it in the blood. The author asks, Does this occur in the lime worker, and is it preventive of tuberculosis in him? Or is his freedom due to the external lime dust being unfavorable to the life and growth of the bacillus outside of the body? It seems curious to suggest an atmosphere of dust for the treatment of tuberculosis; it would have been as curious some generations ago to have suggested fresh air. At the least, have we not in this lime and cement working an occupation which we may recommend to the workingman predisposed to tuberculosis or already in the early stages of it? Or could the neighborhood of a limekiln be organized as a curative tuberculosis colony?

These observations arrived at by conservative medical investigators seem to sustain the generally favorable conclusions concerning the relative noninjuriousness of lime dust with special reference to pulmonary tuberculosis. As a technical problem the lime industry offers exceptional opportunities for the ascertainment of urgently required information concerning the differential effects of mineral dusts in their relation to health and longevity and possibly even concerning the therapeutic value of lime dust as intimated by the rather limited investigations of Reckzeh and Selkirk.

An excellent descriptive account of "Lime: Its properties and uses" has been published as a circular of the United States Bureau of Standards of the Department of Commerce and Labor (Washington, 1911). This account precisely emphasizes all the essential preliminary scientific considerations necessary for a thorough understanding of the underlying conditions which concern the health of workers in occupations, trades, or industries more or less injurious to health and life. The account includes a description of the method of lime manufacture, definition, and classification, followed by a description of general properties and an extended account of the uses of lime and the various kinds of limestone, lime, and hydrated lime in the chemical industries, including natural cement, sand-lime brick, glass, bleaching powder, fertilizer, etc. The classification of limestones according to their physical properties, as to whether hard or soft, porous or dense, coarsely crystalline or fine grained, implies probably widely differential results in health-injurious consequences, proportionate, of course, to the continuity and amount of dust exposure. Limestone, when metamorphosed—that is, when recrystallized after deposition through the agency of heat—is known as "marble," which by inference suggests that marble dust in all probability is not as serious in its consequences as granite dust and possibly sandstone dust, both of which contain a larger proportion of pure silica.

Some exceptionally interesting observations on dust exposure in the working of oolitic limestone on the Isle of Portland, England, contributed by Dr. Howard to the annual report of the chief inspector of factories and workshops (1913), include statistical observations for the 13-year period ending with 1912. The mortality from phthisis per 1,000 living was, among general laborers, 1.9; among stone quarriers, 1.5; among stone masons, 1.4; and among all other males, 1.1. Corresponding statistics are those of Barwise for Derbyshire, elsewhere referred to, according to which the death rate of persons employed in gritstone quarries was 13.7, against 1.2 for limestone workers. A brief reference is made in the discussion to an address by Dr. Collis on the "Effects of dust in producing diseases of the lungs," read at the Seventeenth International Congress of Medicine held in London in August, 1913, in which after the effects of dust on those employed in various industries had been cited, the following conclusions were advanced:

1. Inhalation of all forms of dust is accompanied by diminished power of chest expansion.

2. Diminished power of chest expansion so produced is accompanied by high blood pressure.

3. Animal dusts, apart from the presence in them of pathogenic microorganisms, when inhaled, produce less effects than do vegetable and mineral dusts.

4. Vegetable dusts, when inhaled, tend to produce a type of chest affection best described as asthmatic.

5. Of mineral dusts, those composed of calcium salts are least injurious.

6. Inhalation of mineral dusts which do not contain free silica tends to produce irritation of the upper air passages and respiratory diseases other than phthisis.

7. Inhalation of mineral dusts which contain free silica is associated with an excess of phthisis, an excess which bears a direct relation to the amount of free silica present.

8. In general, dusts appear to be more injurious as their chemical composition differs from that of the human body or from the elements of which the body is normally composed.

Of the foregoing observations the conclusion that of mineral dusts those composed of calcium salts are least injurious is, of course, of special significance, in view of the preceding discussion regarding the health of lime workers, which it is regrettable could not be amplified by other American or foreign vital statistics of a sufficiently trustworthy character.

## PLASTERERS.

The building trades are all more or less exposed to the inhalation of mineral dust, the injurious effects of which are probably most severe in the case of plasterers, masons, and allied occupations. This group of occupations is not clearly defined, since many plasterers are also masons, or bricklayers, while others are whitewashers or paper hangers. The English vital statistics combine plasterers, whitewashers, and paper hangers.

### EARLY OBSERVATIONS ON THE HEALTH OF PLASTERERS.

The health conditions in this trade were commented upon by Ramazzini, who, in the quaint language of the day, states that "Lime and plaster are likewise offensive to those who burn them or handle them, or sell them," and he continues: "I have frequently observed that those who boil, prepare, grind, sift, or sell it, do usually labor under a difficulty of breathing." As a safeguard, Ramazzini points out that: "Though such workmen have a cover for their mouth, they can not avoid receiving the flying particles at the mouth and nose, upon which these particles enter the passages of respiration and mix with the lymph, rise up in hard, chalky concretions, or by daubing the winding passages of the lungs intercept freedom of breath. I found that such as continued in this business did die asthmatic and cachetik." He refers also to a still earlier author, Morton, who connected the inhalation of the dust with pulmonary tuberculosis. He concludes his observations with the statement that: " Care must be taken to observe the caution laid down above, with intent to guard the mouth as much as possible from receiving the offensive particles." All this was written more than 200 years ago!

Thackrah, writing in 1832, took a more favorable view of the employment, holding that bricklayers and their laborers, while particularly exposed to lime dust, suffered from diseases of the eye and cutaneous eruptions, but not from internal disease, and he quotes an adage common to the workmen in the trade of the period, that "bricklayers and plasterers' laborers, like asses, never die." Regarding plasterers and whitewashers, who are also exposed to lime dust, he states: "They suffer from no sensible injury," and that "they are more pallid and less robust than bricklayers." Thackrah, however, did not support his observations with trustworthy data.

### ENGLISH MORTALITY DATA.

The most recent English mortality statistics of plasterers and paper hangers are for the three years ending with 1902, referred to in the Supplement to the Sixty-fifth Annual Report of the Registrar-General, in part as follows:

Between the ages of 35 and 65 years the death rate in this industry exceeds the standard for occupied and retired males, while at ages outside of these limits the rates are below it. In the main working period of life the comparative mortality figure is 1,018, or within 1 per cent of the standard. The mortality from alcoholism and liver disease, from phthisis, from respiratory diseases, and from cancer slightly exceeds the standard, and except that these workers appear to suffer but little from influenza, the figures for other diseases agree closely with the average.

The English occupation mortality statistics for plasterers are somewhat impaired in value by the fact that paper hangers and whitewashers are combined with this occupation, but the statistics may safely be accepted as indicating with approximate accuracy a higher disease liability of men in this employment to pulmonary tuberculosis and respiratory diseases. In Table 84 the mortality from all causes among men in this group is compared with that of occupied males generally, and the result is rather suggestive of conditions in this trade more or less unfavorable to life and health. The excess in the general mortality occurs at ages 35 to 64, when the death rate of plasterers from all causes exceeds the mortality of occupied males generally by from 1.30 to 1.52 per 1,000. The mortality of the group is, however, below the average at ages under 35 and at 65 years or over.

TABLE 84.—MORTALITY FROM ALL CAUSES AMONG PLASTERERS, PAPER HANGERS, AND WHITEWASHERS, 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 plasterers, paper hangers, and whitewashers. | | |
|---|---|---|---|---|
| | | 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 | 1.52 | − 0.92 | 62 |
| 20 to 24 years | 4.41 | 3.44 | − .97 | 78 |
| 25 to 34 years | 6.01 | 4.07 | − 1.94 | 68 |
| 35 to 44 years | 10.22 | 11.52 | + 1.30 | 113 |
| 45 to 54 years | 17.73 | 19.18 | + 1.45 | 108 |
| 55 to 64 years | 31.01 | 32.53 | + 1.52 | 105 |
| 65 years and over | 88.39 | 72.18 | −16.21 | 82 |

The preceding table requires no further comment, except that it confirms the view that the health-injurious effects of this employment are not so pronounced as in many other dusty trades, particularly such occupations as stonecutting, pottery manufacture, and glass blowing. In Table 85 the mortality of plasterers, paper hangers, and whitewashers from pulmonary tuberculosis is compared with the normal mortality of occupied males from this disease by divisional periods of life.

TABLE 85.—MORTALITY FROM PULMONARY TUBERCULOSIS AMONG PLASTERERS, PAPER HANGERS, AND WHITEWASHERS, 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 plasterers, paper hangers, and whitewashers. | | |
|---|---|---|---|---|
| | | 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 | 0.41 | −0.13 | 76 |
| 20 to 24 years | 1.55 | 1.06 | − .49 | 68 |
| 25 to 34 years | 2.03 | 1.22 | − .81 | 60 |
| 35 to 44 years | 2.74 | 3.98 | +1.24 | 145 |
| 45 to 54 years | 3.04 | 3.62 | + .58 | 119 |
| 55 to 64 years | 2.16 | 4.01 | +1.85 | 186 |
| 65 years and over | 1.11 | 1.53 | + .42 | 138 |

## RECENT AMERICAN INVESTIGATIONS.

The most recent investigation into the existing health conditions is by Balentine C. Baker, M. D., published in the Journal of the American Medical Association for May 6, 1916. The results of this investigation, made in connection with the Cornell University Medical College, are, in part, stated as follows:

In the work of the plasterer there is exposure to dust, cold, and dampness. The source of the dust is from the plaster, which is usually composed of lime, sand, and hair moistened. Anyone at all familiar with the work of a plasterer knows what dust there is when the dried plaster is crumbled loose by walking, moving of objects, and sweeping. The drafts of air through the open doors and windows fill the atmosphere with dust, and this the worker has to breathe. There is some controversy among investigators as to the danger of lime to workers. Selkirk was unable to find any instance of phthisis among them, nor could he learn of any worker in limekilns having died of tuberculosis.

The special investigation included 36 cases of plasterers under treatment as patients at the hospital referred to, and of this number 17, or 47.2 per cent, were over 40 years of age. It is said in conclusion that—

The respiratory tract of the plasterers is chiefly affected as in the preceding trades, there being 13 patients in this class. Seven patients had chronic and 6 acute respiratory disease. Three patients had pulmonary tuberculosis, 3 chronic bronchitis, 2 emphysema, 2 acute bronchitis, 3 dry pleurisy, and 1 acute pharyngitis.

These observations are suggestive of nontuberculous respiratory rather than of tuberculous affections, but the number of cases under observation is too limited for a conclusive generalization.

## METHODS OF PLASTER OF PARIS MANUFACTURE.

A clear distinction, of course, must be drawn for practical purposes between the manufacture of plaster of Paris and the occupation of plasterer. The former includes the crushing of raw material, employment at rotary driers, and the so-called "dust room," with supplementary methods of bowl crushing to a condition of minute fineness on buhrstones, and finally calcining in kettles with the terminal processes of handling through hoppers, bins, and conveyers. No conclusive investigations have been made with regard to the specific dust exposure in these processes and their relation to health, but W. Gilman Thompson writes of the occupation of masons and plasterers at some length, including concrete mixers, who, of course, are exposed to fundamentally different conditions. He points out that men in this group of employments inhale much dust of tile, brick, plaster of Paris, gypsum, and cement, and that they are subject from these combined conditions "to catarrhs of the respiratory passages, and such diseases as asthma, bronchitis, rhinitis, and atelectasis are frequently met with among them." There would seem to be much similarity in the dust exposure of these occupations to that observed in the case of lime and cement workers. The exposure to dust of this character is most serious in connection with house-wrecking operations, where heavy clouds of masonry and plaster dust are generated and inhaled in connection with particularly laborious work. Thompson suggests, therefore, that in some cases, as in the tearing down of old plaster in confined spaces, in tunnels, etc., where sprinkling can not be resorted to, respirators may be used to advantage.[1]

### MORTALITY OF PLASTERERS—UNITED STATES REGISTRATION AREA.

The mortality of plasterers has been reported upon for the years 1908 and 1909 by the Division of Vital Statistics of the United States Census Bureau, but for the year 1908 the group includes whitewashers, who, of course, are engaged in a closely allied employment. According to the census report, out of 977 deaths of plasterers from all causes, 163, or 16.7 per cent, were from pulmonary tuberculosis. The details of the mortality by divisional periods of life are shown in Table 86.

TABLE 86.—PROPORTIONATE MORTALITY OF PLASTERERS 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 deaths from all causes. |
| 15 to 24 years | 48 | 12 | 25.0 |
| 25 to 34 years | 108 | 34 | 31.5 |
| 35 to 44 years | 177 | 61 | 34.5 |
| 45 to 54 years | 189 | 31 | 16.4 |
| 55 to 64 years | 205 | 16 | 7.8 |
| 65 years and over | 249 | 9 | 3.6 |
| Age unknown | 1 | | |
| Total, 15 years and over | 977 | 163 | 16.7 |

[1] The dust exposure in the making of plaster casts must be quite considerable on account of the close contact with the material during every operation from the making of the molds to the finished product. Exposure is probably most serious in the scraping department, which is shown by illustration in a descriptive account on "The making of casts in gelatin molds," by W. Frank McClure, published in the Scientific American for June 20, 1908. The wearing of face protectors is necessary in this department. The object of the scraping is the removal of the mold seam and other unavoidable defects. Most of the dust exposure, however, results from the scattered material which dries and is subsequently blown about. How far this employment is as a matter of fact really health-injurious and a predisposing cause to respiratory diseases, whether pulmonary or otherwise, has not been ascertained.

TABLE 87.—PROPORTIONATE MORTALITY OF PLASTERERS FROM NONTUBERCULOUS RESPIRATORY DISEASES, UNITED STATES REGISTRATION AREA, 1908 AND 1909.

| Cause of death. | Deaths from nontuberculous respiratory diseases. | |
|---|---|---|
| | Number. | Per cent of deaths from all causes. |
| Asthma | 3 | 0.3 |
| Bronchitis | 11 | 1.1 |
| Pneumonia | 79 | 8.1 |
| Other nontuberculous respiratory diseases | 11 | 1.1 |
| Total | 104 | 10.6 |

The proportion of deaths from pulmonary tuberculosis in this occupation is fairly high, but not distinctly excessive, excepting at ages 35 to 44, when the proportion is 34.5 per cent for plasterers, against 24 per cent for all occupied males, according to data derived from the same official sources. Aside from the mortality from pulmonary tuberculosis, the mortality from nontuberculous respiratory diseases was also about normal, having been 10.6 per cent for plasterers, against 10 per cent for all occupations, the slightly higher proportionate mortality from nontuberculous respiratory diseases being chiefly attributable to bronchitis; but the numbers under consideration are hardly sufficient for entirely definite conclusions.

## MORTALITY OF PLASTERERS—INDUSTRIAL INSURANCE EXPERIENCE.

In this connection the statistics of the Prudential Insurance Co. are of additional interest and value, in that they include 1,371 deaths from all causes, of which 300, or 21.9 per cent, were from pulmonary tuberculosis.

TABLE 88.—PROPORTIONATE MORTALITY FROM PULMONARY TUBERCULOSIS AMONG PLASTERERS, 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 plasterers, 1897 to 1914, from— | | Per cent of deaths from pulmonary tuberculosis among— | |
|---|---|---|---|---|
| | All causes. | Pulmonary tuberculosis. | Plasterers. | Males in registration area, 1900 to 1913. |
| 15 to 24 years | 58 | 20 | 34.5 | 27.0 |
| 25 to 34 years | 163 | 71 | 43.6 | 30.5 |
| 35 to 44 years | 225 | 91 | 40.4 | 23.4 |
| 45 to 54 years | 281 | 66 | 23.5 | 14.7 |
| 55 to 64 years | 330 | 39 | 11.8 | 7.9 |
| 65 years and over | 314 | 13 | 4.1 | 2.6 |
| Total, 15 years and over | 1,371 | 300 | 21.9 | 13.9 |

According to Table 88 the proportionate mortality from pulmonary tuberculosis is excessive among plasterers at every divisional period of life, but particularly so at ages 25 to 34, when out of 163 deaths from all causes, 71, or 43.6 per cent are from pulmonary tuberculosis, against 30.5 per cent in the male mortality of the registration area. How far this excess in the mortality from pulmonary tuberculosis is the direct result of dust inhalation or due to contributory social and economic causes can not be stated at the present time. Nor is it possible accurately to differentiate plasterers from men employed in the manufacture of plaster of Paris and related occupations, but it may be said in conclusion that such investigations as have been made of existing conditions at plaster works prove that there is abundant room for material improvement, and that in most of the plants only the crudest and most unsatisfactory appliances are employed for the prevention of dust and its inhalation by the men employed.

In this connection a brief reference may be made to an exceptionally valuable tabulation of industries with exposure to inorganic dusts in relation to the mortality from pulmonary tuberculosis and the presence of free silica in the dust, in the annual report of the chief inspector of factories and workshops of Great Britain, for 1912 (p. 216). As regards plaster of Paris, it is said that the composition of the dust is chiefly that of calcium sulphate and that free silica is not present; also that the mortality from pulmonary tuberculosis is not above the normal. A similar reference is made to cement, as regards the composition of which it is said that the dust consists of silicates of magnesium, calcium, and aluminum; that the percentage of free silica is less than 1 per cent (as compared, for illustration, with 30 per cent in granite dust and 75 per cent in quartz dust of the tin mines of Cornwall); and, finally, that the mortality from pulmonary tuberculosis is " not above normal." Attention is directed to the fact that the connection between silica dust and phthisis is now well established, and that it has led to the adoption of preventive measures to suppress this dust when generated in the process of sand-blasting glass for engraving purposes and in the production of finely powdered flint and quartz. Free silica, however, as brought out in this investigation, is not present in the dust of plaster of Paris which on that account chiefly is relatively noninjurious as regards predisposition to pulmonary tuberculosis. The most recent observations, in Kober and Hanson's Diseases of Occupation and Vocational Hygiene, regarding plasterers, are regrettably inadequate and inconclusive.

## CEMENT WORKERS.

The health-injurious conditions of cement-making processes are quite well understood, being not only the dust, but also the noxious vapors which arise through the process of burning. The vapors are probably more a matter of discomfort than injurious, but the subject attracted sufficient attention to suggest an investigation by the Royal Commission on Noxious Vapors in 1878.[1] As a result of the vapors and the dust generated during the processes, cement works, as a rule, are now located outside of large cities.

### GAS, FUME, AND DUST EXPOSURE IN CEMENT-MAKING PROCESSES.

The health conditions in American cement works have never been fully investigated, but it appears to be the consensus of opinion that the effects are not as serious as assumed upon the facts of a casual inspection.[2] Fatal accidents have occurred as the result of asphyxiation by carbon-monoxide gas, but such cases are very rare. Cases of gassing, so called, which do not terminate fatally, are said to be comparatively common. Arlidge considered the employment of cement making at some length, pointing out that the workmen are exposed to dust in an intense form, but experience would seem to prove that the effect on health is not so injurious as expected. He states that the raw materials of cement are clay with flint and lime, and he briefly describes the process of manufacture as follows:

> After the materials have been well mixed and ground together in a sort of mortar mill to the consistency of liquid mud, the next business is to drive off the water by heat, and then to subject the dried substance in tins to a still higher temperature. Later all the cement is withdrawn and then ground between rollers to the requisite fineness. The primary mixing and grinding, being done with a free supply of water, exhibits no insanitary conditions. In working the kilns the workmen suffer from great heat and dust, but the most continuous dusty work is in the mill, the air of which is clouded with cement. Inquiry among the workmen elicited the fact that after a while they become short of breath and suffer cough, though not in a high degree, and that on arising in the morning they had to clear their chests by expectorating viscid mucus containing cement dust.

### QUANTITATIVE EXTENT OF ATMOSPHERIC POLLUTION.

The amount of dust generated in cement-making processes is enormous. The workmen take practically no precaution to avoid this dust, and considerable quantities are of necessity inhaled. It is very rare to find employees who use a respirator or even a piece of

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[1] Report of the Royal Commission on Noxious Vapours, London, 1878. Minutes of Evidence taken before the Royal Commission on Noxious Vapours, London, 1878.

[2] This conclusion is modified by the investigations of Dr. Tucker, of Riverside, Cal. (see pp. 233 to 237). The investigations of Dr. Tucker are a notable contribution to the subject of cement dust in its relation to health, but they can not be considered entirely conclusive, in that the statistical data—either that secured by him from local sources or that derived from insurance experience—are not sufficiently representative of the American cement industry with a due regard to local variations in conditions injurious to health.

ordinary cloth to provide some protection against the health-injurious conditions which surround them. The worst conditions are probably in the sacking or packing department, where such precautions are occasionally adopted. Every department, however, is filled with dust, and the avoidance of its inhalation by the majority of employees is under present methods practically impossible. The disease problem is complicated by a high degree of temperature in some of the departments, in particular at the kilns. While many descriptive accounts of the industry have been published, the hygiene of the occupation has been generally ignored. Tracy refers to it very briefly, holding that "the workmen who make Portland cement are greatly troubled by the dust caused by shoveling the mass into sacks after it has been burned and ground. They have a persistent cough, and expectorate little lumps of cement. They find it impossible to continue this part of their labor day after day, and are obliged to take intervals of rest."

#### PROCESSES OF MANUFACTURE.

Parry, in his Risks and Dangers of Various Occupations, refers to cement workers as follows:

> Those engaged in the manufacture and use of Portland cement are very liable to get the dust into their lungs. Portland cement is made from some substance containing carbonate of lime, such as white chalk, existing in such immense quantities in this country, and some material containing silica and alumina, such as a selected clay or alluvial mud. These are ground together with water to a muddy consistency, which is then dried by heating in chambers. This being a wet process, no dust is raised, but during the next stage, the digging out of the cement, a great deal of dust is created. The material raised is then calcinated, ground between rollers, and finally packed in bags. In the last two operations, the grinding and packing, much dust is also scattered. The particles are of a sharp, irritating character, and therefore dangerous.

In Oliver's Dangerous Trades the manufacture of cement from a hygienic point of view is briefly discussed and illustrated by a microphotograph of cement dust by Migerka. Oliver's description is as follows:

> Under the microscope are seen a few sharp-edged little plates and amorphous masses like small clumps. The particles are not of themselves so dangerous as might at first sight appear. Although cement workers suffer from pulmonary disease, they do not do so to the great extent that might be expected. Probably the harmful effects are largely due to the hygroscopic character of the particles and their alkaline reaction.

#### MEDICAL OBSERVATIONS ON CEMENT DUST.

The cement industry has also been reported upon by Hayhurst with special reference to conditions in Ohio, including, however, only two plants, employing a total of 98 men. It is stated that the work was found to be very dusty and dirty and that the quarters in one place were seldom cleaned. It is, of course, a foregone conclusion that it is practically impossible to keep a cement plant in a thoroughly clean condition while in active operation, since the product itself is the dust which permeates practically every part and portion of the plant. According to Hayhurst, the dust is composed of "cement, lime, silica, and powdered coal," and thus far practically no method has been evolved for the control of the dust menace. Heat was found to be intense for some of the workers and there was practically no protection adopted against it. This, of course, applies to the calcining furnaces, which do not essentially differ from converting furnaces generally. The medical observations are to the effect that there was great opportunity for contracting communicable diseases because of promiscuous spitting, absence of cuspidors, and the dust flying about. It was also noted that the cement dust tended to cake in the nose and that same was more or less contaminated by the dust of pulverized coal, which of course would probably not be a condition common to cement plants generally. The observations can not be considered conclusive in view of the very limited range of the inquiry.

On account of the truly enormous extent of the development of the cement industry during recent years, general conclusions should be accepted with extreme caution. Descriptive accounts of plant conditions vary widely, and for a thorough understanding of the conditions inimical to health a much more extended investigation is required than has thus far been made In the special account of the cement industry of the State of Kansas, prepared in connection with the St. Louis Exposition, 1904, occurs a concise statement of the Iola Portland cement plant, which sets forth the general processes and conditions with admirable brevity, as follows:

> The materials used in the manufacture of the cement are a very pure limestone nearly free from magnesia, a clay with about 75 per cent of alumina, and silica. One thousand tons of rock are used every 24 hours. These substances are mixed in the proper proportion and then ground in a large rock crusher, which takes blocks as large as a man's hand and has a capacity of 15 tons per hour. The gravel from these crushers then passes into a dryer heated by natural gas, where it loses 6 per cent of water, or 60 tons a day passing off as steam. Next the gravel is ground in 21 Griffin mills, which grind 2 tons an hour, or 48 tons per day, to a fine flour which will pass through a 100-mesh sieve of 10,000 holes to the square inch. This flour is then conveyed to the 15 agitators, large cylinders holding 90 cubic yards each, and it is thoroughly mixed in water by revolving propellers.
>
> When the material is thoroughly mixed to the satisfaction of the chemist it is carried into 21 rotary kilns. These are cylinders lined

with fire brick and are 6 feet in diameter. They are in constant rotation and inclined downward slightly toward the gas-heated end, where the temperature reaches over 3,000° Fahrenheit. Each kiln has a capacity of 160 barrels in 24 hours. The mixed flour materials pass out of the kiln in the form of a hard clinker, which is carried by elevators over into the cooling room. When cooled, the clinker is placed in a second set of Griffin mills, 21 in number. Each one of these grinds 9 barrels (or 3,420 pounds) in an hour to a fine flour. The finished cement now passes over into the storage room, where it is run into barrels or sacks.

### COMPARATIVE DUST HAZARDS IN THE DRY AND WET PROCESSES.

The manufacturing processes have also been described by Mr. John Calder, chief inspector of special risks for the Canadian Fire Underwriters' Association, who points out at the outset that there are two methods, generally known as the dry and the wet system, which naturally involve processes and conditions quite varying in their effects on health and longevity. The dust danger in the dry process is, of course, most serious, particularly in connection with the crushing, mixing, and grinding briefly described as follows:

The limestone being received at the mill passes through a jaw crusher. It then goes through rolls for a further reduction and is elevated to storage bins. From the storage bins the rock goes to the rock driers; these usually consist of metal cylinders from 40 to 60 feet long and 5 to 6 feet in diameter, with flanges inside and placed horizontally with a slight inclination and revolving on roller bearings. These driers are usually heated by a coal furnace or by waste gases from the rotary kilns. The shale or clay is treated in a similar manner, the whole going to the raw-stock bins. From these the two materials are drawn and mixed, usually by automatic mechanical mixers taking in the proper proportions required from an analysis of the materials. The further reduction of the mixture is done by two grindings, the first usually in the Ball Griffen or "Kominuter" mills and the latter in the tube mill. The stock is then conveyed to the raw-stock bins ready for burning.

W. Gilman Thompson has described the dust exposure in cement manufacture, with special reference to American conditions, observing in part that—

In the crushing and drying rooms where the limestone is first treated, and in barreling or bagging, the workmen are exposed to risk of bronchial and pulmonary irritation as well as to irritation of the skin and conjunctivae. In the better class of mills the crushing and grinding machinery is inclosed and connected with aspirating ducts or hoods through which the dust is drawn to settling rooms where it is filtered or precipitated with water. The packing in sacks for transportation is sometimes also done by machinery. The workmen frequently further protect themselves by binding thin cloths over the nose and mouth or by wearing respirators. They often complete the filling of the sacks by adding a few handfuls of cement to make up the full weight, thereby scattering much dust and irritating the hands. Cleaning out the clinkers from the ovens in which the raw material has been roasted subjects the workmen to dry heat as well as coarse dust.

Regardless of even the most satisfactory precautions a considerable amount of dust exposure in cement plants is practically unavoidable. In plants in which insufficient attention is paid to dust prevention the quantity of dust exposure is enormous. As observed by W. Gilman Thompson in this connection:

Upon the whole, in proportion to the quantity of dust inhaled, cement dust, like coal dust, produces less damage to the respiratory system than might be supposed—less than the harder, sharper flint or glass dust, although chronic bronchitis, asthma, and pneumoconiosis may result from it. It causes considerable itching in the nose, to relieve which the workmen put their dusty fingers into the nose and scratch the septum. This only increases the trouble, and in some cases ulceration with perforation of the septum occurs, as in chromic-acid poisoning. Workmen with sensitive skins sometimes scratch the dusty skin so that ulcers form which are so slow in healing that they may be compelled to change their work. The cement dust mixes with the perspiration of the skin and gives rise to a general pruritus which the workmen call "cement itch."

### SPECIFIC OCCUPATIONAL DISEASES.

Cement makers' itch is a new disease, apparently neither parasitic nor contagious, but produced by the chemical or mechanical action of the cement upon the skin. According to a brief discussion in the Medical Times (October, 1909)—

Some physicians have attributed the corrosive action to calcium carbonate and to sulphuric acid. Fresh cement, however, does not contain calcium carbonate; and it is questioned whether slacked lime or even partly slacked lime will produce this effect, for masons working with lime mortar are seldom if ever attacked with cement makers' itch. The quantity of sulphuric acid in cement is very small. Possibly the effect may be explained by mechanical friction between the skin and very fine but hard particles of cement. Briquette makers, observes Scientific American, are subject to a similar but less serious annoyance. Cement makers' itch and ordinary itch have one sympton in common—intense itching, especially at night. The itching appears to be increased by the heat of the bed, and is also more annoying in summer than in winter. Scratching may produce infected wounds and swelling. Cement makers' itch is an occupational disease; true itch is seldom such. The latter can be cured comparatively easy; but not so cement makers' itch, which is likely to be followed by eczema and other complications. The managers of cement works should always require their workmen to wear cotton gloves and garments tightly fastened at the neck and at the wrists. Cement workers on arches or ceilings should wear masks. Both gloves and masks should frequently be washed.

The reference is of some importance in connection with the still debatable question as to whether cement dust is or is not, at least in rare industrial cases, really seriously injurious to health.

### EFFORTS AT RESTRICTIVE LEGISLATION.

Under date of January 14, 1913, a bill was introduced into the senate of the State of California providing for the protection of the health of persons employed in the manufacture, packing, or handling of Portland cement, as follows:

The people of the State of California do enact:

SECTION 1. In any factory or other place in the State, where Portland cement is manufactured, packed, or handled provision shall be made for preventing the escape of cement dust into the atmosphere of any room or compartment where people are employed.

SEC. 2. The packing of Portland cement shall be carried on in compartments which shall be separated by dust-proof walls, floors, and partitions from all other parts of the factory or establishment where people are employed; and all conveyors and elevators used for the conveyance of Portland cement shall be inclosed in metal or some other dust-proof material.

SEC. 3. All Portland cement manufactured in the State, or imported from any other State or foreign country shall be packed in dust-proof containers, and the commissioner of the bureau of labor statistics shall have the power to issue orders to prevent the loading or unloading of any Portland cement in or for any vessel in any port in the State of California or in or for any freight cars, or any railroad or railway in the State of California if such Portland cement is not packed in a dust-proof container; and any person, firm, or corporation who shall disobey such order shall be guilty of a misdemeanor.

SEC. 4. All contracts entered into by this State or any political subdivision thereof, for the purchase of Portland cement or other like commodity or for the construction of public work which requires the use of Portland cement, shall contain a proviso that all cement to be furnished in the construction of such public work shall be packed in dust-proof containers.

SEC. 5. Any person, firm, or corporation who shall violate or fail to comply with the provisions of this act shall be guilty of a misdemeanor and shall, upon conviction thereof, be punished by a fine of not less than $50 or more than $200, or by imprisonment for not more than 60 days, or by both such fine and imprisonment.

SEC. 6. The commissioner of the bureau of labor statistics shall enforce the provisions of this act.

### EXPERIMENTAL MEDICAL RESEARCH.

The bill has been included in its entirety as an illustration of contemplated legislation intended to correct an evil of a more or less debatable degree of seriousness by means practically equivalent to the destruction of the industry concerned. The contemplated bill in California led to perhaps the most thorough investigation of the health conditions in a dangerous industry ever made in the United States. The passage of the bill would have involved such serious financial considerations to the cement manufacture of California that all the available information on the subject was brought together at the hearing held for the purpose, subsequently amplified by animal experimentation, etc., under the direction of Dr. George E. Tucker, in behalf of the Riverside Cement Co.[1] A brief was presented by Dr. Tucker, which includes a review of the literature on the subject, the results of the original investigation, including hospital records, anthropometric data, physical examination of employees, with reference to time employed and dust exposure, etc. The investigation was extended to include an original inquiry into the records of California public hospitals and other public institutions for the purpose of ascertaining whether an undue number of patients were being treated on account of tuberculosis possibly contracted in the cement industry, but the evidence was quite negative. The evidence of Dr. Tucker was subsequently presented in the form of a brief discussion on the "Physical examination of employees engaged in the manufacture of Portland cement," read before the American Public Health Association in 1914. Dr. Tucker presented a typical analysis of the raw mix or crude material which enters into the composition of cement, as follows: "Silica, 15.18 per cent; iron alumina oxide, 5.06 per cent; calcium carbonate, 76.34 per cent; magnesium carbonate, 2.90 per cent; undetermined, 0.52 per cent." In contrast to the foregoing, the finished cement shows the following analysis: "Silica, 22.98 per cent; iron alumina oxide, 8.80 per cent; lime, 63.10 per cent; magnesium oxide, 2.42 per cent; sulphuric anhydride, 1.42 per cent; loss on ignition, 0.52 per cent; undetermined, 0.69 per cent." The difference in the silica content is of considerable practical importance, as well as the very high proportion of lime, which, of course, is readily soluble. Tucker quotes Kehmann, of Wurzburg, to the effect that investigations have demonstrated that "most inspired dust finds its way into the stomach and not into the lungs; and most of the dust which enters the upper respiratory tract is caught by the moist mucous membranes of the nose and throat and the dust-laden secretion is then swallowed." It is further stated that—

In the case of insoluble particles the gastrointestinal path may furnish a most satisfactory channel for the consequent elimination of the dust from the body, but soluble dust finds a peculiarly favorable

[1] According to a report made to the State Department by Consul General John P. Bray, of Sydney, New South Wales, a labor controversy has developed between the local cement manufacturers and the wharf laborers at Sydney over the handling of cement in bags, the dust from which, it was claimed by the laborers, was injurious to health. On account of a virtual refusal to handle bagged cement in a form involving considerable dust exposure it is stated that the local cement company, with an approximate output of 30,000 bags per week, made a trial shipment of cement in bags lined with paper, but it was found that the cost of such bags was practically prohibitive, and that efforts would be made to have the bags produced by machinery at a material reduction in cost. No evidence is available as regards the success or failure of this experiment or whether a continued refusal to handle cement in ordinary bags has led to further labor difficulties. It is pointed out, however, that since paper bags are produced which are impervious to coal dust it should not be impossible to produce bags impervious to cement dust.

chance for absorption along the same route, and the opportunity for chronic intoxications is thus easily established. In any event, the lungs escape the major part of the initial irritation.

## CHEMICAL ASPECTS OF CEMENT DUST IN RELATION TO DISEASE.

The application of this conclusion to the cement-dust problem is of exceptional practical importance. It is pointed out by Dr. Tucker that it would appear that, since the principal ingredient of cement is lime in the form of calcium oxide, undoubtedly this material is dissolved in the stomach and converted into lime water, which must be considered to be without injurious effects, since the hydrochloric acid of the stomach would undoubtedly be able to convert the oxide into the chloride, and that this material can be ingested in large quantities over long periods of time without ill effects. Laboratory tests show, according to Tucker—

That 99.7 per cent of five-tenths of a gram of cement is soluble in 500 c. c. of a one-tenth per cent solution of hydrochloric acid, and 99.7 per cent of five-tenths gram of cement is soluble in 250 c. c. of a two-tenths per cent solution. The average per cent of hydrochloric acid varies from one-tenth to two-tenths per cent in the gastric juices of the normal stomach. Similar experiments conducted in the laboratory, using the so-called treater dust, or dust which escapes from the stacks of the kilns heated to 800° C., showed that 81.44 per cent of five-tenths of a gram was soluble in 100 c. c. of a one-tenth per cent solution of hydrochloric acid. This solution became neutral when reaction was complete.

## MECHANICAL ASPECTS OF CEMENT DUST IN RELATION TO DISEASE.

These conclusions are important not only to the cement industry but to many similar employments involving a continuous and considerable inhalation of mineral dust. There have been no other extended studies of this aspect of the dust problem, although the results would be of much practical value to the industries concerned. Apparently strictly scientific and impartial investigations in California public institutions, as well as among the employees of the Riverside Cement Co., show a remarkable rarity of pulmonary tuberculosis. The results of the investigation are summarized in the statement that "the membrane of the nose seems to exercise its complete function and eliminate the dust from the inhaled air." Since the cement dust is practically sterile and chemically nonirritating there is very little inflammation caused by its presence in the nose. The results of the physical examinations of employees were subsequently confirmed by animal experimentation. Out of 956 employees physically examined 7.2 per cent were found to be in bad physical condition, while the proportion in this condition among 544 applicants for employment was 7.7 per cent. Since a large proportion of the employees and applicants for employment were Mexicans and Armenians, the nativity factor naturally complicates the results. The average age of the employees was 31 years 8 months, the average height was 5 feet 6¼ inches, and the average weight was 149¾ pounds. The physical condition of the applicants for employment in these respects was much the same.[1]

### PHYSIQUE OF CEMENT WORKERS.

In further explanation of the physical examinations it is stated by Tucker that—

It should be understood that the men called "employees" were not selected risks and underwent no physical examination prior to employment, nevertheless the average weight of employed men was the same as the average weight of the applicants for employment. The average age of employees in the packing house was 29 years 4 months 23 days; the average weight, 153⅓ pounds; the average height, 5 feet 6½ inches. The average weight of men employed in the packing department was about 4 pounds more than the average weight of all men employed. This is based on the examination of 73 men who had been employed an average of more than two years. In the dusty parts of the mill figures show an average age of 31 years 6 months; average weight, 162 pounds; average height, 5 feet 6¾ inches. This is an average weight of 13 pounds more than general average, and is based upon the examination of 106 men employed for more than an average of two years.

[1] The only trustworthy information regarding the physique of Mexican laborers in this country is made available through an analysis of height and weight of 1,112 applicants for industrial insurance with the Prudential, during the period 1908–1916. Most of these applicants at the time were residents of southern California. The average height of the Mexicans (see table below) was 66 in., against 68.5 in., in accordance with the medico-actuarial standard. The average weight was 146 lbs. for the Mexicans, in comparison with an average of 156 lbs., according to the medico-actuarial standard. The adjusted relative weight was 2.2 lbs. per inch of height for the Mexicans, against a standard of 2.3 lbs. The average Mexican is, therefore, 2.5 in. below the average American standard of height and 10 lbs. below the average American standard of weight. From such investigations as have been made regarding the mortality of Mexican laborers in this country, it appears that the frequency of pulmonary tuberculosis among them is decidedly common.

*Comparative Anthropometry of Mexican Males.*

[Applicants for industrial insurance, experience of the Prudential, 1908–1916, and standard American males according to the medico-actuarial investigation.]

| Age. | Average height (inches). | | Average weight (pounds). | | Relative weight (pounds per inch). | |
|---|---|---|---|---|---|---|
| | Mexicans. | Medico-actuarial standard. | Mexicans. | Medico-actuarial standard. | Mexicans. | Medico-actuarial standard. |
| 15 to 24 years | 66 | 68.3 | 139 | 147 | 2.1 | 2.2 |
| 25 to 34 years | 67 | 68.5 | 147 | 155 | 2.2 | 2.3 |
| 35 to 44 years | 67 | 68.5 | 153 | 161 | 2.3 | 2.4 |
| 45 to 54 years | 67 | 68.5 | 153 | 165 | 2.3 | 2.4 |
| 55 to 64 years | 66 | 68.4 | a145 | 165 | 2.2 | 2.4 |
| 65 years and over | 65 | 66.5 | a157 | 166 | 2.4 | 2.5 |
| 15 years and over | 66 | 68.5 | 146 | 156 | 2.2 | 2.3 |

a Cases too limited in number for safe conclusions.

It would therefore appear that the employment was not physically injurious to the extent of a loss in weight, but rather, to the contrary, a gain resulted among the men exposed in the most dusty parts of the mill.

### INFREQUENCY OF PULMONARY TUBERCULOSIS.

Among all the employees there were only 16 cases of suspected tuberculosis and but two of these had worked in any dusty part of the mill. The employment of these two covered a period of 1 and 10 days, respectively; but others had worked either in the quarry or yard, departments in which there could be no substantial exposure to cement dust, and the average length of employment of these was four and one-half months. Among the applicants seven had physical signs indicative of previous tuberculosis, so that even among the 16 cases previously referred to, it is a safe assumption that a fair proportion at least had contracted the disease before employment. The results of the investigation are summed up in the statement that—

In conclusion, as a result of an investigation of the dust problem in conjunction with the manufacture of Portland cement, based upon the review of literature on the subject, the examination of 956 employees in one plant, examinations of men employed in the dusty departments of four other mills, the medical records of employees and guinea pig experimentation, there appears to me to be no evidence of injurious effects from cement dust upon employees engaged in its manufacture. The reexamination of all employees and the continuation of the records will give us information of more value, and annual reports of the results of the work at the Riverside Portland cement plant will be available to any one interested in this most important phase of the cement industry.

The California investigation has been referred to at length, in view of its exceptional practical importance. It is one of the most thoroughgoing efforts to ascertain precisely and conclusively the possibly health-injurious conditions in a leading American industry. Whether the conclusions are accepted or not, the method of inquiry itself is deserving of special recognition, particularly in view of the fact that the medical and statistical research was amplified by animal experimentation.

### PROBLEMS OF DUST CONTROL.

In the case of the cement industry the problem is both simple and complex. The enormous quantity of dust which is itself the product of the industry must theoretically be assumed to be injurious to health and a predisposing cause of respiratory and possibly tuberculous diseases. Hirt, in the early seventies,[1] presented data according to which the proportionate morbidity from phthisis was

[1] Die Staubinhalations-Krankheiten, by Dr. Ludwig Hirt, Breslau, 1871, p. 30.

only from 8 to 10 per cent among cement makers, against 80 per cent among flint workers, and 70 per cent among needle polishers. The industry in the meantime, however, has undergone such profound changes that these earlier observations are not of practical significance. Koelsch, in a more recent German contribution on mortality in relation to tuberculosis,[1] refers briefly to cement dust as injurious, but without sufficient statistical evidence to sustain his conclusions. His data, derived from the mortality of Bavaria for the year 1898, are limited to four deaths of cement workers out of a labor force of 1,267 exposed to risk. The resulting mortality rate of 3.16 per 1,000 compares favorably with 3.07 for all occupations, but the number of deaths is too small for final conclusions. More trustworthy observations are brought forward in the report of the chief inspector of factories and workshops of the United Kingdom for the year 1911 (p. 183), who remarks as follows:

Cement making has for years been regarded as one of the specially dusty trades in which difficulty has been experienced in confining the dust within reasonable limits during the processes of manufacture, grinding, and packing. The dust, however, has been held by some authorities as "not so damaging to health as might have been expected," though by others it is considered to cause "slight bronchial and lung troubles as well as catarrh of the stomach and inflammation of the eyes."

Modern processes, it is pointed out, have, however, had a tendency to materially reduce the quantity of dust which was formerly allowed to escape into the atmosphere. On the basis of a careful inquiry among friendly societies insuring persons employed in the cement industry the conclusion was arrived at that—

These appear to show that the trade is on the whole a healthy one; that deaths are few; that absence from work is rare and generally due to influenza, colds, or accidents; and that there is often more invalidity among workers in nondusty processes than in the dusty occupations of kiln drawing, milling, and packing.

### NONINJURIOUSNESS OF LIME DUST.

The general conclusion was, therefore, advanced, after a careful special inquiry into actual working conditions, that "while the dust is not of an injurious nature, probably owing to the fact that free silica is present in very small quantities, usually less than 1 per cent, it does cause irritation and trouble in some cases, and if not injurious it is at least a nuisance, and efforts should be made to prevent and reduce the escape of dust wherever practicable." This view has the indorsement of a letter in the British Medical Journal for May 7, 1900, in which, following a reference to the general conclusion that

[1] Arbeit und Tuberkulose, by Dr. med. Koelsch, published in Archiv für Soziale Hygiene, Vol. VI, pp. 29, 212, 276; Leipzig, 1911.

all dust is more or less seriously injurious to health, it is said that "a decided exception should be made in favor of lime dust." In the writer's personal experience "those breathing it habitually at lime-kilns are free from tuberculosis, and a similar observation has been made in France and Germany." Furthermore, it is said that "lime dust in abundant quantity, either by acting on the body or on the tubercle bacillus outside of the body, is antagonistic to tuberculosis." This conclusion would seem to have much in its favor, and, while not entirely sustained by the available insurance mortality statistics, the data at least indicate a relatively lower incidence of pulmonary tuberculosis than is common to the obviously more hazardous dusty trades.

### MORTALITY OF CEMENT WORKERS—INDUSTRIAL INSURANCE EXPERIENCE.

Table 89 shows the industrial mortality experience among cement and lime workers as recorded by the Prudential Insurance Co. for 1897 to 1914. Of 222 cement and lime workers who died during that period, 16, or 20.7 per cent, died from pulmonary tuberculosis.

TABLE 89.—PROPORTIONATE MORTALITY FROM PULMONARY TUBERCULOSIS AMONG CEMENT AND LIME WORKERS, 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 cement and lime workers, 1897 to 1914, from— | | Per cent of deaths from pulmonary tuberculosis among— | |
|---|---|---|---|---|
| | All causes. | Pulmonary tuberculosis. | Cement and lime workers. | Males in registration area, 1900 to 1913. |
| 15 to 24 years | 18 | 2 | 11.1 | 27.0 |
| 25 to 34 years | 40 | 15 | 37.5 | 30.5 |
| 35 to 44 years | 48 | 12 | 25.0 | 23.4 |
| 45 to 54 years | 45 | 10 | 22.2 | 14.7 |
| 55 to 64 years | 49 | 6 | 12.2 | 7.9 |
| 65 years and over | 22 | 1 | 4.5 | 2.6 |
| Total, 15 years and over | 222 | 46 | 20.7 | 13.9 |

The data are particularly suggestive at ages 25 to 34, when out of 40 deaths from all causes 15, or 37.5 per cent, were from pulmonary tuberculosis, against 30.5 per cent expected on the basis of the mortality data for the males of the registration area.

The American cement industry has within recent years attained to such nation-wide importance that the preceding considerations are applicable to a labor problem which at any time may assume serious significance, as made evident by the proposed measure in California aimed at the regulation of the industry by exceedingly drastic methods, as regards the impervious packing of the product, not with reference to the men engaged strictly in cement-making processes but solely for the protection of men employed in the subsequent handling of the finished product while in course of transportation. This suggests future possibilities which make it exceedingly important that the facts concerning the injuriousness or noninjuriousness of cement dust should be ascertained with impartial and strictly scientific accuracy. Cement is produced in practically every State of the United States, although the principal centers of production are Pennsylvania, Indiana, New York, Illinois, California, Missouri, Michigan, Iowa, New Jersey, and Kansas. These 10 States in 1914 produced 82.6 per cent of the aggregate output, and there are no reasons for believing that a material change occurred during more recent years. How far local and important variations in the chemical and mechanical properties of cement dust may affect the preceding conclusions regarding the apparent noninjuriousness of the dust in its relation to pulmonary tuberculosis can not be stated at the present time. As observed by Kober and Hanson in their treatise on "Diseases of Occupation and Vocational Hygiene," the manufacture of Portland cement varies in different countries, and they remark that—

> In England, where chalk is plentiful, this is used in connection with some material containing silica and alumina, such as selected clay or river mud. The raw materials are mixed in certain proportions and ground together to the consistency of liquid mud. The excess of moisture is driven off by heat, and the residue is dried in ovens at a high temperature. The preliminary process, while sloppy, is not dusty work, but the subsequent grinding between rollers and the sacking and packing of the product is an extremely dusty process. According to Koelsch and other German authors catarrhal affections and diseases of the respiratory organs constitute from 30 to 40 per cent of all the sickness. Diseases of the eyes and ears, impacted ear wax, ulceration of the nose with perforation of the nasal septum, and eczema, or cement itch, are also quite common.

Kober refers to a report made by Wittgen with reference to the results obtained in German cement works in the direction of dust removal and in consequence of which respiratory diseases were reduced fully one-third within a period of five years after the installation of exhaust ventilation, and the number of days lost by sickness was reduced proportionately. Further investigations of a more involved scientific nature are essential to the purpose of determining more conclusively the facts of a controversy, which is of importance not only to the cement industry of this and other countries, but also to every occupation involving more or less exposure to inorganic dust.

### GENERAL CONCLUSIONS.

On account of the common occurrence of pulmonary tuberculosis under all labor or industrial conditions, it is self-evident that no crude statistical analysis of this kind can precisely measure the health-injurious effects of any particular occupation, trade, or industry. At best such data are only of approximate value, unless the incidence of pulmonary tuberculosis is so pronounced as to justify unqualified conclusions. In the case of cement dust it is apparently shown that the results, if serious at all, are much less so than in the case of most of the other dusty trades considered. It is difficult to accept, without due reserve, the conclusions advanced by Tucker in their entirety, and particularly his statement that "outside of the packing room and the sack-cleaning room there is no department in which cement dust escapes into the atmosphere in any appreciable quantities." It may be stated with confidence that practically all branches or departments of cement manufacture involve considerable exposure to the dust hazard, and while the evidence may be wanting that cement dust is a predisposing cause of tuberculosis, there can be no question but that certain forms of respiratory affections are relatively common, at least among certain classes of employees. In the entire absence of official vital statistics for the States and sections in which the cement industry is represented by a sufficiently large number of employees, it would seem of sufficient importance to suggest that special inquiries should be made in the more important centers of the cement industry in conformity to the admirable methods of scientific investigation developed by the Riverside Cement Co.

### BRICK, TILE, AND TERRA-COTTA MAKERS.

These occupations are too complex to permit of a satisfactory analysis of the available mortality data which, almost without exception, are quite general and do not refer to specific industries or employments. The dust hazard necessarily varies widely in an industry of such vast extent and which is carried on under such varying conditions. Brickmaking has during recent years undergone material changes on account of the extensive introduction of machinery. It is estimated by Mr. W. Frank M'Clure in the Scientific American for October 7, 1905, that one machine employed in extricating processes accomplishes the work of 75 men. The same writer explains that—

> After coming from the pug mill the pasty material is cut into the shape of bricks by machinery which works automatically, and modern methods also provide for the use of exhaust steam and heat from the kilns for the heating of the drying house.

### BRICKMAKING PROCESSES.

The processes of brickmaking in general are described with admirable brevity by this writer, as follows:

From the cars the clay and shale are shoveled into grinders, which reduce these two products to a powder, which in turn is carried by a bucket elevator to a big hopper. After it has been sufficiently screened the powdered clay and shale next go to the pug mill, that which will not pass the screen going back to the grinders again. In the pug mill—a sort of conical trough—the raw material is tempered with water and kneaded by means of a device somewhat resembling a screw propeller in shape. From this mill it is forced through a mold into one long, continuous brick, and this, as it comes from the mill, is carried on a wide belt to a cutting machine, which automatically cuts the continuous brick into many bricks of the desired size, the machine cutting 16 bricks at one time. As the bricks come from the cutting machine, still soft and still resting on the belt, they are loaded onto flat cars and removed to the drying house, where they remain not less than a day and night. The capacity of a large drying house is about 100,000 bricks. The different apartments of this house are brick lined.

The brick next go to the kilns for baking. One of the engravings gives a good idea of the manner in which these brick are piled within the kilns. Five or six men often work three full days in filling one kiln, which fact gives some idea of the size of the interior. After the entrance to the kiln has been closed and sealed the fire beneath is started. The baking process is then continued for 9 or 10 days, the temperature maintained within being 2,300° F. Then, when the kiln has been cooled, the bricks are taken out and are ready for shipment. Where 15 or 16 kilns are in use the daily capacity of ordinary-sized brick may reach 150,000.

### HEALTH-INJURIOUS CONDITIONS.

In all of these processes there is a considerable degree of dust exposure, the injuriousness of which, however, is materially reduced by the fact that most of the operations are carried on in the open air. The evidence presented to the departmental committee on industrial diseases by Dr. Chalmers was to the effect that brickmaking could not be considered a healthy occupation. The same conclusion had been arrived at in the earlier investigation into the experience of the British Friendly Societies reported upon by Radcliffe. Apparently the most injurious processes are in connection with the molding, drying, and burning, where the dust exposure is occasionally quite considerable, in that the dust is reduced to an extremely dry and finely powdered condition. The process of manufacture with special reference to tempering, molding, drying, and burning has been described by Mr. T. C. Naulty, inspector of the Underwriters' Association of New York, in the Weekly Underwriter, for June 4, 1910. The only comparatively recent investigation into the sanitary conditions of brick and tile making, with special reference to grinding and mixing is by Hayhurst.[1] This investigation included 9 establishments in the State of Ohio, employing 67 workers in the processes of grinding and mixing. In only two instances, however, were health appliances, such as blowers, etc., present, it being observed that boxed-in chutes rendered much aid in limiting the dust. Only 5 of the 67 employees were over 40 years of age. It is said by Hayhurst that—

The chief objectionable features to this process, from a health point of view, were the breathing of clay dust, and the red coloring compound often mixed with it, the dirt underfoot, the dampness, and, for cooler weather, the absence of heating arrangements, all of which were fair to bad hazards. In two places the work was housed in so that the light was poor, and a similar condition existed for ventilation in two places. In one place the mixing machine was so close to a kiln that the workers were affected by the heat. In all places there was a moderate risk of overfatigue, not so much from laborious work, which was not the rule, but from monotonous application, constant standing, and the loud noise from the grinding machine.

### NEGLECT OF SANITARY PRECAUTIONS.

It is further pointed out by Hayhurst that the liability of contracting communicable diseases was found to be bad in all the places investigated, except in one, due to promiscuous spitting into the dried-up clay dust on the floor, the absence of cuspidors, and the lack of proper washing facilities. It is stated, however, that the outdoor character of the work in most places mitigated against this hazard, but attention is directed to the risk of contracting hookworm disease on account of the primitiveness of the sanitary arrangements.

### GRINDING, MIXING, AND PRESSING.

The general appearance of the workers was found to be good in only 40 per cent of the cases observed, but none of the men seen presented a decidedly sickly appearance. The concluding observations with reference to grinding and mixing are to the effect that—

These workers, as well as the rest of those in brick and tile works, should be provided with proper sanitary and drinking facilities because of the risk of typhoid fever and hookworm disease. Workers predisposed to lung troubles should not engage in any part of the brick industry. For certain intervals of very dusty work the workers should put on respirators. Grinding and mixing processes everywhere could be rendered entirely dustless for the places in which the workers are required to remain, as was observed to be the case at one plant.

The same investigation included the pressing process, which follows the grinding and mixing, and which, in general terms, is

[1] Industrial Health Hazards, 1915.

almost entirely mechanical. This investigation included nine establishments, employing 200 men, of whom only 1 was over 50 years of age and 5 per cent were under 20 years. Dust from the drying of wet clays under foot was found to be a bad feature in three places, and fairly so in three others, while in two places it was negligible; but in one large place the dust was so thick in the air "that one could scarcely see 30 feet." In six of the nine places the work was damp enough to be considered hazardous, and workers were found to be unable to keep dry, especially with the forms of footwear and clothing used. In six places there seemed to be a number of factors productive of fatigue. The general conclusions were of much the same effect as previously stated with regard to grinding and mixing.

### KILN SETTING, FIRING, AND DRAWING.

Work at the kilns was investigated at nine establishments employing 116 men in setting, firing, and drawing the kilns of brick and sewer pipe. There were found to be no appliances which could be considered as having to do with the conservation of health, nor were there found to be any instructions or placards suggestive of qualified advice in this direction. Of the 116 men, practically all unskilled laborers, 14, or 12.1 per cent, were over 40 years of age. According to Hayhurst—

> The chief hazards of this process were exposure to heat, alternating with weather conditions. This seemed bad in 3 places, and some hazard in all of the remaining. It depended somewhat upon the methods of drawing the kilns. In some places workmen were put upon them while the temperature was yet extremely hot. In one place premises around the kilns were kept very neat and clean. As elsewhere in this industry, fatigue factors were present, and probably more so in this process than any other. Arranged in descending order, as nearly as possible, these were: Monotonous application, with constant standing for long periods, hurrying piecework, with evidence of speeding up, laborious work under considerable strain, pressure against the body, and long hours.

In conclusion it is said that the appearance of the workers was generally good in most places, but some were found who complained of their health and others who appeared to be in a decidedly inferior physical condition. The conclusion advanced is that "This is a process requiring hard, laborious work at intervals, but this should not proclaim it necessarily unhealthy, provided the many other features mentioned were not present to menace the health of the workers." These observations are far from conclusive and they only indirectly bear upon the question as regards the relative frequency of tuberculosis in consequence of undue exposure to health-injurious conditions. The conclusion, in the main, however, indicates labor conditions far from satisfactory and, broadly speaking, probably predisposing to general ill health. These conclusions apply also, in a general way, to terra-cotta workers and tile makers, at least as regards some of the processes, which are more or less identical with brickmaking, but to a less extent than to brickmakers who in addition, of course, are exposed to numerous other health-injurious conditions, such as the risk of inhaling lime or mortar dust, especially in brick-cleaning processes and the taking down of old walls, etc.

## MORTALITY OF BRICK AND TILE MAKERS—UNITED STATES REGISTRATION AREA.

The mortality of brick and tile makers has been reported upon only for the year 1909 by the Division of Vital Statistics of the United States Census Bureau, and no subsequent information has been made public, so that the data are of rather limited value. According to the census report out of 133 deaths of brick and tile makers from all causes 16, or 12 per cent, were from pulmonary tuberculosis. The details of the mortality, by divisional periods of life, are shown in Table 90.

TABLE 90.—PROPORTIONATE MORTALITY OF BRICK AND TILE MAKERS FROM PULMONARY TUBERCULOSIS, UNITED STATES REGISTRATION AREA, 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 | 14 | 3 | 21.4 |
| 25 to 34 years | 13 | 3 | 23.1 |
| 35 to 44 years | 18 | 5 | 27.8 |
| 45 to 54 years | 20 | 3 | 15.0 |
| 55 to 64 years | 26 | 2 | 7.7 |
| 65 years and over | 41 | | |
| Age unknown | 1 | | |
| Total, 15 years and over | 133 | 16 | 12.0 |

TABLE 91.—PROPORTIONATE MORTALITY OF BRICK AND TILE MAKERS FROM NONTUBERCULOUS RESPIRATORY DISEASES, UNITED STATES REGISTRATION AREA, 1909.

| Cause of death. | Deaths from nontuberculous respiratory diseases. | |
|---|---|---|
| | Number. | Per cent. |
| Asthma | | |
| Bronchitis | | |
| Pneumonia | 8 | 6.0 |
| Other nontuberculous respiratory diseases | 2 | 1.5 |
| Total | 10 | 7.5 |

The number of deaths under observation is too limited for entirely safe conclusions, but in a general way the table is sustained by insurance experience and foreign data. The proportionate mortality from pulmonary tuberculosis is below the average for all occupied males at ages under 35 and only slightly above the average at ages 35 and over. It may be said that the mortality of brick and tile makers from pulmonary tuberculosis approaches so closely to the normal for all occupied males that there are apparently no decidedly health-injurious conditions in this employment predisposing to pulmonary tuberculosis, and, as shown by Table 91, to nontuberculous respiratory diseases. The proportionate mortality from this group is 7.5 per cent for brick and tile makers, which compares with 10 per cent for all occupied males and 9.2 per cent for glassworkers.[1]

## MORTALITY OF BRICK, TILE, AND TERRA-COTTA MAKERS—INDUSTRIAL INSURANCE EXPERIENCE.

Additional statistical data as shown in Table 92 are available for this group of employments through the industrial mortality statistics of the Prudential Insurance Co. of America for the period 1897 to 1914, including 527 deaths from all causes, of which 82, or 15.6 per cent, are from pulmonary tuberculosis.

TABLE 92.—PROPORTIONATE MORTALITY FROM PULMONARY TUBERCULOSIS AMONG BRICK, TILE, AND TERRA-COTTA MAKERS, 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 brick, tile, and terra-cotta makers, 1897 to 1914, from— | | Per cent of deaths from pulmonary tuberculosis among— | |
|---|---|---|---|---|
| | All causes. | Pulmonary tuberculosis. | Brick, tile, and terra-cotta makers. | Males in registration area, 1900 to 1913. |
| 15 to 24 years | 48 | 11 | 22.9 | 27.0 |
| 25 to 34 years | 51 | 18 | 35.3 | 30.5 |
| 35 to 44 years | 81 | 16 | 19.8 | 23.4 |
| 45 to 54 years | 97 | 18 | 18.6 | 14.7 |
| 55 to 64 years | 121 | 13 | 10.7 | 7.9 |
| 65 years and over | 129 | 6 | 4.7 | 2.6 |
| Total, 15 years and over | 527 | 82 | 15.6 | 13.9 |

The proportionate mortality is relatively high at all ages, but not excessively so when compared with more decidedly health-injurious processes with exposure to metallic and more irritating mineral dust.

The corresponding industrial mortality experience of the Metropolitan Co. is limited to masons and bricklayers considered as a

[1] For earlier references to the health of brick makers, see the Journal of Health, Vol. II, page 286, and the Comparative Rates of Mortality in Various Occupations, pages 11, 27, and 45. For modern observations on the health of brick makers with special reference to health-injurious conditions, see the English report on Industrial Diseases, 1907, evidence by Chalmers, page 4304.

group. It includes 1,748 deaths from all causes. Table 93 is derived from Bulletin 207 of the Bureau of Labor Statistics, on "Causes of Death by Occupation."

TABLE 93.—NUMBER AND PER CENT OF DEATHS FROM SPECIFIED CAUSES AMONG MASONS AND BRICKLAYERS, 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 | 1,748 | ........ | 59 | 124 | 250 | 327 | 475 | 513 |
| Tuberculosis of the lungs | 332 | 19.0 | 28.8 | 45.2 | 42.0 | 26.6 | 10.5 | 3.3 |
| Cancer (all forms) | 113 | 6.5 | ........ | 1.6 | 2.8 | 4.6 | 10.3 | 7.8 |
| Alcoholism | 18 | 1.0 | ........ | 2.4 | 1.6 | 1.8 | .4 | .6 |
| Cerebral hemorrhage, apoplexy, and paralysis | 136 | 7.8 | ........ | .8 | 2.4 | 2.4 | 12.2 | 12.3 |
| Organic diseases of the heart | 227 | 13.0 | 3.4 | 6.5 | 8.0 | 9.2 | 14.7 | 18.9 |
| Acute and chronic bronchitis | 18 | 1.0 | ........ | .8 | ........ | .6 | .6 | 2.3 |
| Pneumonia (lobar and undefined) | 132 | 7.6 | 10.2 | 7.3 | 6.0 | 10.1 | 6.7 | 7.2 |
| Cirrhosis of the liver | 34 | 1.9 | ........ | .8 | 2.0 | 1.8 | 2.9 | 1.6 |
| Bright's disease | 178 | 10.2 | 5.1 | 3.2 | 5.6 | 10.1 | 12.2 | 12.9 |
| Suicide (all forms) | 29 | 1.7 | 1.7 | .8 | 1.2 | 1.5 | 1.9 | 1.9 |
| Accidental violence | 133 | 7.6 | 25.4 | 8.1 | 9.2 | 9.8 | 5.7 | 5.1 |
| All other causes | 398 | 22.8 | 25.4 | 22.5 | 19.2 | 21.5 | 21.9 | 26.1 |
| Total | 1,748 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |

[1] This title includes foremen and workmen: stonemasons, bricklayers, masons, bricksetters, tile layers, and plasterers.

This table includes a number of other specified causes of death, but throughout the most important disease is pulmonary tuberculosis, which accounts for 19 per cent of the mortality from all causes at ages 15 and over, and as much as 45.2 per cent of the mortality at ages 25 to 34. As observed by Dr. Dublin in his interpretation of the table, "the United States figures, the English figures, and those of the Prudential Insurance Co., all confirm the occurrence of rising relative indices in successive periods up to age 65, suggesting a direct causal relationship between tuberculosis of the lungs as a cause of death and the duration of service in this occupation." The inherent limitation of all data of this character is due, however, to the inclusion of widely varying employments in a single group, which rather requires the highly specialized consideration of carefully segregated branches or specific occupations to determine the true incidence of health-injurious conditions.

## POTTERS.

The pottery industry includes the manufacture of earthenware, china, and porcelain. It always has been recognized as one of the unhealthiest of trades, but the health-injurious effects vary widely according to particular employments. The most seriously exposed are the dippers, flint-mill workers, ground layers, mixers, scourers, and sweepers. In all of these employments except the first the exposure to health-injurious mineral dust constitutes a serious menace to health. In the case of dippers the liability to dust inhalation is modified and increased in seriousness by the risk of lead poisoning. The degree of dust exposure is also very serious in the case of kilnmen, mold makers, placers, pug-mill workers, sagger makers, and slip makers. In the aggregate the industry gives employment in the United States to about 26,000 persons, of whom one-fifth are women. The sanitary conditions of the trade have often been investigated, and the most recent evidence is to the effect that there have been material improvements within the last few decades. The most careful and useful observations of the industry were made by Arlidge, who for many years lived in the Staffordshire pottery district of England. Before quoting Arlidge the fact may be briefly referred to that as early as 1705 Ramazzini, in commenting upon the diseases of potters, pointed out that "not all who go by the name of potters are subject to the particular disease of the trade," and that, therefore, discrimination was necessary in the medical treatment of the different classes of employees. Ramazzini made a curious observation bearing upon the question of eye strain, which has received qualified consideration only within recent years, stating, with reference to potters, that "those who sit at the wheel and form the vessels by turning it about with their feet are apt to have a swimming in the head if their eyes are otherwise weak."

### SANITARY ASPECTS OF THE POTTERY INDUSTRY.

Arlidge, in discussing the effects of mineral dust in the manufacture of pottery before the Sanitary Institute in 1893, remarked at the outset that—

Scarcely any other manufacture has so strong a claim upon the attention of sanitarians as has that of pottery. It stands nearly at the head of the list of unhealthy occupations, and exercises its pernicious effects almost wholly upon the respiratory organs, by production of bronchitis and of consumption. Thus it is found that while workmen engaged in other employments have a mortality from chest diseases of 7.86 per cent, potters exhibit one of 12.29 per cent. Likewise with respect to phthisis—nonpotters present one of 9.27 and potters one of 12.90.

After describing the various processes of manufacture and their relation to health-injurious circumstances, Arlidge discussed the relation of clay dust and its irritating effects upon the mucous membrane and epithelium of the lungs, holding the opinion that—

Clinical observation abundantly confirms this fact. For a considerable time the inhaled dust is arrested in its advance toward the lung tissue proper by the mucous secretion in the bronchial tubes, and by the expulsive energy of the cilia lining of those tubes. But at length these resistant forces weaken before the constant entry of fresh dust, and in course of time the noxious material passes into the lymph channels, and also along the finer bronchi, until it reaches the intimate structure and the air cells themselves. Here as a foreign substance it sets up inflammatory action; lymph cells spring up, the air vesicles become choked with inflammatory products, the tissue around them gets indurated (lung sclerosis), and useless as breathing tissue.

The history of these pathological changes is reflected in the symptoms exhibited by the sufferers. In the primary stage little inconvenience is felt; there arises a desire to clear the throat of some impeding mucous at the end of the day's work, or upon transition to the outer air from the warm shop, and especially on rising in the morning. This expulsive act soon develops into a cough, and relief is obtained by the expectoration of more or less blackish viscid mucus. Presently there is a feeling of tightness in the chest, and the breathing grows less free and full. As time goes on these signs of disturbed lung function become more pronounced, and in the end the patient grows asthmatic—a victim of potters' asthma.

Until this advanced stage of disorder is reached it is singular to notice how little attention and anxiety are bestowed upon the pulmonary derangements. This is because the general health is, for the most part, not seriously affected, and inasmuch as while the sufferer breathes a warm air in his workshop or home, his lung trouble is felt as little more than an annoyance; or as something which is to be taken as a matter of course, and, like his wages, as an unavoidable incident of his calling.

As with chronic maladies at large, so with potters' bronchitis and asthma, the tendency is to grow worse and the lung lesion to extend, and soon the damaged respiration reacts upon the whole frame; the sufferer can not get proper outdoor exercise, his appetite fails, his sleep is broken, the expectoration augments and grows muco-purulent, the body wastes slowly, while the increased effort to breathe entails strain upon the heart, leading not infrequently to disease of that organ, with the after consequences in the shape of dropsical effusions.

We now have before us the fully developed disease known as potters' consumption or potters' asthma.

### EFFECTS OF SILICA DUST.

The injurious effects of clay dust in the pottery industry are further increased by minute particles of flint, and a possible additional factor injurious to health is the extensive use of plaster of Paris, employed in the making of molds and models. According to Arlidge, the effects of plaster of Paris dust, however, are not apparently as serious as the very destructive effects of silica dust and small particles of flint. He draws attention to the necessity of an efficient system of ventilation as the only means by which material improvements can be brought about.

### LIABILITY TO LEAD POISONING AND PULMONARY DISEASES.

The health-injurious effects of lead, extensively used in potteries, which do not properly fall within the present discussion, must here be passed over.[1] It is true, of course, that a considerable amount of lead dust is inhaled, but the effects are rather upon the system generally than upon the lungs. The observations of Arlidge are so entirely sustained by other qualified observers that it is not necessary to further enlarge upon the sanitary aspects of this trade. The evidence, statistical or otherwise, is conclusive that potters as a class suffer more, perhaps, from phthisis and other diseases of the lungs than employees in any other occupation, and their mortality from bronchitis and other respiratory diseases is many times as high as the mortality of occupied males generally; but it has been pointed out by Tatham, in his contribution to Oliver's "Dangerous Trades," that—

Potters succumb to nontubercular disease of the lungs much more rapidly than they do to tubercular phthisis; and it is certain that much of the so-called potters' phthisis ought properly to be termed cirrhosis of the lung. Deaths from this affection should never be included under the head of phthisis, which term is now restricted, by universal consent, to the tubercular malady of that name.

It is also necessary to keep in mind, in discussing the pottery industry, that it divides itself broadly into two principal departments—that is, first, the making of the articles from potters' clay, and, second, their ornamentation by painting, gilding, etc. The latter group of occupations is usually defined as decorators, and sometimes as printers, and because of this fact many errors occur in occupation statistics as the result of erroneous classification—not based upon the industry as such, but upon the specific title of the employment.

## SPECIFICALLY INJURIOUS PROCESSES.

One of the most health-injurious employments in the industry is that of the brushing, or dusting off, of the ware after it is taken from the kilns. Oliver, in discussing at length the sanitary aspects of china and earthernware manufacture and in particular potters' asthma and pulmonary tuberculosis, draws special attention to this process as observed in the porcelain potteries at Limoges. He remarks that—

The brushing off or époussetage of the fired or biscuited ware is done both by women and men by means of soft feather brushes. It is a very dusty operation, and where there are no fans for its removal, as in some of the factories I visited, the air was thick with dust. The windows were open at the time, but currents of air obtained by this

[1] With respect to lead poisoning in the pottery trades see:

Departmental report on "The Pottery Industry in France," by Thomas Oliver, M. D. London, 1899.

Departmental report on "The Employment of Compounds of Lead in the Manufacture of Pottery," by Thorpe and Oliver. London, 1899.

Departmental report on "Lead in the Manufacture of Earthenware and China," Vols. I, II, and III. London, 1910.

Bulletin of the U. S. Bureau of Labor, No. 104, "Lead Poisoning in Potteries, Tile Works, etc.," by Dr. Alice Hamilton. Washington, 1912.

means exercised no very appreciable influence upon the dust. It is not this kind of ventilation that is required under these circumstances. In the matter of the provision of artificial means for the removal of dust and the renewal of air in the potteries of Limoges, some of the manufacturers seemed to me to be rather behind than in advance of the owners of large factories in Staffordshire. Accordingly I was not unprepared for the information that among the potters, especially the brushers off or scourers, in Limoges, the mortality from pulmonary consumption and chest diseases is high. The harmful operations in porcelain works are the emptying of the kilns, the removal of the ware from the saggers and the brushing of this ware, while the hard dust that rises during the polishing of the all but finished articles is equally dangerous. The polishing has for its object the removal of any roughness from the edges or surfaces of the ware, and it is generally done on a revolving wheel by means of a broken piece of china, the workman using this as a smoothing agent. The men and women employed in these operations are usually well covered with dust, yet it is seldom that they wear respirators. Fans for the removal of the dust were present in only very few of the factories. The employees objected to them on the ground that they created a strong draft of cold air. Dr. Raymondaud, one of the professors in the School of Medicine, Limoges, has made a special study of the diseases of porcelain makers, particularly of pulmonary consumption and chronic bronchitis. He found that the potteries furnished a larger number of patients suffering from lung diseases than did the other trades of the district. Of 75 deaths registered in Limoges as occurring among china makers, 36 were due to phthisis, and of 30 potters whom Raymondaud examined, 20 were suffering from pulmonary consumption. Pulmonary phthisis is regarded as the principal disease affecting the workers in the Limoges potteries.

### ENGLISH OCCUPATIONAL MORTALITY STATISTICS.

The most recent English mortality statistics of potters 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:

Between the ages 20 and 35 years the mortality of potters falls below that of occupied and retired males generally; at every other age, however, it shows an excess which amounts to no less than 74 per cent at ages 45 to 55 years, and to 66 per cent at ages 55 to 65 years. In the main working time of life the comparative mortality figure is 1,493, or 49 per cent above the standard. The principal excess falls under the head of respiratory diseases, for which the mortality figure is 473, or nearly thrice the standard. There is also a considerable excess in the mortality from phthisis, from nervous and circulatory diseases, and from suicide. These workers are also specially liable to lead poisoning, but from accident as well as from influenza, Bright's disease, and alcoholism their mortality is low.

In the last decennial supplement the mortality of potters was described as enormous. From the present report, however, it will be seen that since 1890–1892 their mortality has declined at every stage of life; and in the main working period the comparative mortality figure has fallen from 1,970 to 1,420, or by no less than 28 per cent. It is satisfactory to note that in the recent period the mortality of potters from plumbism has fallen to less than half its former amount, while there has also been a substantial decline under most other headings; the mortality from respiratory and urinary diseases having fallen by about one-third, that from phthisis, nervous and digestive diseases by about one-fourth, and that from circulatory diseases by about one-fifth part. Potters, however, now fall victims in increased proportion to accident, and to suicide, and the mortality from cancer has increased by more than half. Since 1860, '61, '71 the death rates of potters both above and below 45 years of age have fluctuated somewhat, but the recent modified mortality figure is by far the lowest on record. Since 1880–1882 there has been a continuous decline of mortality from phthisis, from liver disease, and from diseases of the nervous and digestive systems.

The English statistics for potters are quite conclusive of the unfavorable effects of this industry on health. In Table 94 the mortality from all causes among potters is compared with that of occupied males generally, and the result is decidedly suggestive of conditions more or less unfavorable to life and health, but in particular at ages 35 or over, when the mortality rate from all causes exceeds by from 4.30 to 29.86 per 1,000 the corresponding mortality of occupied males generally.

TABLE 94.—MORTALITY FROM ALL CAUSES AMONG POTTERS, 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 among potters. | | |
|---|---|---|---|---|
| | | Rate per 1,000. | Greater (+) or less (−) than rate for all occupied males. | Ratio to rate for all occupied males. |
| 15 to 19 years | 2.44 | 2.62 | + 0.18 | 107 |
| 20 to 24 years | 4.41 | 3.68 | − .73 | 83 |
| 25 to 34 years | 6.01 | 5.26 | − .75 | 88 |
| 35 to 44 years | 10.22 | 14.52 | + 4.30 | 142 |
| 45 to 54 years | 17.73 | 31.64 | +13.91 | 178 |
| 55 to 64 years | 31.01 | 54.15 | +23.14 | 175 |
| 65 years and over | 88.39 | 118.25 | +29.86 | 134 |

The preceding table is self-explanatory. A more extended comparison, however, is made in Table 95, in which the mortality of potters from pulmonary tuberculosis and from other diseases of the respiratory system is compared with the normal mortality of occupied males from these diseases, by divisional periods of life. The comparison shows that the mortality from pulmonary tuberculosis among potters is decidedly excessive at ages 35 to 64 by from 1.05 to 4.10 per 1,000. Still more marked is the excess in the mortality from respiratory diseases other than pulmonary tuberculosis among potters at ages 35 or over, which varies from 1.63 to 17.27 per 1,000.

TABLE 95.—MORTALITY FROM PULMONARY TUBERCULOSIS AND FROM OTHER DISEASES OF THE RESPIRATORY SYSTEM AMONG POTTERS, 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 potters. | | | Death rate per 1,000 for all occupied males. | Death rate for potters. | | |
| | | Rate per 1,000. | Greater (+) or less (−) than rate for all occupied males. | Ratio to rate for all occupied males. | | Rate per 1,000. | Greater (+) or less (−) than rate for all occupied males. | Ratio to rate for all occupied males. |
| 15 to 19 years | 0.54 | 0.62 | +0.08 | 115 | 0.24 | 0.46 | + 0.22 | 192 |
| 20 to 24 years | 1.55 | 1.34 | − .21 | 86 | .48 | .58 | + .10 | 121 |
| 25 to 34 years | 2.03 | 2.00 | − .03 | 99 | .77 | .64 | − .13 | 83 |
| 35 to 44 years | 2.74 | 3.79 | +1.05 | 138 | 1.66 | 3.29 | + 1.63 | 198 |
| 45 to 54 years | 3.04 | 7.14 | +4.10 | 235 | 3.32 | 10.78 | + 7.46 | 325 |
| 55 to 64 years | 2.16 | 4.37 | +2.21 | 202 | 6.54 | 23.10 | +16.56 | 353 |
| 65 years and over | 1.11 | .97 | − .14 | 87 | 17.77 | 35.04 | +17.27 | 197 |

## INVESTIGATIONS BY DEPARTMENTAL COMMITTEE ON INDUSTRIAL DISEASES.

With further reference, however, to the excessive mortality from respiratory diseases among potters, which, as subsequently to be shown, is confirmed by American industrial insurance mortality experience, reference may be made to the discussion of the occurrence of potters' asthma, in the Report of the Departmental Committee on Industrial Diseases. The evidence submitted to the committee disclosed a decided improvement in the disease liability of potters to the fibroid form of phthisis, based upon the records of the North Staffordshire Infirmary, at Stoke-upon-Trent, covering the period 1873-1906. Upon a basis of 10,000 patients, the number of cases of fibrosis of the lungs was found to have been 145 during the six years ending with 1878, 107 during the six years ending with 1897, and only 4 during the six years ending with 1906.[1] In the opinion of a qualified medical witness, the diminution was not the result of a difference in the practice of diagnosing, but a real reduction in the prevalence of the disease. The improvement in the disease liability was attributed to a betterment in the conditions of work and a more effective method of factory supervision, inspection, and control. Aside from these favorable conclusions, however, the general mortality statistics of this trade indicate continued unfavorable circumstances, reflected in the decidedly excessive degree of pulmonary tuberculosis frequency and a correspondingly excessive mortality from other respiratory diseases in the more advanced years of life.

[1] Minutes of Evidence, Departmental Committee on Compensation for Industrial Diseases, London, 1907, p. 60.

## DESCRIPTIVE ACCOUNT OF THE AMERICAN POTTERY INDUSTRY.

These preliminary observations are strongly indicative of an industry in which the dust problem is of exceptional importance in its relation to health and longevity. The aggregate value of pottery products in the United States in 1915 was nearly $40,000,000, or almost twice the value reported for 1901. The principal branches of manufacture are (1) red earthenware; (2) stoneware and Rockingham ware; (3) whiteware, including CC ware; (4) china, bone, delft, and belleek ware; (5) sanitary ware; (6) porcelain, electrical supplies; (7) miscellaneous. The number of active manufacturing plants in 1913 was 426. The principal pottery-producing States are Ohio, New Jersey, and West Virginia, which, combined, produce 76 per cent of the total product. The pottery industry has been admirably described in a report of the Bureau of Foreign and Domestic Commerce,[1] including descriptive accounts of the various special processes, with observations on methods and labor conditions in other countries. The principal departments of the industry are (1) preparation of materials; (2) forming the ware; (3) firing the ware; (4) decorating; (5) packing, etc. Each branch consists by itself of numerous and often highly specialized processes, which do not permit of being briefly described. Practically without exception, however, it may be said that all processes involve more or less dust exposure, the nature of which, of course, will vary considerably according to the product. As a general conclusion, based upon reasonably thorough investigations in this country and abroad, it may be said that the sanitary and other conditions affecting the health of potters in this country are decidedly better than those which affect the health of potters, for illustration, in England and Wales. The workshops in this country, as a rule, have a greater abundance of light and ventilation and more adequate provision for heating during the winter. The more extensive use of machinery, by which most of the very hard labor in mixing the clay and running the so-called jigger and jolly machines is largely done away with, is also a factor of considerable practical importance. On account of the specific liability to lead poisoning in the pottery industry, it is suggested that the proportion of lead used in the dipping processes in this country should be generally much less than in England and Wales. The climatic conditions in the United States are also in favor of a lower mortality rate from respiratory diseases resulting from weather exposure.[2]

[1] The Pottery Industry. Miscellaneous Series, No. 21. U. S. Bureau of Foreign and Domestic Commerce. Washington, 1915.

[2] Lead Poisoning, by Sir Thomas Oliver. London, 1914.

### DESCRIPTION OF PROCESSES ACCORDING TO DUST EXPOSURE.

The disease liability of employees in the various branches of the pottery industry in the United States, roughly approximated, is as follows:[1]

1. Office workers, dust exposure very slight and general conditions favorable.

2. General outside laborers, dust exposure slight, but general conditions often far from favorable.

3. Mixers of materials for glaze, etc., dust exposure very considerable, especially of clay, flint, and white lead.

4. Slip makers, pug-mill workers, etc., considerable dust exposure and dampness.

5. Mold makers, some dust exposure, chiefly to plaster of Paris.

6. Throwers, some dust exposure. Occupation is more or less obsolete.

7. Jigger men and jolly men, considerable dust exposure, but fairly favorable indoor conditions.

8. Pressers of hollow ware, some dust exposure, but fairly favorable indoor conditions.

9. Pressers of flat ware, some dust exposure, but fairly favorable indoor conditions.

10. Pressers of sanitary ware, a lesser degree of dust exposure, but occasionally considerable dampness.

11. Sagger makers, exposure to dust and dampness and frequently heavy physical strain.

12. Kiln men, placers, considerable exposure to flint dust and other unfavorable conditions.

13. Kiln men, drawers, considerable exposure to dust and frequently extreme heat.

14. China scourers, brushers (women), very considerable exposure to irritating flint and other dust.

15. Dippers and dipper helpers, exposure to risk of lead poisoning and much dampness.

16. Decorators, printers, and fillers-in, exposure to mineral poisons, lead poison, and atmospheric pollution on account of odor of turpentine.

17. Ground layers (decorators), very considerable exposure to risk of inhalation of dry dust of mineral paints.

18. Warehousemen, slight degree of exposure to inorganic dust.

19. Packers, considerable exposure to dust of straw and inorganic dust.

20. Sweepers, exceptionally serious exposure to flint and clay dust.

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[1] This list is based upon personal investigations into the pottery industry, chiefly in the States of New Jersey, Ohio, and West Virginia.

21. Flint-mill workers, considerable and continuous exposure to the most dangerous form of irritating flint dust.

These observations are only approximate, and it should be considered that the different employments are frequently carried on in conjunction with or in continuance of one another. The most exposed employments are those of china scourers, ground layers, sweepers, and flint-mill workers.

### PATHOLOGY AND SYMPTOMOLOGY OF THE DUST PROBLEM.

The pathology and symptomology of the dust problem in the pottery industry has attracted the serious attention of all authorities on occupational diseases. A concise and exceptionally conclusive though very brief contribution to the study of lung sclerosis in porcelain workers was made by a French authority—Dr. Lemaistre—in Le Progres Medical and translated in the Medical Record for December 27, 1890, in connection with which it is stated that—

Sections of the lung are generally colored, according to the material that has been introduced; but here the lung is blackish, although the substance introduced may be white, owing to inflammatory conditions. The symptoms are analogous to tuberculosis and the diagnosis is difficult. The posterior aspect of the lung is most frequently the seat of the sclerosis. Sometimes the sounds of pulmonary emphysema or of pleurisy may be heard. It is, however, differentiated from emphysema by the absence of tympanitic sounds. The sputa are characteristic. There is no hectic fever or nocturnal sweating. Men are more frequently attacked than women. He has found bacilli in the sputa and regards the disease as a tubercular fibrosis. The siliceous particles produce ulcerations in the bronchi, upon which the tubercular matter is grafted, and continues to exert an irritant action which induces hyperplasia of the connective tissue. This, to a certain extent, is salutary.

### POTTERS' ASTHMA.

Partly in consequence of this condition inimical to the health of pottery employees generally the term "potters' asthma" has been widely accepted as typical of the highly specialized conditions under which respiratory affections resulting from continuous dust exposure in the pottery industry are likely to occur. In a measure potters' asthma resembles miners phthisis, but it is frequently indistinguishable from true tuberculous phthisis, without the preceding lung fibrosis. It was brought out in the evidence collected by the departmental committee on industrial diseases that china scourers and biscuit placers were probably the most liable to potters' asthma, but all the indoor occupations in the potteries are more or less affected, though, of course, to a considerably varying degree. A table was presented by Dr. Dawes of the deaths of potters in Longton, Staffordshire, for the period 1898 to 1906, showing conclusively the excessive incidence among potters of deaths from bronchitis, potters' asthma, and fibroid phthisis. All of these terms are more or less inclusive of each other.

## COMPARATIVE OCCUPATIONAL MORTALITY STATISTICS.

A table was also introduced into the evidence by Dr. Tatham, based upon the mortality of England and Wales for 1900 to 1902, including comparative statistics for other dusty trades, as follows:

TABLE 96.—COMPARATIVE MORTALITY FROM PHTHISIS AND DISEASES OF THE RESPIRATORY SYSTEM IN CERTAIN SPECIFIED OCCUPATIONS, ENGLAND AND WALES, 1900 TO 1902.

| Occupation. | Phthisis and diseases of the respiratory system. | | Mortality figure. | |
|---|---|---|---|---|
| | Mortality figure. | Ratio. | Phthisis. | Diseases of respiratory system. |
| Agriculturist | 161 | 100 | 79 | 82 |
| Dock laborer, wharf laborer | 632 | 393 | 291 | 341 |
| Potter, earthenware, etc., manufacturing | 741 | 460 | 277 | 464 |
| Cutler, scissors maker | 812 | 504 | 516 | 296 |
| Tin miner | 1,577 | 980 | 838 | 739 |
| Nail, anchor chain, and other iron and steel manufactures | 493 | 306 | 182 | 311 |
| Stone, slate quarrier | 390 | 242 | 186 | 204 |
| Brass, bronze, manufacturer, founder, finisher, worker | 469 | 291 | 262 | 207 |
| Bricklayer, mason, builder | 364 | 226 | 188 | 176 |

NOTE.—This table is to be read thus: Among a certain number of males aged 25 to 65 years in the general population, 1,000 deaths occurred during the years 1900 to 1902; of these 1,000 deaths, 186 were due to phthisis and 174 to diseases of the respiratory system. Among an equal number of agriculturists living, at the same ages, there were 79 deaths from phthisis and 82 from diseases of the respiratory system. Among an equal number of dock laborers, 291 and 341, respectively, and so on.

## RESULTS OF SANITARY IMPROVEMENTS.

Attention was directed in the evidence to the material improvement in the health conditions of the pottery industry of England and Wales during the last 30 years, particularly by Dr. Frank Shufflebotham, who presented data relative to the frequency of fibrosis of the lungs as observed in the experience of the North Staffordshire Infirmary, Stoke-upon-Trent, which is a center of the English pottery industry. The seriousness of the existing situation, however, in 1907, when the departmental committee on industrial diseases made its investigations, is concisely set forth in a brief statement by Dr. C. Petgrave Johnson, as follows:

I find that during the seven years, 1900-1906, of potters' pressers living in Stoke, 47 died. Of these, 14 died of bronchitis, 15 of phthisis, and 5 of pneumonia, i. e., over 72 per cent of the deaths were due to lung diseases. If the deaths in the North Stafford Infirmary and the Stoke-upon-Trent Union Hospital are included, then 112 deaths among potters' pressers occurred in the same seven years. Of these 31 were due to bronchitis, 43 to phthisis, and 4 to pneumonia, i. e., 70 per cent of the deaths were due to lung diseases. These figures are correct.

I find that during the seven years, 1900–1906, in not a single instance in any of the deaths amongst potters' pressers occurring in the North Stafford Infirmary or in the workhouse hospital or in the borough of Stoke, is fibroid phthisis or potters' asthma, or cirrhosis of the lungs, or fibroid pneumonia given as the cause of death. Bronchitis, phthisis, pulmonary tuberculosis, pneumonia, are the diseases of the lungs which are mentioned.

I should like to supplement this by stating that the changes in the lungs caused by particles of dust progress very slowly, years passing during the development. Should tuberculosis of the lungs supervene, the man dies in a comparatively short time, and any lung changes due to dust do not attract attention. Should bronchitis develop, however, he survives for years, and latterly, in the intervals—if any—of comparative freedom from bronchitis, the lung changes due to dust may attract attention or may not. The bronchitis symptoms, however, always attract more attention.

### INJURIOUSNESS OF SCOURING PROCESS.

These general observations concerning the pottery industry as a whole are amplified by an extensive amount of evidence concerning health-injurious processes in detail. Concerning china scouring, for illustration, it is said in the report of the chief inspector of factories and workshops for 1908, that—

"Scouring" is one of the many operations to which china is subjected during the course of its manufacture and is comparatively simple, being, in fact, merely subsidiary to the manufacturing process. In order to prevent the pieces of soft unbaked clay from becoming fused to each other, or to sides of the saggers in which they are placed during the firing in the kiln, each piece is separately buried in a bed of fine flint dust with which the sagger is filled. After the firing is accomplished this flint dust, which resembles fine sand, has to be removed. The heat causes a considerable portion of it to become fused to the surface of the baked ware to which it adheres, and it is therefore necessary to get rid of this by scrubbing each piece of ware with a dry and very stiff brush. The operation, as its name implies, is more drastic than that of mere dusting. The piece is first "knocked" and the sharp jars cause the loose dust to fall off, then scrubbed with a revolving motion with a stiff brush (often worked by power), and then it is rubbed with coarse flannel; finally, the remains of the rough adhering particles are smoothed off by means of sandpaper. From this description it will be seen that the operation is a very dusty one.

### INJURIOUSNESS OF FLINT DUST.

Attention is directed in this statement to the difference between china scouring and earthenware "towing," it being stated that in earthenware the material to be removed is soft clay dust, while in china it is a very finely ground flint, the microscopical particles of which are sharp and jagged. The conditions are particularly unfavorable in small plants where rules and regulations regarding mechanical methods of dust removal can not be effectively applied except at prohibitive expense. At the same time it is thoroughly well recognized, and as pointed out in the report referred to, that "a microscopic examination of the flint in which china is bedded shows that owing to the shape of the particles it forms one of the most mechanically injurious of all dusts." And in the Staffordshire district the relation of this dust to pulmonary tuberculosis is so well known that death certificates frequently merely mention as cause of death the significant term "flint." Since most of this work is done by women, in the United States as well as in England and on the Continent, the mortality data, usually limited to males, have not become available. A special investigation, however, was made in the Longton district concerning the female population, with the result shown in Table 97.

TABLE 97.—MORTALITY FROM RESPIRATORY DISEASES (INCLUDING PHTHISIS) IN LONGTON: CHINA SCOURERS AND TOTAL FEMALE POPULATION COMPARED, 1896 TO 1898.

[Rates are based on female population in 1891 (10,561) and number of china scourers in 1898 (160), ages 15 to 70.]

| Year. | Deaths from respiratory diseases (including phthisis) among— | | | |
|---|---|---|---|---|
| | All females. | | China scourers. | |
| | Number. | Rate per 1,000 per annum. | Number. | Rate per 1,000 per annum. |
| 1896 | 45 | 4.3 | 12 | 75.0 |
| 1897 | 49 | 4.6 | 11 | 68.9 |
| 1898 [1] | 29 | 5.5 | 6 | 75.0 |

[1] From January to June.

The data, of course, are of rather limited extent, but they are quite sufficient for the purpose of emphasizing the extreme injuriousness of china scouring as carried on under existing conditions which, as a general rule, preclude adequate consideration of effective methods for the control of the dust evil. As is well said in connection with the foregoing table in the report referred to—

In order to reduce the appalling death rate shown in the table it is necessary to prevent the inhalation of flint by the workers. It is a fact that every form of dust produced during the course of a manufacturing process can be extracted from the workroom by means of a sufficient number of properly placed and efficiently contrived exhaust fans. The important point is that this should be done in such a manner as to prevent the dust from becoming dispersed in the air or from being drawn past the faces of the workers. In several factories we found that fans had been introduced, and when these were efficient the atmosphere and the clothes of the women themselves were strikingly free from flint. In two factories we found substitutes for a fan, but we observed no difference between these and the places in which there were no means of removing the dust; in most cases the benches are placed directly in front of the windows, so that when these are open the dust is blown directly into the faces of the workers. The structural conditions of some of the smaller china factories are such that we are in agreement with the opinion of the medical members of the committee of 1893, and with that expressed in the special report of Profs. Thorpe and Oliver that "they are wholly or in part unfitted for use as work places, inasmuch as work can not be carried on in them without injury to health." In others, however, alterations entailing a small expense would very materially improve the conditions, while in all, so long as they are permitted to remain in use, effective means of drawing off the clouds of unhealthy dust are a necessity.

### CONTINUOUSNESS OF INJURIOUS CONDITIONS.

This lamentable condition has remained practically unchanged in the pottery industry since its development on a large scale, for, as shown by the evidence before the royal commission of 1841,[1] inquiring into the employment of children and young persons, the excessive frequency of respiratory diseases resulting from exposure to flint and other dust was thoroughly well recognized at the time but considered inherent in the conditions under which the industry was carried on. Conditions in this country have not been subjected to an equally thoroughgoing scientific investigation, but the recorded observations of factory inspectors, health officials, and others quite fully confirm the prevailing view that while the health and mortality of potters in America are more favorable this is chiefly because of better sanitary surroundings, housing, food, etc., higher wages and shorter hours, and a decidedly lesser incidence of habits of intoxication. Dr. H. R. M. Landis, of the Phipps Institute of Philadelphia, in an investigation regarding American potteries points out that—

His own observations had led him to believe that more care should be exercised on the part of the workmen in the disposal of the fragments of clay which were thrown off in the fashioning of the various utensils. Too much of it was allowed to fall on the floor about the work bench, and as a result was walked upon and quickly pulverized into dust. Face masks had been repeatedly advocated, but had never been particularly successful, for the reason that the workmen were averse to using them. He believed that these individuals, especially those working in the dusty departments, should be subjected to frequent medical inspections. A compulsory examination three or four times a year would undoubtedly result in detecting many cases which would otherwise pass into the terminal stages of potters' asthma or tuberculosis.[2]

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[1] Physical and Moral Condition of the Children and Young Persons Employed in Mines and Manufactures, London, 1843.

[2] Medical Record, July 25, 1914.

## SANITARY ASPECTS OF THE POTTERY INDUSTRY IN OHIO.

Hayhurst in his numerous reports on industrial conditions in Ohio has extensively dealt with the pottery industry, and in a general way the results of his investigations confirm conclusions based upon foreign experience. Concerning slip making, which means the removing of the clays in the form of dust and lumps from the stock bins, followed by grinding, water washing, and sifting processes, through the use of pug mills, agitators, compressing machines, and drying kilns, the dust hazard was found to be serious in 23 work places, fairly serious in 6, and of small importance in 9, out of a total of 38. It was found that the chief causes of dust in the atmosphere in connection with slip making were the more or less constant shoveling of clays in the dry form, its escape from grinding machines, and its being raised from the floor by moving air currents, etc. In 20 of the places dampness was an additional occupational hazard, chiefly because of faulty floor drainage, leaky vats, etc. The general appearance of the workers was not more than fair in 30 of the 38 work places. Many prematurely aged, pale, and underweight men were seen among those longest employed. According to a report in the Ohio Public Health Journal for January-March, 1916, "the chief complaints of the workers were the breathing of dust, damp quarters, heat, fatigue, poor washing facilities, and general insanitary quarters." Excepting, however, the dust hazard, none of the other conditions was considered seriously injurious to health.

## INJURIOUSNESS OF FLINT-DUST MAKING.

Flint-dust making without question is the most hazardous process in the pottery industry. Only a few of the large firms were found to employ this process on their own account, but the attention of the investigators was directed to two firms employing foreign laborers engaged in making this product, which involves crushing, grinding, conveying, and packing, in connection with all of which there was observed "an unusual amount of fine, hard flint dust, which pervaded the air of the work place and coated the openings of windows, doors, and roof vents with a white flourlike powder." It is, therefore, properly suggested that dust-confining machinery, short hours, and respirators are needed in all such places.

## MOLD AND SAGGER MAKING.

In the same investigation the process of mold making was reported upon for 16 plants. The molds are made of plaster of Paris, which involves considerable exposure to a recognized injurious form of mineral dust. Health appliances to handle and confine the dust mechanically were found to be absent in all places. In 10 of the 16 places the dust was considered to constitute a fairly serious health hazard. In 10 of the work places the appearance of the workers was considered unsatisfactory. The chief complaint was on account of the breathing of the dust and general unsanitary features. It is suggested that it would appear "that mechanical means could be contrived to convey and weigh the dusts used, for being a dusty occupation and an injurious type of dust, workers should be under medical supervision, and, in addition, respirators should be furnished and worn during the performance of unavoidably dusty operations."

Sagger making is described by Hayhurst as consisting in the making, shaping, baking, finishing, and repairing of the clay containers in which the pottery ware is baked in the kilns. This occupation employs relatively few persons in the pottery industry. The dust factor was considered of importance in 10 out of 19 plants investigated. The chief cause of the dust was "the careless handling and dumping of clays and the disturbance of the dust on the floors and benches by the workmen or by air currents." The chief occupational hazard, however, was not the dust, but the liability to chronic lead poisoning. The general complaint was on account of the breathing of dust and exposure to dampness, with resulting liability to rheumatism. Heat exposure was not considered serious.

### JIGGERMEN, JOLLYMEN, AND PRESSERS.

Pottery-making processes proper include the work of the throwers, the jiggermen, the jollymen, and the pressers. More precisely the employments in the Ohio pottery industry are stated by Hayhurst to include "batters-out, pressers, jiggermen, jollymen, turners, handlers, stickers-up, dish-specialty makers, finishers, machine pressers, mold boys (called also mold runners and dog trotters), and helpers." The processes in connection with these employments were investigated in 53 plants, including all branches of the industry, employing 3,048 wage earners, of whom 2,521, or 82.7 per cent, were males and 527, or 17.3 per cent, were females. The majority of all potters, it is stated, are employed in the bisque-making rooms. The class of workers was found to be mostly native and above the average. In 40 of the work places the employees were found to be exposed to a considerable hazard on account of the breathing of fine clay dust. Some machine pressrooms were free from dust, but others were very dirty, apparently because clays were handled drier. The finishers, chiefly women, who scrape rapidly revolving articles, ran the greatest dust hazard, while the mold boys and helpers, who handled the dried bisques in the ovens, suffered next in hazards. In no places were local exhaust systems found for the protection of finishers. Dampness was quite common and was found to be a serious hazard in 25 of the work places investigated. Complaint was made of insufficient heating, and poor ventilation was reported in more than half of the plants investigated, especially during the winter months. The basis of this complaint was the large number of work people assembled together, the presence of the baking ovens, and the lack of air agitators and air-conditioning systems, and often to the absence of ordinary vents in types of buildings which it was impossible to ventilate sufficiently without mechanical means. The general appearance of the workers was favorable in only 10 places, but in the balance many fatigued, under-weight, and physically inferior employees were observed. The usual complaints were on account of the heat, fatigue, dust, poor ventilation, dampness, and cold. It is held that this particular process is the chief source of tuberculosis in the pottery industry, and that many instances of the disease were brought to the attention of the investigators of the Ohio State Board of Health by both workmen and employers, usually, however, with the information that its occurrence was unavoidable. Among the hygienic shortcomings pointed out, the investigation emphasized the injurious nature of atmospheric changes and the absence of physical examination. Attention is directed to the fact that pneumonia is a frequent occupational disease among those who inhale clay and other mineral dust. The generally dust-contaminated nature of the atmosphere in the workrooms was sufficiently established to justify the conclusions arrived at.

Similar conclusions apply more or less to other processes in the pottery industry, the dangers of which in some cases, however, are materially increased by the risk of lead poisoning. How far there is a possible relation between lead poisoning and pulmonary tuberculosis has not been determined.[1] It is, however, fair to assume that whatever conditions result in a diminution of vital resistance generally must more or less act as a predisposing cause of pulmonary tuberculosis.

### LEAD POISONING AND PULMONARY DISEASES.

The dangers of lead poisoning in the pottery industry have been reported upon in numerous official investigations, including Bulletin 104 of the United States Bureau of Labor Statistics. Dr. George Reid, in a discussion of the evidence of the departmental committee appointed to inquire into the dangers attendant on the use of lead in the manufacture of earthenware and china, published by the

[1] Sir Thomas Oliver, in his "Lead Poisoning," London, 1914, pp. 83–88, carefully considers the question as to whether or not lead poisoning of itself predisposes to tuberculosis, including the opinion of Prof. Hahn of Munich and the animal experimentation of G. Loriga. Oliver concludes that "the only way in which it can do so is by reducing the general vital resistance of the individual."

British Government in 1910, raises, however, a very important question when, according to the British Medical Journal (Sept. 24, 1910), he remarks that, "without minimizing the gravity of the situation so far as lead poisoning is concerned, the mortality from this cause is a cipher compared with the deaths from phthisis and respiratory diseases—the death rate from plumbism per 1,000 being 0.81 compared with 7.05 for phthisis." In the same publication it is said that another interesting and far-reaching problem, which was also raised by Dr. Reid, was with reference to compensation in cases of lung diseases among potters, which is referred to as a problem bristling with difficulties. In proportion, of course, as industrial lung diseases are brought within the range of workmen's compensation for industrial injuries, as possibly quite separate and distinct from industrial diseases in the strictly limited sense of the term, the necessary methods and means of dust prevention will receive more adequate consideration.

The report of the departmental committee on the pottery trade is one of the most important contributions to the literature of occupational diseases, and although chiefly with reference to the dangers of lead poisoning, the report includes a mass of related evidence of exceptional usefulness in general consideration of the health problem in industry. The investigation of the special committee included 550 pottery works employing 63,000 persons and 7 lithographic transfer works. It was found that out of 63,000 workers 6,856, or 11 per cent, were brought in contact with lead, whereas 23,000, or 37 per cent, were exposed to the inhalation of dust. The latter conclusion, however, must be accepted in a restricted sense, since the committee apparently concerned itself only with dust obviously seriously injurious and sufficiently determinable as to quantity and health-injurious qualities. It is difficult to accept the conclusion that 53 per cent of the workers in English potteries, as stated in a letter in the Journal of the American Medical Association, dated London, July 9, 1910, "are not exposed to any particular danger to health." Investigations in this country, particularly in Ohio, indicate that a much smaller proportion of pottery employees is engaged in relatively harmless employments.

### MORTALITY OF POTTERS—UNITED STATES REGISTRATION AREA.

The mortality of potters has been reported upon only for the year 1909 by the Division of Vital Statistics of the United States Census Bureau and no subsequent information has been made public, so that the data are of rather limited value. This is particularly regrettable in the case of so important an occupation as the pottery industry, for the mortality returns for the United States registration area for the year referred to are limited to 136 deaths from all causes, of which 47, or 34.6 per cent, were from pulmonary tuberculosis. The details of the mortality by divisional periods of life are shown in Table 98.

TABLE 98.—PROPORTIONATE MORTALITY OF POTTERS FROM PULMONARY TUBERCULOSIS, UNITED STATES REGISTRATION AREA, 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 | 13 | 6 | 46.2 |
| 25 to 34 years | 27 | 12 | 44.4 |
| 35 to 44 years | 26 | 11 | 42.3 |
| 45 to 54 years | 32 | 12 | 37.5 |
| 55 to 64 years | 12 | 5 | 41.7 |
| 65 years and over | 26 | 1 | 3.8 |
| Total, 15 years and over | 136 | 47 | 34.6 |

TABLE 99.—PROPORTIONATE MORTALITY OF POTTERS FROM NONTUBERCULOUS RESPIRATORY DISEASES, UNITED STATES REGISTRATION AREA, 1909.

| Cause of death. | Deaths from nontuberculous respiratory diseases. | |
|---|---|---|
| | Number. | Per cent of deaths from all causes. |
| Asthma | 1 | 0.7 |
| Bronchitis | 1 | .7 |
| Pneumonia | 9 | 6.7 |
| Other nontuberculous respiratory diseases | 6 | 4.4 |
| Total | 17 | 12.5 |

Table 98, although limited to a relatively small number of deaths, quite conclusively sustains the results of other investigations as regards the excessive frequency of pulmonary tuberculosis in the pottery industry throughout practically the entire working period of life. Aside from the distinctly excessive proportion of deaths from pulmonary tuberculosis the mortality from nontuberculous respiratory diseases, shown in Table 99, is also excessive, or 12.5 per cent, compared with 9.2 per cent for glassworkers and 10 per cent for all occupied males, according to data received from the same official American sources.

### MORTALITY OF POTTERY EMPLOYEES—MEDICO-ACTUARIAL EXPERIENCE.

The only really conclusive statistics regarding the mortality of potters in the United States are derived from life insurance experience. As a general rule both life insurance companies and fraternal societies are extremely cautious in accepting risks on the lives of persons employed in at least the more health-injurious processes of the pottery industry. Dippers, flint-mill workers, ground layers, mixers, scourers, and sweepers are generally declined, unconditionally. Kilnmen, mold makers, placers, pug-mill workers, sagger makers, and slip makers are occasionally accepted, but at somewhat higher premium rates than those charged men in recognized healthy employments. Most of the risks accepted in the pottery industry include decorators, fillers-in, jiggermen, jollymen, pressers, printers, throwers, and warehousemen. These observations require consideration in view of the results of the medico-actuarial investigation concerning pottery employees, chiefly molders, excluding foremen and superintendents.

TABLE 100.—MORTALITY FROM ALL CAUSES AMONG POTTERY EMPLOYEES (CHIEFLY MOLDERS, EXCLUDING FOREMEN AND SUPERINTENDENTS) BY AGE GROUPS.

[Medico-Actuarial Investigation.]

| Age at death. | Number exposed to risk one year. | Actual deaths. | Expected deaths. | Ratio of actual to expected deaths. |
|---|---|---|---|---|
| 15 to 29 years | 1,194 | 13 | 5.44 | 239 |
| 30 to 39 years | 999 | 9 | 5.93 | 152 |
| 40 to 49 years | 391 | 4 | 3.68 | 109 |
| 50 to 59 years | 45 | 1 | .66 | 152 |
| 60 years and over | 16 | 1 | .74 | 135 |
| Total | 2,645 | 28 | 16.45 | 170 |

It is shown in Table 100 that the general mortality of pottery employees, subject to the preceding qualifications, is 70 per cent in excess of the expected. The small number of risks under observation precludes final conclusions, but the data are decidedly suggestive of distinctly health-injurious conditions inherent in the American pottery industry, even after excluding the recognized unhealthy branches of the trade. In industrial insurance no such discriminations prevail, all employments being accepted. Unfortunately, in the mortality returns the death certificates frequently fail to state the precise occupation, and on account of the peculiar nomenclature common to the pottery industry there is a considerable degree of confusion. Thus decorators, pressers, printers, warehousemen, sweepers, etc., may be returned under entirely different occupational terms unless it is specifically stated that the employment was in connection with the pottery industry.

### MORTALITY OF POTTERS—INDUSTRIAL INSURANCE EXPERIENCE.

In Table 101, derived from the industrial insurance experience of the Prudential Insurance Co. of America, the term "potters" is limited to only such deaths as were clearly of persons connected with the pottery industry, which, in part, explains the rather limited mortality under observation. The table includes 801 deaths of potters from all causes, of which 258, or 32.2 per cent, were from pulmonary tuberculosis.

TABLE 101.—PROPORTIONATE MORTALITY FROM PULMONARY TUBERCULOSIS AMONG POTTERS, 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 potters, 1897 to 1914, from— | | Per cent of deaths from pulmonary tuberculosis among— | |
|---|---|---|---|---|
| | All causes. | Pulmonary tuberculosis. | Potters. | Males in registration area, 1900 to 1913. |
| 15 to 24 years | 77 | 24 | 31.2 | 27.0 |
| 25 to 34 years | 137 | 68 | 49.6 | 30.5 |
| 35 to 44 years | 181 | 72 | 39.8 | 23.4 |
| 45 to 54 years | 172 | 52 | 30.2 | 14.7 |
| 55 to 64 years | 147 | 31 | 21.1 | 7.9 |
| 65 years and over | 87 | 11 | 12.6 | 2.6 |
| Total, 15 years and over | 801 | 258 | 32.2 | 13.9 |

The table exhibits an excessive frequency of pulmonary tuberculosis at all ages; in fact, an extremely high proportion is maintained throughout the older ages when in the general experience other diseases tend to predominate. The experience confirms the preceding observations and conclusions derived from American and foreign experience, that the pottery industry in general, and among many of the more specialized processes in particular, must be considered seriously injurious to health and life, and for the reasons stated the requirement of thoroughgoing sanitary rules and regulations is self-evident. While there has been some progress in the direction of improved methods of factory supervision in this country with special reference to the pottery industry, we are as yet far from having attained to the more well-considered governmental practices of European countries.

### FOREIGN SANITARY REGULATIONS OF THE POTTERY INDUSTRY.

Attention may be directed in this connection to the regulations adopted under date of January 2, 1913, by the British Government with special reference to the manufacture and decoration of pottery, reprinted in a special bulletin of the New York Department of Labor.[1] The particular regulations concerning the suppression of dust, the use of respirators, and ventilation are as follows:

[1] European Regulations for Prevention of Occupational Diseases. Special Bulletin No. 76, published by the New York State Industrial Commission, Albany, March, 1916.

REGULATIONS FOR THE SUPPRESSION OF DUST.

(*a*) The following processes shall not be carried on without the use of an efficient exhaust draft:

(i) The fettling of flat ware, whether china or earthenware, by towing or sandpapering, provided that this shall not apply to the occasional finishing of pieces of china or earthenware without the aid of mechanical power;

(ii) The sand-sticking of sanitary ware;

(iii) Any other process of fettling on a wheel driven by mechanical power, except where:

(*a*) The fettler is fettling, as an occasional operation, only ware of his or her own making; or

(*b*) The fettling is done wholly with a wet sponge or other moist material; or

(*c*) The fettling is done by the worker who has made the articles, whilst the latter are still in a moist state.

(iv) The sifting of clay dust for making tiles or other articles by pressure, except where:

(*a*) This is done in a machine so inclosed as effectually to prevent the escape of dust; or

(*b*) The material to be sifted is so damp that no dust can be given off.

(v) The pressing of tiles from clay dust; an exhaust opening being connected with each press; this clause shall also apply to the pressing from clay dust of articles other than tiles, unless the material is so damp that no dust is given off.

(vi) The fettling of tiles made from clay dust by pressure, except where the fettling is done wholly on or with damp material; this clause shall also apply to the fettling of other articles made from clay dust, unless the material is so damp that no dust is given off.

(vii) The processes of bedding and flinting.

(viii) The brushing of earthenware biscuit, unless the process is carried on in a room provided with efficient general mechanical ventilation or other ventilation which is certified by the inspector of factories for the district as adequate, having regard to all the circumstances of the case.

(ix) Scouring of biscuit ware which has been fired in powdered flint, except where this is done in machines so inclosed as effectively to prevent the escape of dust.

(x) Batting of biscuit ware which has been fired in powdered flint.

(xi) Glaze blowing.

(xii) Ware cleaning after the application of glaze by dipping or other process, except as set forth later in this regulation.

(xiii) The preparation or weighing out of flow material which yields to dilute hydrochloric acid more than 5 per cent of its dry weight of a soluble lead compound calculated as lead monoxide when determined in the manner described in the definition of low solubility glaze.

(xiv) The lawning of dry colors, except where not more than an ounce at a time is lawned for use in painting.

(xv) Ground laying, including the wiping off of color after its application to the surface of the ware.

(xvi) Color dusting, whether underglaze or on-glaze, including the wiping off of color after its application to the surface of the ware.

(xvii) Color blowing or aerographing, whether underglaze or on-glaze, including the wiping off of color after its application to the surface of the ware.

(xviii) The making of lithographic transfers, including the wiping off of color after its application to the surface of the transfer sheets.

(*b*) In the process of mold making, every bin or similar receptacle used for holding plaster of Paris shall be provided with an efficient exhaust draft so arranged as to prevent the escape of plaster of Paris dust into the air of the work place, except where a cover is provided for the bin or other receptacle and the plaster of Paris is conveyed in a sack, the mouth of which is tied and only loosened after it has been placed in the bin or other receptacle.

(*c*) The dry grinding of materials for pottery bodies shall be done either with an efficient exhaust draft for the removal of dust, or in machines so inclosed as effectually to prevent the escape of dust; except that it shall not be deemed necessary in pursuance of this regulation to provide an exhaust draft to remove small amounts of dust given off at the hopper of an inclosed machine in the course of feeding the same, if an outlet into an exhaust duct or to the outside air is fitted to the receptacle into which the powdered material is delivered.

(*d*) In the process of sand sticking of sanitary ware, suitable provision shall be made for collecting any material which falls on the floor.

(*e*) In the process of making tiles from clay dust by pressure, supplies of material shall be conveyed to the workbenches in such a manner as to disperse as little dust as possible into the air; clay dust shall not be carried into any press shop in sacks except where hoppers or similar receptacles are provided for receiving the clay dust, in which case a sack in sound repair shall be used and the mouth of the sack shall be tied and only loosened after it has been placed in the hopper or other receptacle, which shall be provided with a cover. This clause shall also apply to the making from clay dust of articles other than tiles, unless the material is so damp that no dust is given off.

(*f*) After one year from the date on which these regulations come into force, biscuit flat ware which has been bedded for firing shall not be removed from the saggers after firing, except at a bench fitted with an efficient exhaust appliance for the removal of dust.

(*g*) Flat knocking and fired-flint shifting shall be carried on only in inclosed receptacles, which shall be connected with an efficient exhaust draft, unless so contrived as to prevent effectually the escape of dust.

(*h*) In the process of ware cleaning of earthenware after the application of glaze by dipping or other process, wherever it is practicable to use damp sponges or other damp materials they shall be provided in addition to the knife or other instrument, and shall be used.

(*k*) Nothing in these regulations shall render it compulsory to provide an exhaust draft for ware cleaning if this process is carried on entirely with the use of wet materials; or if the ware cleaning be done within 15 minutes after the moment when the glaze was applied; but an efficient exhaust draft shall always be provided and used if any dry materials or implements, such as knives or scrapers, are used after the glaze is dry or more than 15 minutes after the moment when the glaze was applied.

(*l*) In the process of ware cleaning, after the application of glaze by dipping or other process, sufficient arrangements shall be made for any glaze scraped off, which is not removed by the exhaust draft, to fall into water. All water troughs or other receptacles provided in pursuance of this clause shall be cleaned out and supplied with fresh water as often as necessary, and in no case less often than once a week; and no scrapings of glaze shall be allowed to collect in a dry condition on the sides of the water receptacle. Where grids or gratings are fitted over the water trough or other receptacle named in the foregoing paragraph, they shall be kept clean by repeated sponging or wiping with wet material during the time that the process of ware cleaning is being carried on. No boards or other articles shall be placed, even temporarily, on any such water trough, in such a way as to interfere with the efficient use of the trough.

(*m*) In all processes the occupier shall, as far as practicable, adopt efficient measures for the removal of dust and for the prevention of any injurious effects arising therefrom.

(*n*) Every process for which an exhaust draft is prescribed shall be carried on inside a hood or exhaust funnel, provided that where the occupier can show that this is impracticable it shall be sufficient if the work is done within the effective range of an exhaust opening.

### Respirators.

(*a*) No person shall be allowed to work without wearing a suitable and efficient respirator, such as a damp sponge tied across the mouth and nostrils, in any of the following processes:

(i) The emptying of sacks of plaster of Paris into a bin in a mold-making shop.

(ii) The weighing out, shoveling, or mixing of unfritted lead compounds in the preparation or manufacture of frits, glazes, or colors containing lead, or any process carried on in a room wherein any such weighing out, shoveling, or mixing has taken place within the previous 30 minutes.

unless an efficient exhaust draft is provided to prevent the escape of dust into the air of the work place.

(*b*) All respirators required by this regulation shall be provided and maintained in a cleanly state by the occupier, and each respirator shall bear the distinguishing mark of the worker to whom it is supplied.

### Ventilation.

(*a*) Every place in which any worker or workers are employed shall be thoroughly ventilated.

(*b*) All workrooms in which articles are left to dry shall be ventilated in such a way as to insure a continuous movement of the air in the room in a direction away from the workers and toward the articles in question.

(*c*) All drying stoves shall be ventilated direct to the outside air by shafts having upward inclinations and terminating vertically or by louvers in the roof or by other effective means.

(*d*) All mangles shall be so ventilated as to provide for the maintenance of a flow of air into the hot chamber from the adjoining workroom.

In the case of vertical or "tower" mangles:

(i) The pipes for heating the mangle shall be fixed above the top of any opening at which workers put in or take off ware; and

(ii) There shall be a free outlet into the air above so formed and placed as to insure an outflow whatever the direction of the wind.

(*e*) Fresh air shall, where practicable, be admitted to all workrooms by inlets placed along the sides of the room at a height of as nearly as possible

6 feet above the floor level, hopper opening being used for the purpose wherever possible.

(*f*) Where it is not practicable to provide such fresh air inlets arrangements shall be made for the entry of an adequate amount of pure air by a flue with apertures at intervals along its length or other means, which will secure an even distribution of the air through the room.

(*g*) In no case shall fresh-air inlets be so arranged that a draft can blow direct from them onto any worker.

(*h*) Wherever the natural air currents are found to be insufficient without assistance to afford thorough ventilation, exhaust fans, or other artificial means of creating a current of air shall be provided and maintained in use.

(*k*) Where an exhaust draft is provided for the removal of dust generated in a manufacturing process precautions shall be taken to prevent dust being drawn into the general atmosphere of the room from other sources of dust in places in the vicinity; communication with such places shall be stopped wherever possible, and the fresh-air inlets hereinbefore mentioned shall be so arranged as to insure that no extraneous dust is drawn toward the workers by the exhaust draft.

### GENERAL CONCLUSIONS.

These rules and regulations are an admirable illustration of really effective methods by which the intrinsic health-injurious factors in a given industry can be reduced to a practically attainable minimum. The conclusions, while specifically applicable to the pottery industry, are equally suggestive of a far-reaching reduction of occupational hazards in other dusty trades.

## PAINT AND COLOR WORKERS.

The dust hazard in paint and color manufacture is chiefly of a mineral nature, but the use of metallic substances frequently includes industrial poisons which it must be assumed tend to increase the resulting hazard to health and life. Antimony, arsenic, chromium, lead, manganese, mercury, zinc, etc., are the usual ingredients of paints and colors used extensively in the industries and arts. Mineral paints are divided into three groups—(1) natural mineral pigments, (2) pigments made directly from ores, and (3) chemically manufactured pigments, all of which during ordinary processes of manufacture expose the workmen to a considerable amount of dust. Many minerals or mineral products, it is stated in the annual report of the United States Geological Survey for 1914, by James M. Hill, "are used in the paint trade, such as asbestos and products derived from it, aluminium, asphalt, barytes, clay, graphite, gypsum, magnesite, mica, pyrite, quicksilver, shells, silica, talc, tripoli, and many by-products."

### CHEMICAL ASPECTS OF PAINT MANUFACTURE.

How far these wide variations in the basic nature of the materials used affect health and life with special reference to pulmonary tuberculosis is at the present time not even a matter of scientific conjecture. The natural mineral pigments which constitute an important group, comprise, according to the same authority, "ocher, umber, sienna, ground slate and shale, metallic paint, and mortar colors." The three ores of iron, hematite, siderite, and limonite, are the basic constituents of metallic paints which enter to a considerable extent into numerous processes of manufacture directly or indirectly, as the case may be. Pigments made directly from ores, it is stated, comprise zinc oxide, leaded zinc oxide, sublimated white lead, and sublimated blue lead.[1] In the chemically manufactured pigments basic carbonate white lead, litharge, red lead, orange mineral, lithophone, and Venetian red are extensively used. The importance of the mineral paint industry is best illustrated by the statement that during 1914 the United States product was valued at nearly $40,000,000.

## EXPOSURE TO METALLIC DUST.

The amount of metallic dust in paint manufacture would be relatively unimportant were it not for the frequently poisonous nature of the substances used. As observed by W. Gilman Thompson with reference to white lead, the material is first dried, then pulverized, and diluted with oil and pigment, in connection with which processes the dust hazard is quite important, while there exists the additional risk of an increased susceptibility to pulmonary tuberculosis. Painters, in connection with the use of paints, are probably exposed to a lesser liability to dust inhalation than is common to dry-color grinding and related processes, but it is quite possible that the risk of lead poisoning is more serious.

## HYGIENE OF THE PAINTERS' TRADE.

The hygiene of the painters' trade has been reported upon with admirable completeness, but with special reference to industrial poisoning, by Alice Hamilton, M. D., in Bulletin 120 of the United States Bureau of Labor Statistics. The importance of dust as a cause of lead poisoning is emphasized by Dr. Hamilton, it being stated that British experiments show that lead enters the bronchial tubes and lungs and even penetrates the capillaries, thus reaching the blood stream. She refers to German authorities as holding that "if any lead is absorbed through the respiratory tract, it must be small in amount, and while it is true that the breathing of lead dust causes poisoning, this is not because the lead reaches the bronchial tubes, but because it is caught in the mouth and throat, mixed with the saliva, and swallowed." Lehmann, a German authority, is quoted to the effect that "the great bulk of the inhaled dust finds its way into the stomach and not into the lungs." It is said that the dust lodges on the nasal and pharyngeal mucous membrane, and that

[1] Lead and Zinc Pigments, by Clifford Dyer Holley, M. S., Ph. D., New York, 1909.

the dust-laden secretions are then swallowed. It is estimated that at most less than one-fourth of the dust reaches the lungs. Soluble dusts are easily absorbed, and the conclusion is advanced that, irrespective of the theory accepted, "there is no question that poisoning takes place more rapidly the dustier the occupation, and therefore those parts of the painters' trade that are accompanied by dust production are the most dangerous."

These observations bear directly upon the broader question of increased liability to pulmonary tuberculosis in consequence of metallic or mineral dust inhalation. The serious importance of lead poisoning in paint manufacture and the painters' trade probably account for the very limited consideration which has been given to the equally important question of a possibly enhanced liability to pulmonary tuberculosis.

### SANITARY CONDITIONS IN THE GERMAN PAINT INDUSTRY.

The most important investigation into the health of persons employed in the manufacture of paint was published in 1893 through the cooperation of the color manufacturers, Meister, Lucius & Brüning, of Höchst a. M., and Dr. Grandhomme, who thoroughly examined into the sickness experience for the preceding decade and whose observations include the results of a study of factory conditions, raw materials, and the processes of manufacture in detail, but with special reference to the analine-dye industry.[1] On account of the excellence of hygienic precautions and the emphasis placed upon the personal hygiene of the workmen, the observed experience is probably not conclusive with regard to paint and color factories in the United States. The amount of sickness was relatively high and apparently on the increase, but the average duration of the sickness was comparatively favorable, having varied between 5 and 9 days per case and between 4.1 and 8.4 days per workman per annum. The medical results of the investigation are too involved to permit of a brief analysis, but with special reference to pulmonary tuberculosis it may be said that the number of cases observed was apparently not excessive. Of the entire morbidity, including 18,723 cases of sickness, 2,762, or 14.7 per cent, were attributed to diseases of the respiratory organs, including pulmonary tuberculosis. The mortality from all causes during the period 1883–1892 was 7 per 1,000, which can not be considered excessive, although the proportion of young persons employed was probably relatively high. Out of 126 deaths from all causes, 55 were from pulmonary tuberculosis, 11 from pneumonia, and 12 from other respiratory diseases. An excessive amount of mortality from tuberculosis and other respiratory diseases is, therefore, conclusively

[1] Die Fabriken der Aktien-Gesellschaft Farbwerke vorm. Meister, Lucius & Brüning zu Höchst a. M., Frankfurt a. M., 1893.

brought out by the mortality analysis, although apparently in contradiction to the morbidity experience. This is in part explained by the relative frequency of digestive disorders and general nutritional disturbances, as well as affections of the skin. Aside from the considerable number of cases of industrial injuries, as far as the experience permits of a definite conclusion, it would appear that the mortality from pulmonary tuberculosis in the German paint and color industry, even under a well-considered plan of hygienic supervision is unduly high, and that it is safe to assume that the excess in the incidence of the disease is directly attributable to the more or less considerable risk of continuous inhalation of metallic and mineral dust, increased in the severity of its effects by the presence of poisonous substances, generally arsenic and lead.

### LIABILITY TO METALLIC POISONING.

The paint industry was inquired into by the New York State Factory Investigating Commission. In the report for 1913 (vol. 2, p. 1152) it is said that six factories were inspected and that three used arsenic colors, but to a limited extent, the principal output being lead colors. No cases of poisoning were found among the workers, and the information secured was, therefore, negative. It is stated, however, "That there is danger can not be doubted, for the reports of other countries and the report of one case to the department of labor demonstrate the fact. The process wherein the danger lies is from the dust created in handling the dry arsenic color. In this industry there is danger of mixed poisoning." Other observations on the part of the commission have reference to the risk of lead poisoning, but there is an extended description of a plant engaged in the manufacture of arsenic color with regard to which it is said that the special process of mixing the materials is "very dusty." No provision was made for keeping down the dust or exhausting it. It is interesting to note that one worker was examined who said he had been employed for 32 years, but who showed no symptoms and gave no history of ever having had arsenic poisoning. The irritant action of arsenic dust was fully demonstrated by experimental inquiry, and the conclusion is advanced that the chief danger from the dust is in the processes of drying, bolting, and packing. No direct relation between arsenic dust inhalation and a predisposition to pulmonary tuberculosis was shown to exist by the investigation referred to.

### MORTALITY OF PAINTERS, GLAZIERS, AND VARNISHERS.

The mortality of painters, glaziers, and varnishers considered as a group has been reported upon for the years 1908 and 1909 by the Division of Vital Statistics of the United States Census Bureau. The group, unfortunately, is so very large and inclusive of so many widely different specific employments or occupational conditions that the results of the analysis must be accepted with reserve. Proportionately, of course, painters predominate in the group under consideration and it is a safe assumption that the other occupations do not very materially modify the proportionate mortality figure from pulmonary tuberculosis. Thoroughly specialized investigations, however, regarding particular employments (for, of course, even the term "painter" covers quite a group of more or less varying occupations) might and probably would disclose important differences in the specific liability to pulmonary tuberculosis, particularly with reference to exposure to health-injurious minerals and metallic dust. Among painters, naturally, the liability to lead poisoning is a special occupational danger, but the actual mortality from lead poisoning is proportionally so small, at least among American painters, that the relative effect of the same can not be considered of material importance. According to the census report, out of 7,294 deaths of painters, glaziers, and varnishers from all causes, 1,361, or 18.7 per cent, were from pulmonary tuberculosis. The details of the mortality by divisional periods of life are shown in Table 102.

TABLE 102.—PROPORTIONATE MORTALITY OF PAINTERS, GLAZIERS, AND VARNISHERS 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 deaths from all causes. |
| 15 to 24 years | 429 | 132 | 30.8 |
| 25 to 34 years | 968 | 357 | 36.9 |
| 35 to 44 years | 1,423 | 415 | 29.2 |
| 45 to 54 years | 1,598 | 278 | 17.4 |
| 55 to 64 years | 1,474 | 132 | 9.0 |
| 65 years and over | 1,398 | 46 | 3.3 |
| Age unknown | 4 | 1 | 25.0 |
| Total, 15 years and over | 7,294 | 1,361 | 18.7 |

TABLE 103.—PROPORTIONATE MORTALITY OF PAINTERS, GLAZIERS, AND VARNISHERS FROM NONTUBERCULOUS RESPIRATORY DISEASES, UNITED STATES REGISTRATION AREA, 1908 AND 1909.

| Cause of death. | Deaths from nontuberculous respiratory diseases. | |
|---|---|---|
| | Number. | Per cent of deaths from all causes. |
| Asthma | 11 | 0.2 |
| Bronchitis | 47 | .6 |
| Pneumonia | 533 | 7.3 |
| Other nontuberculous respiratory diseases | 64 | .9 |
| Total | 655 | 9.0 |

## COMPARATIVE MORTALITY OF PAINTERS, GLAZIERS, VARNISHERS, AND AGRICULTURAL LABORERS.

The proportionate mortality from pulmonary tuberculosis among painters, glaziers, and varnishers considered as a group was above the average for all occupied males throughout the entire working lifetime, but the excess does not assume serious proportions, which, however, does not preclude the conclusion that more selected groups of occupations in the entire group of allied employments under consideration would show a much more decided liability to pulmonary tuberculosis than is shown to be the case for the employment considered in the aggregate. In a general way, however, the mortality of painters, glaziers, and varnishers from pulmonary tuberculosis conforms to the general average for all occupied males, but it is decidedly above the average when comparison is made with agricultural employments, as is shown in Table 104.

TABLE 104.—COMPARATIVE MORTALITY FROM PULMONARY TUBERCULOSIS AMONG PAINTERS, GLAZIERS, AND VARNISHERS, AND FARMERS, PLANTERS, AND FARM LABORERS, UNITED STATES REGISTRATION AREA, 1908 AND 1909, BY AGE GROUPS.

| Age at death. | Per cent of deaths from all causes due to pulmonary tuberculosis. | |
|---|---|---|
| | Agricultural employments. | Painters, etc. |
| 15 to 24 years | 23.5 | 30.8 |
| 25 to 34 years | 26.2 | 36.9 |
| 35 to 44 years | 19.1 | 29.2 |
| 45 to 54 years | 12.1 | 17.4 |
| 55 to 64 years | 6.7 | 9.0 |
| 65 years and over | 2.4 | 3.3 |
| Age unknown | 7.9 | 25.0 |
| Total, 15 years and over | 8.7 | 18.7 |

The preceding comparison is especially suggestive in that it emphasizes the inherent limitations of a mortality comparison in which all occupations are considered the standard. For the present purpose it has seemed advisable to compare painters, who, of course, numerically constitute an exceptionally important group of occupations, with employments typical of outdoor labor carried on under the most wholesome conditions as regards physical activity, air, relative freedom from dust exposure, etc. The comparison, throughout, is distinctly in favor of agricultural employments, and emphasizes the more or less health-injurious conditions under which painters, glaziers, and varnishers, considered as a group, are employed throughout practically the entire working period of life. How far the relatively high mortality from pulmonary tuberculosis as determined by this comparison is attributable to the special risk of lead poisoning can not be determined at the present time; but it is a safe conclusion that there is some such relation, although the recorded mortality from lead poisoning among American painters is comparatively low; in other words, it is rather because of complications resulting from gradual lead absorption as a factor in other diseases, including pulmonary tuberculosis, than as a direct cause of death that lead poisoning assumes importance in occupational or industrial hygiene. Aside from the relatively high proportion of deaths from pulmonary tuberculosis the mortality from nontuberculous respiratory diseases among painters, glaziers, and varnishers in comparison with farmers, planters, and farm laborers is not excessive. For painters, etc., considered as a group the proportionate mortality from all nontuberculous respiratory diseases is 9 per cent, which compares with 9.3 per cent for farm laborers. The proportions for asthma, pneumonia, and other respiratory diseases are about the same, but for bronchitis the mortality figure for agricultural workers is exactly twice the average for painters, considered as a group, or 1.2 per cent against 0.6 per cent. These conclusions, however, must not be carried too far, in view of the fact that two groups are compared which include quite a number of employments with a more or less varying degree of exposure to conditions unfavorable to health and longevity.

## MORTALITY OF PAINT MIXERS—INDUSTRIAL INSURANCE EXPERIENCE.

There are no conclusive vital statistics of men employed in the American mineral paint industry, whether considered as a group or according to its several more important subdivisions. In the experience of the Prudential Co. (1897–1914) 36 deaths from all causes in paint factories, excepting mixers, occurred, of which 6, or 16.7 per cent, were from pulmonary tuberculosis. The experience is, of course, too limited to be conclusive. Among paint mixers, separately considered, however, there were 88 deaths from all causes, of which 21, or 23.9 per cent, were from pulmonary tuberculosis. This experience is given in detail in Table 105.

TABLE 105.—PROPORTIONATE MORTALITY FROM PULMONARY TUBERCULOSIS AMONG PAINT MIXERS, 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 paint mixers, 1897 to 1914, from— | | Per cent of deaths from pulmonary tuberculosis among— | |
|---|---|---|---|---|
| | All causes. | Pulmonary tuberculosis. | Paint mixers. | Males in registration area, 1900 to 1913. |
| 15 to 24 years | 6 | 4 | 66.7 | 27.0 |
| 25 to 34 years | 17 | 5 | 29.4 | 30.5 |
| 35 to 44 years | 16 | 5 | 31.3 | 23.4 |
| 45 to 54 years | 27 | 7 | 25.9 | 14.7 |
| 55 to 64 years | 13 | | | 7.9 |
| 65 years and over | 9 | | | 2.6 |
| Total, 15 years and over | 88 | 21 | 23.9 | 13.9 |

The statistics, though unfortunately too limited for entirely safe conclusions, may be accepted as a sufficiently trustworthy indication that paint mixers are unquestionably liable to an excessive mortality from pulmonary tuberculosis, which in all probability upon further inquiry will be found to correspond proportionately to the nature and the quantity of the dust inhaled in the mixing processes. Even in the case of men employed in paint factories, excluding mixers, the experience is fairly suggestive of unfavorable conditions, though obviously much less so than those known to exist in the mixing processes separately considered. When the data for paint factories are made to include mixers, the experience is represented by 124 deaths from all causes, of which 27, or 21.8 per cent, were from pulmonary tuberculosis. At ages 35 to 44, out of 25 deaths, 10, or 40 per cent, were caused by pulmonary tuberculosis, which, of course, is decidedly excessive.

### GENERAL CONCLUSIONS.

In the absence of more definite and trustworthy data, the foregoing brief observations concerning an important and rapidly intending industry are suggestive of the urgency of better sanitary conditions, chiefly the use of practical methods of dust prevention, both by more adequate dust-removing processes at the point of origin and the use of respirators in processes where the control of the dust danger must necessarily be one of exceptional difficulty.

### LITHOGRAPHERS.

Lithographers constitute an important branch of the printing trade. According to the census of 1910 there were some 8,138 lithographers in the United States, of which number 477 were females. For hygienic reasons the employment of the lithographer should be considered separately from printing and engraving, since the former is exposed chiefly to mineral dust, while the latter are exposed primarily to the inhalation of metallic dust. Lithographic stone has been defined as a fine, compact homogeneous limestone, practically all of which is (or was) imported from Germany. The small amount of lithographic stone quarried in the United States varies in its mineral and metallic constituents from the Bavarian stone, containing nearly 7 per cent of magnesia. No accurate observations have been made a matter of record to determine the degree of possible lung injury resulting in the case of the lithographer's occupation, but it is safe to assume that the employment should be included in the group of dusty trades. This conclusion is fully sustained by a knowledge of the technical processes which constitute the lithographic art.

The sanitary conditions of this employment received consideration by Sir John Simon in his report as medical officer of the Privy Council. Simon called attention to the dust resulting from the use of colors and pigments, against the inhalation of which only very few of the workmen had adopted intelligent precautions. The most pernicious of the mineral or metallic colors employed in connection with lithography were emerald green and bronze. Simon did not connect the inhalation of this dust with the occurrence of phthisis, but the inference would seem warranted that such a connection exists, at least in exceptional cases.[1]

Parry, in his "Risks and Dangers of Various Occupations," confirms the earlier opinion, and holds that in lithographing green arsenical pigments are used, the poisonous dust of which is inhaled and conveyed to the stomach. It is evident that the poisonous character of the colors or pigments is a more serious factor than the dust of the stone itself, but how far either form of dust increases the liability to tuberculosis has not been determined.

### MORTALITY OF ENGLISH LITHOGRAPHERS.

The most recent English mortality statistics of lithographers 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 (p. lix), in part as follows:

> At all ages except 20 to 25 and 45 to 55 the death rates among these workers exceed the standard for all occupied and retired males. These workers experience a lower mortality than printers up to the age of 45, but beyond that age the mortality in the two occupations differs but slightly. In the main working period of life the comparative mortality figure of lithographers is 964, or 4 per cent, below the average. Their mortality from influenza and phthisis considerably exceeds the standard, while that from respiratory diseases is below it by about an equal amount.

The English mortality statistics for lithographers are rather inconclusive as to a decidedly unfavorable effect of this industry on health, and while in Table 106 a comparison is made of the mortality from all causes of men in this group with occupied males generally, the death rates are, as a rule, below the average for occupied males generally except at ages 20 to 24 and 45 to 54, inclusive.

[1] Report of the medical officer of the Privy Council for 1860, pp. 30 et seq. and 102 et seq.; for 1861, pp. 11 et seq. and 138 et seq.; for 1862, pp. 10 et seq. and 126 et seq.; and for 1863, pp. 29 to 31.

Table 106.—MORTALITY FROM ALL CAUSES OF LITHOGRAPHERS, 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 lithographers. | | |
|---|---|---|---|---|
| | | Rate per 1,000. | Greater (+) or less (−) than rate for all occupied males. | Ratio to rate for all occupied males. |
| 15 to 19 years | 2.44 | 1.55 | −0.89 | 64 |
| 20 to 24 years | 4.41 | 5.36 | + .95 | 122 |
| 25 to 34 years | 6.01 | 5.62 | − .39 | 94 |
| 35 to 44 years | 10.22 | 8.41 | −1.81 | 82 |
| 45 to 54 years | 17.73 | 19.94 | +2.21 | 112 |
| 55 to 64 years | 31.01 | 30.84 | − .17 | 99 |
| 65 years and over | 88.39 | 82.25 | −6.14 | 93 |

The preceding table is self explanatory, but a more extended comparison is made in Table 107, in which the mortality of lithographers from pulmonary tuberculosis is compared with the normal mortality of occupied males from this disease, by divisional periods of life. This table shows that the mortality of lithographers from tuberculosis is above the average at all ages by from 0.23 to 2.17 per 1,000. The excess is not very marked and does not warrant decidedly unfavorable conclusions.

Table 107.—MORTALITY FROM PULMONARY TUBERCULOSIS AMONG LITHOGRAPHERS, 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. | | | |
|---|---|---|---|---|
| | Death rate per 1,000 for all occupied males. | Death rate for lithographers. | | |
| | | Rate per 1,000. | Greater (+) or less (−) than rate for all occupied males. | Ratio to rate for all occupied males. |
| 15 to 19 years | 0.54 | 0.77 | +0.23 | 143 |
| 20 to 24 years | 1.55 | 2.68 | +1.13 | 173 |
| 25 to 34 years | 2.03 | 2.70 | + .67 | 133 |
| 35 to 44 years | 2.74 | 3.13 | + .39 | 114 |
| 45 to 54 years | 3.04 | 4.27 | +1.23 | 140 |
| 55 to 64 years | 2.16 | 4.33 | +2.17 | 200 |
| 65 years and over | 1.11 | 1.44 | + .33 | 130 |

The preceding table, derived from English experience, requires no further comment except that it may be pointed out that the data under observation are far from sufficient to warrant definite conclusions. The occupation has been investigated in the United States by Hayhurst, with regard to 10 establishments in Ohio, employing

539 persons, of whom all but 14 were males. Only 50 of the employees were over 40 years of age. There were no special complaints of importance, except as relating to the ventilation of lithographic workrooms. Neither the fume nor dust hazard seemed to be of serious importance. W. Gilman Thompson only briefly refers to lithographers, stating that they suffer from sedentary work and close application, resulting in dyspepsia and anemia, and that they have a somewhat high mortality from tuberculosis.

### MORTALITY OF LITHOGRAPHERS—INDUSTRIAL INSURANCE EXPERIENCE.

The conclusions based upon Table 108 are sustained by the industrial insurance experience data of the Prudential Co. for the period 1897 to 1914, according to which, out of 325 deaths from all causes, 125, or 38.3 per cent, were from pulmonary tuberculosis.

TABLE 108.—PROPORTIONATE MORTALITY FROM PULMONARY TUBERCULOSIS AMONG LITHOGRAPHERS, 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 lithographers, 1897 to 1914, from— | | Per cent of deaths from pulmonary tuberculosis among— | |
|---|---|---|---|---|
| | All causes. | Pulmonary tuberculosis. | Lithographers. | Males in registration area, 1900 to 1913 |
| 15 to 24 years | 70 | 37 | 52.9 | 27.0 |
| 25 to 34 years | 81 | 42 | 51.9 | 30.5 |
| 35 to 44 years | 69 | 27 | 39.1 | 23.4 |
| 45 to 54 years | 53 | 13 | 24.5 | 14.7 |
| 55 to 64 years | 32 | 4 | 12.5 | 7.9 |
| 65 years and over | 19 | 2 | 10.5 | 2.6 |
| Age unknown | 1 | | | |
| Total, 15 years and over | 325 | 125 | 38.3 | 13.9 |

### GENERAL CONCLUSIONS.

The mortality from pulmonary tuberculosis is, therefore, extremely high in this occupation at ages under 45 and in marked contrast to the mortality from this disease among the male population of the registration area. The statistics, though limited, may be accepted as conclusive and indicative of more or less unsatisfactory sanitary conditions common to the lithographic industry. For reasons partly inherent in the occupation, ventilating devices are often quite defective and occasionally impracticable. The dust hazard is only one of several which tend to make this employment a particularly unhealthy one, and this conclusion is sustained by the fact that out of 325 deaths of lithographers at known ages from all causes, only 19, or 5.9 per cent, were of ages 45 and over.

It is regrettable that the mortality of lithographers was not separately considered in the occupational mortality statistics of the Division of Vital Statistics of the United States Census Bureau, in which lithographers are combined with printers and pressmen. It has been observed in this connection by Kober, in Kober and Hanson's "Diseases of Occupation and Vocational Hygiene" (p. 614), that the work of chromolithography "is often carried on under unfavorable hygienic conditions as regards light, air space, and ventilation, which is all the more regrettable, as some of the processes involve the employment of injurious agents, such as arsenic pigments, chromium, lead, and bronze powder." It is said further that—

The lithographic process varies in different establishments; the design or picture may be engraved by means of a diamond or steel needle upon a fine-grained sandstone, generally imported from Bavaria, or the drawing may be made upon the stone with a greasy composition. In photolithography the printing surface is largely prepared by a photographic process. In all of the processes of chromolithography the stone is dampened on those portions of the design which are not to appear in the first printing; this prevents taking the ink or colors. The actual application of colors and presswork is performed by another set of operatives. According to Leiser (Weyl's Handbuch der Gewerbekrankheiten, 1908, p. 339), in a total membership of 11,807 employees in this industry in Berlin during 1904, 2,002 males and 1,840 females, or 32.6 per cent, were reported sick, with 90 deaths; of the sick about 12 per cent suffered from tuberculosis; 11 per cent had skin affections, especially obstinate forms of eczema caused by contact with acid dips, bronzing powder, toxic color pigments, impure turpentine, etc.; 10.5 per cent of the sick suffered from disorders of the digestive system; and 19 per cent of the females were anæmic. There were 356 accidents, mostly contusions of the fingers contracted in presswork. Cohen estimates that about 45 per cent of the lithographers suffered from near sight or other visual defects.

The possible serious exposure to bronze dust in chromolithography can not be discussed on account of the want of precise and conclusive data. As far as the available information derived from fairly trustworthy sources justifies a preliminary conclusion, there does not appear to be an excessive incidence of pulmonary tuberculosis among men employed in the manufacture of bronze powder. As regards the bronzing process in chromolithography, Kober observes that this may be done by the dry or wet method or by hand or machinery, and that in spite of the metallic covering of the machinery and methods of exhaust ventilation the bronze powder escapes freely into the air and the employees who tend the machine "wear handkerchiefs over the nose and mouth" and "look pale and unhealthy, and all show the characteristic green perspiration due to contact with bronze." The great majority of employees, however, he remarks, appear to be healthy, which no doubt has reference to the men not directly connected with dust-producing processes. In the absence of more conclusive information and the required statistical evidence derived from official or insurance sources, no final conclusion can be arrived at further than that with reference to lithographers as a class the evidence is entirely sufficient to prove the excessive incidence of pulmonary tuberculosis and the prevalence of more or less decidedly unsatisfactory sanitary conditions in the lithographic industry.

### FOUNDRY-MEN AND MOLDERS

Foundry-men and molders are to a considerable degree exposed to the continuous inhalation of both metallic and mineral dusts. While the proportion of metallic dust is quantitatively small, it is probably the more injurious of the two, although its effects are modified by the relatively much larger amount of mineral dust. The industry is varied, of large extent, and widely distributed throughout the country. The conditions affecting health naturally vary, and chiefly so on account of the metal used in casting, which may be iron, steel, brass, etc. The employments in foundry practice are chiefly those of molders and clay mixers, of which molders, again, are subdivided into those who work at a bench, or in the making of small ware, and those who work on the floor or in the pits in the making of castings of larger size. Within recent years labor-saving appliances have been extensively introduced into the large foundries, chiefly in connection with iron and steel works, but corresponding progress has not been made in the smaller establishments. The introduction of machinery has led to the employment of much unskilled labor of low grade, which complicates the use of the available mortality returns. It is also necessary to take into consideration the not inconsiderable accident liability of men employed in foundries, and the occasional or general exposure to extreme heat and the liability to overstrain inseparable from the lifting of heavy weights of metal.

An investigation into the sanitary aspects of this employment made by the State board of health of Massachusetts disclosed the fact that at 14 foundries in which castings of all kinds were made, in 7 the conditions as to light, ventilation, and dust removal were very poor. Of 9 stove foundries inspected, 4 presented moderately bad and 1 distinctly bad conditions affecting the health of employees. In the polishing room of one factory, conducted under almost ideal conditions, the emery wheels were well-equipped with hoods and exhaust ventilators, but the report states that "the men, unmindful of the protection provided, habitually remove the hoods, and become covered with emery and iron particles."

In reporting in some detail upon the establishments found to be more or less unsatisfactory as to light, ventilation, and dust removal, the report states that one shop "employs 275 men, in low-studded, poorly lighted, unventilated buildings, in which there is no attempt to remove the dust arising from the processes of polishing and buffing, by hoods and exhaust ventilation. In the tumbling room the dust is so thick that objects a few feet distant can not clearly be made out. Many men refuse to work in this establishment in the hot months, on account of the excessive heat and general discomfort."

The high mortality of foundry-men and molders from pulmonary tuberculosis observed to occur at advanced ages is decidedly suggestive. Evidently the progress of the disease in these occupations is slow, and often, if not as a rule, assumes the form of fibroid phthisis. There can be no question of doubt that there is in these occupations an intimate connection between the continuous exposure to metallic and mineral dust inhalation and the relative frequency of the disease. Considering the nature of the dust inhaled, this is what would be expected. The dust being largely mineral, but partly metallic, the proportion of iron dust, while considerable, is not so excessive as the iron or steel dust inhaled by men engaged in cutlery grinding or file cutting. No doubt many of the dangers of the employment could be guarded against by attention to safety devices, chiefly respirators, to be worn during some of the mold-making processes. The employment, by its very nature, however, precludes radical methods of dust prevention, and the most effective safeguard would be short hours of labor and a more rational use of leisure hours and vacations.[1]

### MORTALITY OF MOLDERS—INDUSTRIAL INSURANCE EXPERIENCE.

There are no official vital statistics of these occupations either for the United States or for England and Wales. The recorded industrial insurance mortality statistics of foundry-men and molders are very extensive and include 3,294 deaths from all causes, of which 758, or 23 per cent, were from pulmonary tuberculosis. Of the deaths of foundry-men and molders from nontuberculous respiratory diseases, 25 were from asthma, 51 from bronchitis, 463 from pneumonia, and 65 from other diseases of this class. If the deaths from pulmonary tuberculosis and from other respiratory diseases are combined, 41.3 per cent of the mortality of foundry-men and molders were from diseases of the lungs and air passages. The mortality of foundry-men and molders from pulmonary tuberculosis was excessive at all ages over 25, but the excess was most pronounced at ages 25 to 34, when out of every 100 deaths of foundry-men from all causes, 40.4 were from pulmonary tuberculosis, against a normal expected proportion of 30.5. The analysis of the mortality from pulmonary tuberculosis of foundry-men and molders in detail is set forth in Table 109.

[1] For a brief but practically useful account of occupational hazards in foundries, see "Practical Safety Methods and Devices," by George A. Cowee, New York, 1916.

TABLE 109.—PROPORTIONATE MORTALITY FROM PULMONARY TUBERCULOSIS AMONG FOUNDRY-MEN AND MOLDERS, 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 foundry-men and molders, 1897 to 1914, from— | | Per cent of deaths from pulmonary tuberculosis among— | |
|---|---|---|---|---|
| | All causes. | Pulmonary tuberculosis. | Foundry-men and molders. | Males in registration area, 1900 to 1913. |
| 15 to 24 years | 266 | 63 | 23.7 | 27.0 |
| 25 to 34 years | 540 | 218 | 40.4 | 30.5 |
| 35 to 44 years | 694 | 213 | 30.7 | 23.4 |
| 45 to 54 years | 690 | 149 | 21.6 | 14.7 |
| 55 to 64 years | 624 | 87 | 13.9 | 7.9 |
| 65 years and over | 480 | 28 | 5.8 | 2.6 |
| Total, 15 years and over | 3,294 | 758 | 23.0 | 13.9 |

The preceding observations and statistical data, derived from industrial insurance mortality experience, confirm the conclusion that this employment is more or less injurious to health, and that the degree of frequency of pulmonary tuberculosis is excessive at ages 25 and over.

### SANITARY CONDITIONS IN MASSACHUSETTS FOUNDRIES.

The sanitary conditions in foundries have been investigated by the Massachusetts State Board of Health and reported upon under date of April, 1911. Two hundred and nine foundries were inspected, including a large variety of processes of more or less importance from a hygienic point of view, but with special reference to extremes of temperature, and more or less irritating dust, gases, and vapors. Many of the foundries inspected were found to be improperly heated during the winter months, and the workmen were said to suffer more or less discomfort from the cold. In the immediate vicinity of the furnaces, however, particularly in the pouring of the metal, the heat was apt to be excessive. Gases and vapors were ascertained to prevail in some instances to an injurious degree, and especially was this found to be the case in brass foundries, with reference to the occurrence of so-called brass-founders' chills. It is a fair assumption that unfavorable temperature conditions and continuous exposure to noxious vapors must tend in a measure to reduce vitality and predispose to diseases, particularly of the respiratory organs, for as has been thoroughly well established for the metal mining industries, a preexisting condition of fibroid phthisis materially increases the liability to pulmonary tuberculosis. Fibroid phthisis contracted in consequence of dust exposure predisposes to pulmonary tuberculosis. The same conclusion applies to other unfavorable health conditions tending toward a lowering of vital resistance and an increased predisposition to particular specific diseases.

### DUST EXPOSURE IN SAND BLASTING.

In the Massachusetts investigation of foundries it was found that the floors, benches, and the hands of operatives were covered with sand dust, and it is explained that the dry sand from which the cores are made is sifted on a fine wire netting, a process which gives rise to considerable fine dust. This process, however, is not usually carried on to any prolonged extent, but is done, for the most part, several times a week for only a few hours at a time. In one foundry the dust generated was decidedly objectionable, and upon the suggestion of the State inspector of health a covered sifter was provided to remove this source of annoyance. The most dusty process was ascertained to be the cleaning of castings, elsewhere briefly referred to under sand blasting. It is explained in this connection that—

Castings are cleaned in tumbling mills, by sand blasts, emery wheels, or by hand with wire brushes. The tumbling mills are barrel-like chambers in which the castings are placed, together with small pieces of scrap iron. After the doors are closed, power is applied and the mills are set in a rotary motion. From the constant action of the castings upon each other and upon the scrap iron the surfaces are smoothed and the castings are cleaned of any sand which may be adherent. The dust generated by this process was, in most foundries, removed by exhausts. Moreover, these mills were usually located in some corner away from the workmen who did not have to attend to them during operation. The emery wheels on which the castings were cleaned were in many cases provided with hoods and exhausts.

These observations apply in a general way to modern foundries, but exceptions are sufficiently numerous to suggest the urgency of qualified and continuous supervision of the processes referred to. Neglect in this direction is invariably followed by health-injurious consequences, for as pointed out in the Massachusetts report—

A serious exposure to fine dry sand was observed in those foundries where sand blasts were in use for cleaning the castings. This process, which is usually carried on in a room separated from the rest of the foundry, consists of playing a stream of fine dry sand, by means of compressed air, upon the castings. So great is the force of the sand stream that the steel nozzle which is used is quickly cut through. In some foundries exhaust fans and hoods were provided to carry off the dust, although in spite of this precaution the rooms were so filled with dust while the sand blasts were in operation that objects could not be clearly seen. When doing this work the workmen usually wore masks to protect the eyes. These masks, however, did not prevent the inhalation of dust, which appeared to enter the respiratory passages with a good deal of force. In one factory a man was observed to wear a helmet with a tubing through which fresh air was supplied from the outside. In another foundry such a helmet was provided, but the man did not use it "as it was too much bother to put it on and take it off." The length of time a man can keep at this work is said to be short; in about a year or a year and a half he begins to show the effects of the work and is forced to leave.

### PHYSICAL EXAMINATION OF MOLDERS IN THE FALL RIVER DISTRICT.

The foregoing observations have been quoted in full as evidence of the thoroughness with which the Massachusetts investigation was carried out. In the Fall River district physical examinations were made of 320 molders, with the following results: Bronchitis, asthma, and emphysema were ascertained in 41, or 12.8 per cent, of the molders examined. In addition thereto 39, or 12.2 per cent, were suffering from diseases of the heart, chiefly valvular disease or dilation; and 23, or 7.2 per cent, were suffering from diseases of the kidneys. In the aggregate, of the 320 examined 103, or 32.2 per cent, were found to be in a more or less serious condition of ill health. The ages of those examined ranged from 45 to 72, so that the conclusions apply entirely to molders well advanced in years, and no doubt for a considerable period engaged in the occupation.

### NATURE AND PROPERTIES OF MOLDING SANDS AND DUSTS.

In the main, the health-injurious exposure is to the highly comminuted sand disseminated in the form of dust throughout the foundries, but chiefly in connection with cleaning and so-called sand blasting processes. The nature and properties of molding sands have been described by Mr. Percy Longmuir before the British Foundrymen's Association, in the Engineering Magazine.[1] Sand used for casting iron molds usually contains 84 per cent of silica and, in addition thereto, varying amounts of alumina, magnesia, lime, and metallic oxides. The pure silica is, however, recognized as the most injurious form of dust, but especially so when very finely comminuted, as is generally the case in molding processes. The health aspects of foundry work are, therefore, of special importance, but particularly so with reference to the control of the needless degree of dust exposure. What can be done in this connection is emphasized in a brief reference to the subject in the annual report of the chief inspector of factories and workshops for the year 1913, in which it is said that—

Early in 1913 the prevention of dust in various departments of iron foundries was discussed at Falkirk with representative employers, and it was agreed that steps should be taken to improve the conditions in dressing, grinding, and fitting shops. Satisfactory arrangements have already been installed in some of the foundries, and before long it is hoped that all principal machines will be dealt

[1] Engineering Magazine, vol. 30, March, 1906, pp. 909–911.

with. Experiments are also to be tried to devise means for carrying off dust generated by the hand brushing of castings, as this operation frequently leads to most undesirable conditions. Meanwhile some effort is being made to keep floors cleaner, so as to reduce the dust stirred up by the movements of the workers.

### FOUNDRY INVESTIGATIONS IN OHIO.

Quite recently, also, the conditions of employment in iron foundries have been investigated by Hayhurst, of the Ohio State Board of Health, including 43 establishments in 14 cities, employing a total of 4,721 wage earners. Foundry processes, it is said, are carried on in connection with a variety of industries, chiefly, however, foundry and machine shop products, iron and steel mills, stoves and furnaces, agricultural implements, automobiles and parts, musical instruments, brass and bronze products, electrical apparatus, etc. Reference is made to a report by the financier of the International Molders' Union of North America to the effect that, out of 204 deaths in the Ohio branch of the molders' union in the five-year period 1909 to 1913, the chief causes of death were pneumonia, 30, or 14.7 per cent; heart disease, 30, or 14.7 per cent; tuberculosis, 27, or 13.2 per cent; and violence, 18, or 8.8 per cent. With reference to the experience of the same organization, it is said that—

We can well understand that foundry conditions are such as to promote the prevalence of both throat and lung disorders, and also rheumatism. The violent changes in temperature, the drafts and dampness of the foundry, are conducive to suffering of this kind. It might truly be said that rheumatism in its several forms appears to be the nearest approach, if any, to what might be designated as an "occupational disease."

These observations were in a large measure confirmed by the investigations of Hayhurst, who states that—

The presence of foundry dust appeared a negligible hazard in 7 places, fairly so in 17 more, and bad in the remaining 19. This dust was composed chiefly of mold sand, iron oxides, iron, dross, slag, cinders, and dirt. Of these the first is to be considered the most harmful. While it is practically impossible to avoid dust in iron foundries, the presence of subprocesses, such as casting cleaning, and furnacing, as well as other processes, which might be carried on in separate quarters, add greatly to the amount of fine dust floating in the air.

### AIR CONTAMINATION BY GAS AND SMOKE.

Further reference is made to air contamination by mold fumes, gas fumes, smoke, and steam, and in a number of work places the air was badly vitiated during the winter season by the presence of coke-burning braziers used for heating, placed about in the quarters and yielding immense amounts of invisible coke gas due to the absence of flue connections to the outside. Cold, due either to the lack of efficient heating or to the rush of cool drafts, was considered a hazard to many workers in at least 15 of the places inspected. With reference thereto it is said by Hayhurst that—

It is but natural that chilling of certain muscles and groups of muscles, which at intervals must be called into sudden severe straining actions, usually in hot places, should be greatly affected with sprains and rheumatism, shown as lumbago, wry neck, sciatica, neuritis, severe chest and shoulder pains, stiffness of joints, etc. Particularly is this condition favored by the going out-of-doors to closets, or at noontimes, or going home while wearing sweaty underclothes.

The results of the inquiry are summarized in the conclusion that—

Founding is an example of an industry which in itself should be harmless; in fact, should promote health and longevity the same as any application requiring the general use of nearly all of the body functions. It is rendered dangerous chiefly because it is done indoors. On this account a great many precautions are necessary to be taken, as indicated, including the general medical supervision of the workers.

### DUST EXPOSURE IN CASTING CLEANING.

With special reference to casting cleaning it is said that this is necessarily a very dusty process, as usually performed, and whether done by hand or steel brushes or with sand and air blasts, or by knocking and tapping, laborers so engaged should be protected from the dust, probably best by helmets supplied with compressed-air blasts, and the tumbling of small pieces or cleaning within inclosures or other dust-confining means should be used wherever possible.

### GENERAL CONCLUSIONS.

Regardless of the foregoing conditions, which are quite generally known and understood, there has not thus far been the required degree of sanitary progress urgently called for by the highest considerations of the health and longevity of the men employed. The special liability to pulmonary tuberculosis as brought out by the statistical analysis of the available mortality data is confirmed by specialized investigations, summarized in an editorial note on tuberculosis among metal molders in Massachusetts, in the July (1914) issue of the Journal of the Massachusetts State Sanatoria, where it is said that—

The chief factors, then, in the molder's life in connection with the development of tuberculosis are the exhausting nature of the work, the overheat and subsequent exposure while exhausted to cold outdoor air, the exposure to dust and gases, and, as stated, the exposure of certain molders to the debilitating effects of the fumes of poisonous metals. And to these must be added that factor so common to all exhausting occupations, the abuse of alcohol, which appears to be almost a direct result of the nature of the work.[1]

## CORE MAKERS.

Core making is an essential branch of foundry practice. This occupation gives employment to a considerable number of young persons, mostly boys, but of late years girls have been drawn into the trade, although it is held that the more arduous duties and surrounding conditions of the occupation are unsuited to the female sex. No qualified investigation appears to have been made into the health conditions of this employment, but in a general way the conditions approximate those of foundry practice in general.[2] There is a considerable exposure to both mineral and metallic dust, but the fact that large numbers follow this occupation for only a comparatively short time no doubt prevents the more serious results which would follow if the exposure were continued for many years.

### SANITARY CONDITIONS IN FOUNDRIES.

The process of core making in connection with foundries is, of course, quite general to the iron and steel industry, the brass industry, etc. The general exposure, however, is rather to mineral dust than to metallic dust, although under given conditions the latter may assume prior importance. The dust in connection with the core-making process is described by Hayhurst[3] as consisting of sand, earths, and mold powders, but this conclusion no doubt was one based upon general observation rather than upon microscopical analysis. Among related sanitary features injurious to health Hayhurst refers to dampness, poor light, and poor aeration, the latter, of course, being chiefly due to the fumes and smoke. Variations in temperature conditions are also noticed, and fatigue is mentioned as a considerable hazard in the majority of the work places investigated. The chief complaint of the workers was the breathing of burned-gas fumes and smoke; but apparently no specific complaint was made of health-injurious dust.

### NEW YORK STATE FACTORY INVESTIGATION.

The condition of foundries was inquired into by the New York State Factory Investigating Commission, who directed particular attention to the employment of women, chiefly in connection with

[1] American Journal of Public Health, 1914, p. 1254.

[2] Of special interest and value in this connection are the Rules and Regulations of the New York State Department of Labor regarding foundries and work in core-making rooms in which women are employed. (Labor Law and the Industrial Code, Albany, 1916, Rules 582–585.)

[3] Core making is discussed by Hayhurst in the Ohio State Bulletin of the Board of Health, February, 1915, p. 165.

core-making processes.[1] They state, as a result of their investigation, that molders were found to suffer from rheumatism, pulmonary diseases, and kidney troubles, which by implication applies also to core makers. They refer to the fumes and the heavy dust from the castings cleaned in the workrooms, which, being inhaled by the workers, render them more or less susceptible to all forms of respiratory diseases. They give expression to the opinion that "the employment of women in work of this kind in the foundries of the State should be prohibited."

## MORTALITY OF CORE MAKERS—INDUSTRIAL INSURANCE EXPERIENCE.

The only available vital statistics of core makers are those derived from industrial insurance experience, including 357 deaths, of which 105, or 29.4 per cent, are from pulmonary tuberculosis. The details of the mortality are shown in Table 110.

TABLE 110.—PROPORTIONATE MORTALITY FROM PULMONARY TUBERCULOSIS AMONG CORE MAKERS, 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 core makers, 1897 to 1914, from— | | Per cent of deaths from pulmonary tuberculosis among— | |
|---|---|---|---|---|
| | All causes. | Pulmonary tuberculosis. | Core makers. | Males in registration area, 1900 to 1913. |
| 15 to 24 years | 113 | 36 | 31.9 | 27.0 |
| 25 to 34 years | 98 | 42 | 42.9 | 30.5 |
| 35 to 44 years | 63 | 19 | 30.2 | 23.4 |
| 45 to 54 years | 42 | 5 | 11.9 | 14.7 |
| 55 to 64 years | 26 | 3 | 11.5 | 7.9 |
| 65 years and over | 15 | | | 2.6 |
| Total, 15 years and over | 357 | 105 | 29.4 | 13.9 |

When considered by divisional periods of life it appears that the proportionate mortality from pulmonary tuberculosis is highest at ages 25 to 34, when out of the mortality from all causes 42.9 per cent are from this disease, against 30.5 per cent expected on the basis of the mortality experience for the United States registration area. There are no corresponding statistics available for women. The data suggest the importance of further investigation and the possibility of a material improvement in sanitary conditions in consequence of the use of dust-laying devices. It may be said in conclusion that, according to the United States census of 1910, the number of male core makers was 16,479, and of female core makers, 1,836. A considerable portion of core makers of both sexes were under 20 years of age.

[1] For a brief discussion of the employment of women in core rooms see New York State Factory Investigating Commission Report for 1913, Vol. I, pp. 255–263.

### GENERAL CONCLUSIONS.

Core making is so generally carried on in connection with foundries that the occupation is frequently combined with molders, etc. Core makers in brass and iron foundries are briefly referred to by Kober and Hanson in their recent work on "Diseases of Occupation and Vocational Hygiene," but the observations are quite inadequate and inconclusive. In view of the fact that a large proportion of women are employed as core makers, it is reasonable to assume that with them the health-injurious consequences are more serious on account of dust exposure than in the case of men more resistant to disease and more inclined to change their occupation. Kober observes in this connection that core and mold makers are "exposed to the inhalation of large quantities of dust, especially in sifting the sand for the cores and in dusting the completed molds with powdered charcoal and graphite." He also remarks that female labor is often employed in the making of cores for small castings, and that the men engaged in breaking up the hot molds "naturally inhale large quantities of dust," determined by Ahrens on the basis of German investigations to amount to 28 mg. of dust per cubic meter in the air of foundry rooms, and by Hesse to amount to 71.7 mg. per cubic meter in the air of the cleaning and polishing room, which it is calculated would subject each operative to the inhalation of 42 grams of dust per annum. It is self-evident that the occupation is one which requires thoroughly well-considered methods of factory supervision if the readily apparent dust hazards are to be reduced to a harmless minimum. On account of the considerable employment of relatively young persons, including women, in core-making processes, intelligent supervision and control are urgently required.

### THE GLASS INDUSTRY.

The glass industry in the United States in 1909 gave employment to some 69,000 wage earners, of whom about 5 per cent were children under 16 years of age. The industry is a varied one, including among others the manufacture of blown and pressed ware, of window glass and plate glass, and finally of so-called crystal or cut glass, which for the present purpose is considered as a separate industry. The labor division of the trade includes numerous and well-defined occupations, each of which is subject to more or less injurious circumstances, but of these the handling of materials and the mixing are the most liable to the risk of continuous inhalation of mineral dust. The most important employment is that of the glass blower, but there are few accurate statistics which separate this employment from the industry as a whole. For the present purpose, however, it has seemed best, as far as practicable, to consider separately the mortality of glass blowers, although the medical and statistical observations subsequently to be quoted refer more or less to glassworkers as a class. Changes in manufacturing processes and the introduction of labor-saving machinery have resulted in sanitary improvements, which in consequence have had a favorable effect upon the health of glass blowers, at least in the United States, as far as the rather fragmentary statistical data can be relied upon. Among glassworkers as a class pulmonary tuberculosis is of exceptional frequency, in addition to which there is a comparatively high mortality from other respiratory diseases, lead poisoning, and heat prostration.[1]

### EARLY OBSERVATIONS ON THE HEALTH OF GLASSWORKERS.

Thackrah, writing in 1832, held that glassworkers as a class were liable to catarrh and cough, but not to pleurisy and pneumonia. He commented upon the appearance of a fine dust at the furnaces which, however, in his opinion did not produce any marked effect on the health of the operatives. He also mentioned individual cases of glassworkers remaining at their employment at ages 70 to 80, but in the majority of instances failing eyesight at ages 50 to 60 disqualified for the employment. Thackrah's account of this occupation was, however, very superficial, and some of his conclusions were not at all in conformity to the facts as reported by other authorities. Tracy, writing in 1879, held that—

> In the manufacture of glass the workmen who grind and powder the siliceous material inhale great quantities of very irritating dust and suffer from constant hacking cough and conjunctivitis. It is rare to find a sound man among them and they are not able to continue long at the work. According to Hirt, they should not be allowed to labor, at a stretch, more than two or three weeks, and should then work at something else, or, at any rate, give up this occupation for at least double the working time. In this way, by the use of relays, the health of the men may be sustained.[2]

### ENGLISH OCCUPATIONAL MORTALITY STATISTICS.

As shown by the census returns the actual numbers, as well as percentages, of glassworkers at advanced ages are surprisingly small. It is evident that the rapid diminution of the number at work after age 35 must be partly, at least, the result of a high death rate at the younger ages, and in particular due to an excessive mortality from pulmonary tuberculosis, which at this period of life causes from one-

[1] See, Working Conditions and Efficiency as Affected by Heat, by Basil M. Manly, in Report on Conditions of Employment in the Iron and Steel Industry. U. S. Bureau of Labor Statistics, Vol. III, 1912, pp. 287–332.
[2] Buck's Hygiene and Public Health, Vol. II, pp. 36, 37.

third to one-half of the deaths from all causes. Tatham, in Oliver's "Dangerous Trades" (p. 139), considers this employment at some length, and his observations, based largely upon English mortality data, are quoted in part as follows:

The making, blowing, and engraving of glass occupies a prominent place among unhealthy trades for several reasons. In the first place, the workers are exposed to extreme variations of temperature—in some processes, that of glass blowing especially, the operatives are constantly exposed to the intense heat of the furnace, as well as to that which radiates from the pots of molten glass which they are engaged in blowing. The intense heat and profuse sweating naturally induce painful thirst, which the workmen evidently allay by excessive drinking; this is shown by the fact that their mortality from alcoholism and from nervous disorders is nearly double that experienced by operatives in other trades. * * * The comparative mortality figure for glass makers is 1,487, and is, therefore, in excess of the average by 56 per cent. Phthisis and diseases of the respiratory system are especially fatal to workmen in this industry, and they suffer more severely than other occupied males from diseases of the circulatory, digestive, and urinary systems, as well as from cancer. Since 1881 the mortality of glassworkers has increased considerably, and this is true of the younger as well as the older workers in this industry.

The English mortality statistics upon which these conclusions rest include 1,092 deaths of glassworkers, and of this number 229, or 21 per cent, died from pulmonary tuberculosis. At ages 25 to 34, however, out of 177 deaths of glassworkers from all causes, 79, or 44.6 per cent, were caused by this disease. Of the mortality from other causes, bronchitis caused 146 deaths, pneumonia 123, and other respiratory diseases 25. These combined with deaths due to pulmonary tuberculosis make a total of 523, or 47.9 per cent, from diseases of the lungs and air passages in the mortality of glassworkers from all causes. The most recent English mortality statistics of glass manufacture 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:

In this occupation the death rates exceed the standard for occupied and retired males at all stages of life by proportions ranging from 12 to 32 per cent. In the main working period the comparative mortality figure is 1,260, or 25 per cent above the standard. The excess of mortality among these workers is most marked in the case of plumbism, phthisis, respiratory diseases, and Bright's disease; they also suffer heavily from influenza and from diseases of the nervous and circulatory systems. The mortality from alcoholism, accident, and suicide, however, is below the average.

## COMPARATIVE MORTALITY FROM ALL CAUSES AND FROM DISEASES OF THE LUNGS.

The recent English mortality statistics for glassworkers are quite conclusive of the more or less unfavorable effect of this industry on health. In Table 111 the mortality from all causes among men in this group 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. The excess in the general death rate of glassworkers is met with at all ages, but the relative and actual excesses are greatest with advancing years, being 6.41 per 1,000 at ages 45 to 54, 10.83 at 55 to 64, and 30.99 at 65 and over.

Table 111.—MORTALITY FROM ALL CAUSES AMONG GLASSWORKERS, 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 glassworkers. | | |
|---|---|---|---|---|
| | | Rate per 1,000. | Greater(+) or less (−) than rate for all occupied males. | Ratio to rate for all occupied males. |
| 15 to 19 years | 2.44 | 3.22 | + 0.78 | 132 |
| 20 to 24 years | 4.41 | 5.09 | + .68 | 115 |
| 25 to 34 years | 6.01 | 6.74 | + .73 | 112 |
| 35 to 44 years | 10.22 | 13.14 | + 2.92 | 129 |
| 45 to 54 years | 17.73 | 24.14 | + 6.41 | 136 |
| 55 to 64 years | 31.01 | 41.84 | +10.83 | 135 |
| 65 years and over | 88.39 | 119.38 | +30.99 | 135 |

A more extended comparison is made in Table 112, in which the mortality of glassworkers from pulmonary tuberculosis and other respiratory diseases is compared with the normal mortality of occupied males from these diseases, by divisional periods of life. The comparison shows that the mortality from pulmonary tuberculosis is excessive at all ages, 15 to 64 inclusive, the excess being most marked at ages 35 to 54. The table further shows that the mortality of glassworkers from other respiratory diseases is excessive at all ages, the excess being most marked at ages 45 or over. The two tables derived from English experience fully confirm the previous conclusion that the mortality of glassworkers is excessive when comparison is made with the mortality of occupied males generally, and that this excess is largely because of the high degree of pulmonary tuberculosis frequency at ages 25 to 54, and a high mortality from other respiratory diseases at ages 35 or over.

TABLE 112.—MORTALITY FROM PULMONARY TUBERCULOSIS AND FROM OTHER DISEASES OF THE RESPIRATORY SYSTEM AMONG GLASSWORKERS, 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 glassworkers. | | | Death rate per 1,000 for all occupied males. | Death rate for glassworkers. | | |
| | | Rate per 1,000. | Greater (+) or less (−) than rate for all occupied males. | Ratio to rate for all occupied males. | | Rate per 1,000. | Greater (+) or less (−) than rate for all occupied males. | Ratio to rate for all occupied males. |
| 15 to 19 years | 0.54 | 0.56 | +0.02 | 104 | 0.24 | 0.28 | + 0.04 | 117 |
| 20 to 24 years | 1.55 | 1.81 | + .26 | 117 | .48 | .60 | + .12 | 125 |
| 25 to 34 years | 2.03 | 2.88 | + .85 | 142 | .77 | .99 | + .22 | 129 |
| 35 to 44 years | 2.74 | 4.56 | +1.82 | 166 | 1.66 | 2.43 | + .77 | 146 |
| 45 to 54 years | 3.04 | 4.87 | +1.83 | 160 | 3.32 | 5.76 | + 2.44 | 173 |
| 55 to 64 years | 2.16 | 2.97 | + .81 | 138 | 6.54 | 10.75 | + 4.21 | 164 |
| 65 years and over | 1.11 | ........ | ........ | ........ | 17.77 | 28.68 | +10.91 | 161 |

## MATERIALS USED IN GLASS MANUFACTURE.

The American glass industry has made considerable progress during recent years, but it may be questioned whether material modifications have been introduced into the manufacturing processes with special reference to necessary precautions against health-injurious conditions. The processes have been described in detail by Charles C. Dominge, who, with reference to the materials used, states that—

The principal ingredients are washed and dried sand (white), lime, soda ash, potash and cullet, i. e., old broken glass and waste from melting pots. In some risks you may also find charcoal, oxide of lead, kelp, saltpeter, and cobalt (the latter used for coloring purposes). The lime and charcoal should be skidded and kept under a tight roof. The saltpeter or niter bags are likely to take fire spontaneously, therefore they should be removed from the building as soon as they are emptied.

The same authority describes the actual process of glass manufacture, in part, as follows:

The above materials are mixed together, forming what is known as "batch," which is placed in a fire-clay pot, inserted in brick-inclosed pot furnace, with soft coal feed. This "batch" is then subjected to a temperature of approximately 2,500° F., which causes a perfect union and fusion of the materials. When this "batch" (i. e., glass ready for working) has cooled to a temperature of, say, 1,900° F., it is ready to be gathered. This is done by means of an iron blowpipe, which is thrust into the fire-clay pot, the molten glass clinging to the end of the pipe, resembling a ball. To make his material perfectly true, concentric with his iron pipe, the worker rolls it dextrously on an iron table or wooden block of special design. The glassmaker then blows through the blowpipe, which inflates the batch "soap-bubble fashion," at the same time deftly shaping, altering, coaxing it into form and proportion with cunningly devised hand tools. The glass design is then placed in a water-jacketed mold, after which it goes to the brick-set tempering oven (known as "lehr"), which resembles a long, horizontal, brick-set boiler. These lehrs are fed by coke or gas, with the heat directly at the entrance, where the glass objects are placed on a traveling platform. About 1,000° F. is maintained here. The object is to give the glass the vital "temper," a provision against the piece bursting later in the decorator's hand. The glass cools slowly in its travel from the entrance where the heat is maintained to the other end, sometimes 40 to 125 feet long. Some of the heavier glass pieces require a week before they are removed from the oven.

Conditions of employment, with special reference to occupational hazard, vary, of course, according to the type of melting furnace used. Dust exposure is apparently more serious at the old style pot furnaces than at modern tank furnaces, which are usually built in three compartments or sections, each of which is heated to a different temperature. It is explained by Mr. Dominge that—

The newer factories now use what is known as the melting tank or melting furnace or continuous tank. They are usually built in three compartments or sections, each of which is heated to a different temperature. The heated glass runs through an orifice near the base of the first section into the second section, where it is refined, after which it flows into the third compartment. The glass is now ready to be "gathered" by the glass worker. The temperature in the first section is about 2,500° F., the molten glass being at this stage colorless and translucent. The temperature in the second section is about 1,900° F., while the last section is so heated as to allow the glass to get into a form resembling paste.

Other processes involving heat and dust are the working of the so-called "glory holes," which are small, brick-inclosed circular furnaces used for heating glassware, for edge trimming, and other purposes; annealing furnaces, "which resemble somewhat a baker's oven, arranged in a series of three or four adjoining and heated by open and gas flames about waist high above the foundation." Into this "the hot glassware is introduced by hand and removed from one oven to the other, each being heated at a reduction in temperature to perfect annealing without rupture." The so-called "lehr" or tempering furnaces are of quite a different type, but the work involves about the same degree of temperature and dust exposure. Theoretically the most hazardous process is probably the so-called "pot making," which consists in the making of the furnace mold of fire clay molded by hand and the grinding up of old pots on the premises, with a considerable exposure to irritating mineral dust.[1]

[1] A useful and descriptive account of the glass-making process occurs in the Annual Report of the New Jersey Bureau of Labor for the year 1906. The account includes all of the essential subdivisions of the industry and among others wooden-mold blowers, carboy blowers, lamp workers, batch makers, tending boys, shearers, etc.

**LABOR CONDITIONS IN OHIO AND NEW YORK.**

Hayhurst, in a brief description of glass-making processes, adds much new and useful information, stating that the process consists "in combining the various siliceous materials, alkalis, and other ingredients," and that the work is usually done in part by machinery and in part by hand labor, "the latter causing a great deal of dust because of shoveling and scooping." Dust in the air was noted in all work places investigated, and in the majority the conditions were bad, "due to the manner of handling the ingredients." With special reference to the mixing process it is suggested that "this work should be done in light, ventilated, dry quarters, above ground preferably, and, where mechanical means will not confine dust, workers should be furnished respirators of some sort and compelled to wear them. Those handling or exposed to poisonous dusts should be selected for intelligence, properly instructed, and seen by a physician at least once a month." This last suggestion has special reference to exposure to dust contamination by arsenic and red lead. The glass industry was also briefly inquired into by the New York State Factory Investigating Commission, who, in their second report, 1915 (Vol. II, p. 1115), refer to two different kinds of glass manufactured—a flint glass containing no lead and used principally for bottles and a glass containing lead compounds and other poisonous ingredients used chiefly for other purposes. It is explained that—

The lead and other compounds are weighed and mixed in one room, then taken to the furnace room and mixed with a quantity of old glass; the entire mixture is then put into the furnace or pot and fused. The material in the pot is kept in a liquid state by high temperature, and into this the glass blower dips his pipe, taking out the amount he wishes to work. The greatest danger is from the handling of the dry ingredients and inhaling the dust created during the weighing and mixing.

Conditions in a typical mixing room are described, and it is said that during the mixing process no methods were employed "to carry away the dust created, but although the men were furnished respirators none were found to wear them." Evidence of lead poisoning was met with in a number of cases. The chief factor of neglect is the absence of precautions to guard against dust. Analyses of samples taken in the mixing room showed 3.3 mg. of lead per cubic meter of air. In another plant it was also found that no special precautions were employed, and while mixers were furnished respirators they would not wear them.

### OCCUPATIONAL HAZARDS IN GLASS MANUFACTURE.

The most recent observations with regard to American conditions are by W. Gilman Thompson, who points out that—

> Glassworkers are subject to four principal forms of occupation hazard, namely, (1) exposure to great heat; (2) mechanical and chemical dust irritation; (3) poisoning by certain metals, such as lead oxide, zinc oxide or arsenic, used for coloring, etc.; (4) irritation of the eyes, caused by excessive heat and light.

It is explained that certain raw materials, such as flint, sand, quartz, powdered marble, limestone, soda, Glauber's salt, and potash, are finely ground and mixed, usually in open vessels, which he considers extremely dusty work. The temperature near the heating furnaces may reach 140° F., and the workmen in winter are, therefore, subjected to great changes of temperature in passing in and out. He explains further that—

> The result of inhalation of so many kinds of dust, from the raw materials used, the particles of ground glass, and the grinding materials, such as emery, etc., may give rise to pulmonary fibrosis and chronic bronchitis, which predispose to tuberculosis, but emphysema is not produced by glass blowing, as formerly supposed, despite the deep inspiration and prolonged expiration employed in the process. Emphysema is due to connective tissue changes in the lungs, and this disease is no more frequent among glass blowers than among any similar group of workmen when due regard is had for age, alcoholism, chronic pulmonary disease, and other predisposing factors.

### PRACTICAL SANITARY PRECAUTIONS.

Thompson concludes these exceptionally interesting and useful observations with suggestions for the prevention of the more specific health-injurious conditions, as follows:

> The raw materials of glass, when being mixed, should be kept in covered receptacles as much as possible. The introduction of mechanical apparatus for glass blowing is doing much to mitigate the evils of this occupation when performed by mouth. Workmen should be examined by a physician, and all who are actively syphilitic excluded. The excessive heat from the furnaces may be guarded against by the use of asbestos screens and forcible introduction of a stream of cool air by means of a blow fan and duct. The eyes should be protected from the light and heat of the ovens by blue and gray goggles, and face masks may be worn to protect the skin of the face from blistering. All grinding rooms should be thoroughly cleaned daily and dust removed from the wheels, tables, and benches. The wheels should be incased as much as possible, and a strong exhaust duct should be operated in connection with them. Women and children should be excluded from the more hazardous departments of work. When handling sharp-edged glass vessels or working with lamp chimneys or thin bottles which are liable to explode, the hands

should be protected from injury by stout leather gloves. The grinding or cutting of quartz, crystal and jet, jade, and similar substances presents the same hazards to the respiratory system as those of glass grinding.

### PRESENT-DAY LABOR CONDITIONS.

An exhaustive report upon labor conditions in the glass industry, with some extended references to sanitation and mortality, was included in the Senate report of the Commissioner of Labor on the "Condition of Woman and Child Wage Earners in the United States," Washington, 1911. This report includes a descriptive account of American glass-making processes, with observations on physical strain, interchange of occupations, dust, fumes, heat conditions, hours of labor, night work, etc. The mortality data are limited to glass blowers, elsewhere referred to, but in a general way the conclusions are applicable to glassworkers as a class. An extended descriptive account is included, from the Twenty-fourth Annual Report of the Bureau of Statistics of Labor and Industries of New Jersey, for 1901, which in a large measure is applicable to the present time. Attention is directed in this report to the improvement in working conditions introduced into glass works during the last two decades, but apparently much remains to be done to eliminate many objectionable features, especially such as refer to weather exposure, dampness, extreme heat, etc. It is said in this connection, however, that the improvements referred to "have removed some of the most serious causes of ill health, and they have greatly lessened the workmen's liability to contract disease while at work." A new element of danger, however, has been introduced in consequence of the extensive use of the so-called "continuous-tank furnace," which is said to be "severe upon all blowers and especially so on the older men who have been accustomed for years to work out of a pot furnace and only during the day." The heat of a tank furnace is much greater than that of a pot furnace, and "the alternation from day to night work weakens the system and reduces its power of resistance to attacks of disease." In concluding the report, it is pointed out that "it is certain that the environments of the workmen" (in glass factories) "create tendencies to disease, which, taken with their own lack of care have greatly aggravated attacks of sickness and in many cases caused them to assume characteristics very difficult to treat." Out of 314 cases of sickness specifically reported there were no cases of pulmonary tuberculosis, but there were 18 cases of pneumonia, 21 of inflammation of the lungs, 16 of inflammation of the throat, and 10 of bronchitis, aside from 76 cases of la grippe. It is self-evident, of course, that without a qualified medical examination of the employees the true extent of incipient tuberculosis could not be ascertained, and it is a reasonable assumption that in a more advanced condition of the disease the employee would not be at work. The statistics, however, suggest a relatively high frequency of respiratory diseases, which, as elsewhere observed in the general discussion of pneumoconiosis, is generally a predisposing condition in pulmonary tuberculosis.

### SPECIFIC LIABILITY TO RESPIRATORY AND TUBERCULOUS DISEASES.

In so far as the evidence is available, the general conclusion is distinctly unfavorable regarding employment in the glass industry, with special reference to an increased liability to respiratory and tuberculous diseases. The rather inconclusive American evidence is quite fully confirmed by more extensive investigations into the hygiene of glassworkers in Germany[1] and Austria, referred to at some length in the report of the Commission of Labor on the condition of woman and child wage earners in the United States, with special reference to the glass industry, which should be referred to for more extended consideration. It seems sufficient for the present purpose to conclude these observations with the following extract from a translation of a German treatise on the diseases of glassworkers, by Dr. C. F. Schmidt:

> In the foreground among all diseases of the glass grinders stands the damage to the lungs by glass dust. This glass dust produces its effect by the mechanical irritation of the fine, sharp-angled and needle-pointed particles of glass. The dust particles may at length find their way into the lymph current and be deposited in the lungs and bronchial glands. Meinel, for example, found in the lungs of a glass blower a siliceous content of 30.7 per cent. Soon there supervenes a chronic catarrh of the larger bronchial tubes and bronchioles, the desquamated and inflamed mucous membrane of which finally affords a congenial soil for colonies of tubercle bacilli. Tuberculosis of the lungs makes early victims of a large proportion of the glass grinders. This is readily explicable, because, even as apprentices, they are exposed to the glass dust.

These observations, in addition to the foregoing statistical data and descriptive references, quite fully sustain the conclusion that employment in the glass industry must be considered as obviously injurious to health, with a measurable predisposition to pulmonary tuberculosis, partly, if not largely, on account of the considerable and continuous exposure to the inhalation of mineral dust.

### INDUSTRIAL INSURANCE MORTALITY STATISTICS.

Since glass blowers and cutters are separately considered, and in view of the foregoing observations with special reference to mixers

[1] A most usful reference to hygienic conditions in the German glass industry occurs in the report of Consul General Frank Dillingham, reprinted in the Daily Consular and Trade Reports, Washington, Feb. 4, 1909.

and handlers of raw materials, as well as workmen generally exposed to the dust hazard, the following vital statistics derived from the industrial insurance mortality experience of the Prudential Insurance Co. of America are only for glassworkers other than blowers and cutters. Table 113 includes 897 deaths of glassworkers not otherwise specified, and of this number 274, or 30.5 per cent, are deaths from pulmonary tuberculosis.

TABLE 113.—PROPORTIONATE MORTALITY FROM PULMONARY TUBERCULOSIS AMONG GLASSWORKERS, EXCLUDING BLOWERS AND CUTTERS, 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 glassworkers, 1897 to 1914, from— | | Per cent of deaths from pulmonary tuberculosis among— | |
|---|---|---|---|---|
| | All causes. | Pulmonary tuberculosis. | Glassworkers. | Males in registration area, 1900-1913. |
| 15 to 24 years | 257 | 81 | 31.5 | 27.0 |
| 25 to 34 years | 186 | 95 | 51.1 | 30.5 |
| 35 to 44 years | 151 | 52 | 34.4 | 23.4 |
| 45 to 54 years | 108 | 25 | 23.1 | 14.7 |
| 55 to 64 years | 103 | 16 | 15.5 | 7.9 |
| 65 years and over | 92 | 5 | 5.4 | 2.6 |
| Total, 15 years and over | 897 | 274 | 30.5 | 13.9 |

The table shows further that the proportionate mortality from pulmonary tuberculosis was extremely high among glassworkers not otherwise specified at ages 25 to 34, or 51.1 per cent, against the expected normal mortality of 30.5 per cent. The data are extremely suggestive and emphasize the importance and in fact the necessity of thorough-going methods of factory supervision and State control of industrial processes inimical to health and longevity.

## MORTALITY OF GLASSWORKERS—UNITED STATES REGISTRATION AREA.

The mortality of glassworkers has been reported upon for the years 1908–1909 by the Division of Vital Statistics of the United States Census Bureau, but blowers and workers in general are included only for the year 1908. No explanation is made in the text of the report regarding the inclusion or exclusion of particular occupations for either one of the two years, during which the analysis was made by industries or occupations with reference to specific causes of death by divisional periods of life. According to the census report, out of 867 deaths of glassworkers from all causes 260, or 30 per cent, were from pulmonary tuberculosis. This is distinctly excessive when contrasted with 14.9 per cent for all occupied males and 16.7 per cent for plasterers. The details of the mortality by divisional periods of life are shown in Table 114.

TABLE 114.—PROPORTIONATE MORTALITY OF GLASSWORKERS FROM PULMONARY TUBERCULOSIS, UNITED STATES REGISTRATION AREA, 1908 TO 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 | 176 | 83 | 47.2 |
| 25 to 34 years | 202 | 86 | 42.6 |
| 35 to 44 years | 169 | 56 | 33.1 |
| 45 to 54 years | 117 | 23 | 19.7 |
| 55 to 64 years | 101 | 8 | 7.9 |
| 65 years and over | 101 | 4 | 4.0 |
| Age unknown | 1 | | |
| Total, 15 years and over | 867 | 260 | 30.0 |

TABLE 115.—PROPORTIONATE MORTALITY OF GLASSWORKERS FROM NONTUBERCULOUS RESPIRATORY DISEASES, UNITED STATES REGISTRATION AREA, 1908 TO 1909.

| Cause of death. | Deaths from nontuberculous respiratory diseases. | |
|---|---|---|
| | Number. | Per cent of deaths from all causes. |
| Asthma | 2 | 0.2 |
| Bronchitis | 5 | .6 |
| Pneumonia | 67 | 7.7 |
| Other nontuberculous respiratory diseases | 6 | .7 |
| Total | 80 | 9.2 |

According to Table 114 the proportionate mortality was excessive at all ages throughout the entire working period of life, but particularly so at ages 15 to 24, when out of the mortality of glassworkers from all causes 47.2 per cent were from pulmonary tuberculosis. The corresponding proportion for potters was 46.2 per cent, and for marble and stonecutters 26.2 per cent. At ages 25 to 34 the differences are less pronounced, the proportion of deaths from pulmonary tuberculosis having been 42.6 per cent of the mortality from all causes among glassworkers, against 44.4 per cent for potters and 43.5 per cent for marble and stonecutters. In a general way the table confirms other investigations and may be considered fairly conclusive, except in so far that the same applies to the glass industry in general rather than to specific occupations or employments subject to the most trying conditions of mineral dust exposure, complicated, of course, by physical strain, heat exposure, temperature changes, etc. Aside from the mortality of 30 per cent from pulmonary tuberculosis glassworkers show an additional mortality from nontuberculous respiratory diseases of 9.2 per cent, which compares with 12.5 per cent for potters and 12.2 per cent for marble and stone workers. As far as it is possible to judge, therefore, the mortality from nontuberculous respiratory diseases is not distinctly excessive, for in comparison the mortality of all occupied males is 10 per cent, or respectively, 7.8 per cent for pneumonia against 7.7 per cent for glassworkers, and 0.9 per cent for bronchitis against 0.6 per cent for glassworkers.

### GENERAL CONCLUSIONS.

Employment in the glass industry, therefore, while predisposing to pulmonary tuberculosis, appears to have no directly measurable relation to the occurrence of nontuberculous respiratory diseases. This conclusion is of special importance on account of the assumption that heat exposure and sudden temperature changes, which are quite common to the glass industry, predispose decidedly to pneumonia and other nontuberculous respiratory diseases. In the American glass industry this is apparently not the case.

## GLASS CUTTERS.

Glass cutters, including under this term all who are employed in the manufacture of crystal or so-called cut glass, constitute a separate and well-defined occupation division in glass manufacture.

### SANITARY ASPECTS OF GLASS CUTTING AND POLISHING.

The most important employments are roughing, smoothing, polishing, and puttying, but of these the last named is the most injurious, chiefly because of a specific liability to lead poisoning. The sanitary aspects of the employment have received the special consideration of a British committee on dangerous trades, which, in its Third Interim Report, remarked with special reference to the injurious effects of putty powder in the form of dust that—

> It will thus be seen that all persons employed in places where "putty powder" is used, though themselves not handling it, are liable, through inhalation of the dust, to illness and even death through juxtaposition with those engaged in its use. Under existing circumstances the wet powder splashes onto the clothes not only of the polisher who uses it, but onto those of his neighbors; it gets dry after a time, comes off in fine dust, and enters the system either by inhalation through the lungs or by swallowing or through the pores of the skin.

Among other recommendations for the amelioration of the more or less health-injurious conditions inherent in this employment, the committee suggested that all persons engaged in the department of glass cutting and powdering, where so-called putty powder is used, should be examined once a month by the certifying surgeon for the district, who should be empowered to order temporary or permanent suspension of work.

### EXPOSURE TO MINERAL AND METALLIC DUSTS.

Aside from the exposure to the inhalation of dust containing lead or other metallic ingredients, there is a further liability to the inhalation of considerable quantities of mineral dust in a large variety of forms. It would obviously be very difficult to estimate with even approximate accuracy the degree of lung injury resulting from dust exposure in glass cutting and polishing, but it is the opinion of qualified authorities that practically every branch of the trade is more or less affected, with a resulting excess in the mortality from pulmonary tuberculosis. Tracy comments briefly upon the health-injurious aspects of this occupation, in part as follows:

But the most dangerous work is that of the grinders and polishers of cut glass. About 35 per cent of them have chronic pneumonia (phthisis), and their average age at death is variously given at from 30 to 42 years. Putégnat (de Lunéville) has described a peculiar form of gingivitis which he has observed among glass cutters, and which, he says, attacks 95 out of every 100 workmen. It comes on in about three months after the person begins work, and toward the sixth month is well developed. It attacks by preference the upper jaw, and is accompanied by the same blue line that is found in cases of lead poisoning. The acid secretion of the gums destroys the enamel of the teeth, which soon become pointed, brittle, and break off close to the alveoli, leaving a permanent stump. The gums remain soft and spongy, and the breath is very fetid. At no time is there any pain or hemorrhage. He supposes it to be caused by malnutrition, bad air, etc. (Tardieu.) These symptoms certainly appear suspiciously like those of lead poisoning, and the suspicion is rendered stronger by the fact that French flint glass contains about 20 per cent of lead, and that other symptoms of lead poisoning are not uncommon in glass cutters, as colic, constipation, muscular pains, etc. Garrod has noticed the frequency of gout among them, and brings it forward to support his theory of a connection between that disease and saturnine poisoning.

The grinding or etching of glass by the sand blast fills the rooms with a dust composed of particles of sand and glass mingled. The business is a comparatively new one, and the workmen so far do not appear to be injured by it, with the exception of a slight tickling cough when they first begin work. The dust is rather coarse and heavy, and I am inclined to think it does not penetrate very far into the lungs, perhaps not even getting beyond the trachea, whence it is easily expectorated.

Lloyd also considered this employment, holding that—

Flint glass contains lead, being chemically a compound of silicon (silicic acid) with an alkaline and an earthy base, the latter being represented by lead. It is this flint, or lead, glass that is used for cut glass because of its brilliancy. The glass cutter's mill is a revolving disk of wrought or cast iron on which is fed a mixture of sand and water, with which the cutting and polishing are accomplished. In this process, which requires the artisan to bend closely over his mill, dust and fine particles of glass are given off. Emery and putty powder also are used, the latter containing lead. These are the noxious agents by which these cutters and polishers of flint glass acquire lead poisoning.

Unfortunately there are no official vital statistics of this occupation, since the comparatively small group of cutters of crystal glass is included in the census vital statistics with glassworkers generally. Cutters of crystal glass are continuously and considerably exposed to the inhalation of fine particles of mineral dust, which must indeed disastrously affect the lungs of the workmen, but in particular such as are otherwise predisposed to pulmonary tuberculosis. The suggestion of Oliver and others that crystal glass polishers and cutters should be periodically medically examined for cases of lead poisoning applies equally to the purpose of discovering incipient cases of tuberculosis more or less the result of the employment.[1]

#### MORTALITY OF GLASS CUTTERS—MEDICO-ACTUARIAL EXPERIENCE.

According to the medico-actuarial investigation, which, however, combines glass bevelers, grinders and cutters, excluding foremen and superintendents, the relative mortality from all causes was extremely high, or 46 per cent in excess of the normal. The details of this experience are shown in Table 116.

TABLE 116.—MORTALITY FROM ALL CAUSES AMONG GLASS BEVELERS, GRINDERS, AND CUTTERS, EXCLUDING FOREMEN AND SUPERINTENDENTS, BY AGE GROUPS.

[Medico-Actuarial Investigation.]

| Age at death. | Number exposed to risk one year. | Actual deaths. | Expected deaths. | Ratio of actual to expected deaths. |
|---|---|---|---|---|
| 15 to 29 years | 4,857 | 26 | 22.24 | 117 |
| 30 to 39 years | 3,187 | 33 | 17.45 | 189 |
| 40 to 49 years | 813 | 9 | 7.73 | 116 |
| 50 to 59 years | 193 | 6 | 3.43 | 175 |
| 60 years and over | 39 | 3 | 1.75 | 171 |
| Total | 9,089 | 77 | 52.60 | 146 |

[1] For additional references to the health-injurious circumstances in glass cutting and polishing, see the Reports of the Chief Inspector of Factories and Workshops for 1895, Vol. I, p. 36; 1896, p. 25; 1899, pp. 16, 313; 1900, p. 207; 1901, Part I, p. 220. For a descriptive account of the various manufacturing processes, see Scientific American for Apr. 30, 1904.

### MORTALITY OF GLASS CUTTERS—INDUSTRIAL INSURANCE EXPERIENCE.

It is regrettable that the foregoing experience should not be available with reference to causes of death. The mortality from pulmonary tuberculosis among glassworkers is, however, clearly shown in Table 117, derived from the industrial insurance mortality experience of the Prudential Insurance Co. of America, for the period 1897 to 1914, including 220 deaths from all causes, of which 80, or 36.4 per cent, were from pulmonary tuberculosis.

TABLE 117.—PROPORTIONATE MORTALITY FROM PULMONARY TUBERCULOSIS AMONG GLASS CUTTERS, 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 glass cutters, 1897 to 1914, from— | | Per cent of deaths from pulmonary tuberculosis among— | |
|---|---|---|---|---|
| | All causes. | Pulmonary tuberculosis. | Glass cutters. | Males in registration area, 1900-1913. |
| 15 to 24 years | 53 | 21 | 39.6 | 27.0 |
| 25 to 34 years | 55 | 28 | 50.9 | 30.5 |
| 35 to 44 years | 48 | 20 | 41.7 | 23.4 |
| 45 to 54 years | 28 | 6 | 21.4 | 14.7 |
| 55 to 64 years | 24 | 2 | 8.3 | 7.9 |
| 65 years and over | 11 | 3 | 27.3 | 2.6 |
| Age unknown | 1 | | | |
| Total, 15 years and over | 220 | 80 | 36.4 | 13.9 |

According to this table the proportionate mortality of glass cutters from pulmonary tuberculosis is highest at ages 25 to 34, when out of 55 deaths from all causes 28, or 50.9 per cent, are from pulmonary tuberculosis. The mortality from this disease, however, must be considered excessive at every divisional period of life. There appears to have been no material improvement in the health condition of glass cutters during recent years; and, with possibly the exception of the reduction of the liability to lead poisoning, there can be no question of doubt but that sanitary conditions are generally far from satisfactory and that effective dust-removing devices are frequently absent. There are no reasons for questioning the possibilities of a material improvement in the health conditions of this specific group of occupations in the glass industry, nor can the conclusion be called into question that the principal cause of ill health is the dust generated in connection with glass-cutting processes and inhaled to a more or less considerable and measurable degree.

### LABOR CONDITIONS IN MASSACHUSETTS.

Glass cutting and polishing were reported upon in the Massachusetts investigation of 1907, but it should be considered that the industry is, relatively, of very limited extent in that State. It is said in the report referred to that—

Operations which cause glass dust in the air are recognized as especially dangerous to health, such dust being quite as irritating as steel dust, if not more so. This being the case, glass cutting and polishing are conducted with a minimum of danger in the wet way. In cutting, the pattern is marked out with red lead or with graphite, and then the object is held against a rapidly revolving steel wheel upon which fine quartz sand and water are dropped continuously, or upon a wheel of fine emery and corundum. When the pattern has been cut out the glass is plunged into hydrofluoric acid in lead tanks, connected with the exhaust pipe of a steam-propelled blower. This smooths the cut surfaces, but acts on the uncut parts to such an extent as to make polishing necessary. This is done with pumice or rottenstone and water or oil on revolving brushes, and putty powder or rouge and wax on wooden wheels. The use of oil or water serves to prevent dust, and the employment of wooden shields protects the worker from being spattered with the mixture of oil and glass powder and other materials thrown off in the process. For successful work good light is very necessary, and in this respect all five of the establishments visited were found to be beyond criticism. The conditions as to ventilation and toilet arrangements were found to be equally commendable. All cutting and polishing is done by the wet method, and in no instance was any dust perceptible. In two of the establishments in which glass blowing also is carried on the employees are necessarily exposed to high temperatures and to the possible danger which resides in the use of blowpipes, which are introduced indiscriminately into the blowers' mouths. Otherwise no objectionable features were noted. The number of persons employed in the several factories ranged from about 30 to several hundred. As a class they appear to be of a rather high order of intelligence and to enjoy good health.

These observations should be accepted with caution for the reason stated.

### LABOR CONDITIONS IN PENNSYLVANIA AND OHIO.

In Pennsylvania, where glass cutting is quite extensively developed, no qualified investigation has been made by official authority, but private inquiries have disclosed a considerable variation in sanitary conditions, sufficiently so to suggest the possibility of material and far-reaching improvements.

Hayhurst, in the Ohio survey of 1915, gives expression to the opinion that "the work at glass grinding was done only at intervals and created a great deal of dust." This may have reference to exceptional conditions in Ohio plants, for as a rule cut-glass grinding is a continuous process and relatively free from health-injurious dust when sufficient water is used and the surroundings are kept scrupulously clean. The dust danger rises chiefly from unsanitary conditions rather than from the grinding which, as a rule, is carried on by the wet process. The danger to be guarded against is rather the liability to lead poisoning, but there are reasons for believing that the occupation also involves, though only to a limited extent, an increased liability to pulmonary tuberculosis. The four essential processes of roughing, smoothing, polishing, and puttying all involve exposure to widely varying conditions, but the risk is most serious in the puttying, chiefly on account of the liability to lead poisoning. In this process a mixture of oxide of lead is used, which, by means of a brush wheel, is applied to the nearly finished article for the purpose of giving the same the brilliant polish, which is the most distinctive feature of the highest grade of cut glassware. A "dust," or rather "splash," is created, and small particles of the same are readily observed on the faces and hands of the operators. The hands are constantly dipped into a mixture of lead, putty, and water, and unquestionably some lead is occasionally introduced into the system in small quantities, either by inhalation or by habits of uncleanliness. Lead poisoning resulting from this occupation has, however, been very materially reduced during recent years, and cases of lead paralysis are now rarely met with.

Reference may be made here to a brief statement regarding glass polishing in the Report of the Chief Inspector of Factories and Workshops for 1898. The evidence is quite conclusive that in this country lead poisoning in glass cutting is less common than in the United Kingdom. The most recent investigations in this country have been reported upon by the New York State Factory Investigating Commission, 1913 (vol. 2, p. 1116), chiefly with reference to the risk of lead poisoning, but it is said in conclusion that "in this industry the principal measures to be taken are cleanliness, especially on the part of the worker; and while there may be some dust in the air, it is negligible, as the results of our analyses fail to show any lead present in the samples taken." This conclusion, of course, has reference only to lead and has no bearing upon the question of mineral dust in relation to lung diseases, whether of the tuberculous or nontuberculous variety.

### GENERAL CONCLUSIONS.

In a general way it would seem that the available evidence regarding glass cutters and polishers indicates a very marked improvement in the hygienic conditions of the principal plants which have been thoroughly investigated and the practical elimination of lead poisoning. In the principal centers of the glass-cutting industry in the United States cases of lead paralysis are now extremely rare. The process of puttying has been largely eliminated and in place thereof the use of the method of dipping the nearly finished glassware into hydrofluoric acid has become quite general. The underlying cause of the practical elimination of lead poisoning is, however, the decidedly more sanitary condition of the shops, which by inference suggests a similar improvement in the partial control of the dust hazard. Processes of ventilation and dust removal have not been as thoroughly developed as would be desirable, but there can be no reasonable question of doubt as regards a material recent improvement in the health and longevity of glass cutters and polishers in contrast to the truly deplorable conditions prevailing in the past.

## GLASS BLOWERS.

The hygiene of glass blowing with special reference to pulmonary tuberculosis is of exceptional interest as a labor problem in the glass industry. The number of blowers employed proportionate to the total number of wage earners is relatively large, and, from a wage point of view, the employment is of the first order of importance.

### DESCRIPTIVE ACCOUNT OF GLASS-BLOWING PROCESSES.

In a descriptive account of the glass industry, published in the Pennsylvania Labor Report for 1888, it is stated that—

> The occupation of blowing requires great dexterity and nimbleness of the fingers to manipulate the glass; and while not laborious in the sense of requiring great muscular power, every limb and muscle is brought into use in molding a bottle, whether a large or small one. The blower in a shop is constantly on his feet, moving in a circle, and usually takes from six to seven steps to each bottle he molds. When it is considered that in making some sizes he molds from 175 to 200 dozen in a day we have some idea of the endurance required. There is scarcely an affliction that man is liable to that does not interfere with his work. The least sore on any of his fingers, hands, or feet, sore lips, sore throat, or toothache, or any of these, and he is obliged to lay off. The gaffer sits while at his work and is not liable to be laid up by so many ailments as the blower. Although subjected to heat, dust, and the gases that arise from the use of coal or oil in heating the glory hole, his workmanship is not impaired by most of the afflictions that disqualify a blower. Hence gaffers are usually superannuated blowers.

### SPECIAL OCCUPATIONAL HAZARDS.

Health conditions vary considerably, according to the nature of the blowing process, whether for the purpose of bottle making,[1]

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[1] For a brief but thoroughly scientific account of glass bottle manufacture from the mixing of the ingredients to the molding of bottles by machinery, see the Scientific American Supplement, No. 2135, for Dec. 2, 1916. With reference to the ingredients used it is said in part that "The basis of bottle glass is a silicious sand, to which is sometimes added limestone, together with sulphate or carbonate of soda. These ingredients, in pulverized form, are thrown into a large tank furnace, where they are melted and combined, forming a thick liquid of sirupy consistency. In the factories that make the better grades of glass such as tableware and window glass, it is periodically desirable to clean out their melting pots, and there is also considerable damaged material that must be discarded; that is called "cullet," and is sold to the bottle maker, who mixes it with his materials, together with all the damaged bottles that accumulate around the factory."

The relation of this process to dust exposure and health-injurious conditions is obvious.

carboy making, or window glass, etc. According to Sir Thomas Oliver—

The risks to health incurred by makers of glass are mainly those due to exposure to excessively high temperatures, e. g., bronchial and pulmonary affections; many of the men die from phthisis. They bear pneumonia badly, owing to their intemperate habits. Dr. Scheele, in the Berlin Kleinische Wochenschrift, March, 1900, has drawn attention to what is known as "glass-blowers' mouth." Large swellings like air cushions can be seen and felt in some glass blowers, extending from the angle of the mouth to below the ears. The swellings look like mumps. They involve the parotid gland only. They crepitate under the finger and by pressure can be made to disappear. It is only recently that these swellings in the cheeks of glass blowers have attracted attention, and especially in France. The relaxation of the cheeks, the jous casees of French glass blowers, is by some attributed to a faulty method of blowing. From glass blowers under my care in the Newcastle Infirmary I have ascertained that the malady is not unknown among the men in the work on Tyneside. Dr. Scheele found that it was present in only 2.5 per cent of blowers, some of whom had worked for years. In those who had thus suffered the duct that leads from the interior of the mouth to the parotid gland had become dilated, owing to the repeated entrance of air into it under considerable pressure; the mucous membrane of the inside of the cheek, too, showed thick pale patches, plaques opalines, which Guinard regarded as the result of the great pressure and straining the buccal mucous membrane was exposed to during the act of blowing. Under ordinary forced expiration the pressure inside the closed mouth is equivalent to from 6 to 9 millimeters of mercury, but in glass blowing it may rise to 90 and even as high as 110 mm. In the course of an ordinary day a good workman will blow as many as from 600 to 700 bottles.

## FREQUENCY OF LUNG DISEASES.

The foregoing observations are far from conclusive, but they emphasize the urgency of more extended investigations. A brief reference to lung affections in glass blowers occurs in an abstract of a paper on the subject by Prettin,[1] as follows:

Prettin found that the muscles seem to adapt themselves to their task, so that glass blowers are not apparently more liable than others to have pulmonary emphysema. But, on the other hand, he found an unusually large proportion of tuberculous lesions among them. Fully 20 per cent of the workmen presented evidences of a tuberculous lung affection, while emphysema was observed in only 5 out of the 230 glass blowers examined. It was very slight in the 2 subjects between 40 and 50 years old, and the 3 others were 52 to 58 years old, and had been glass blowers for 34 to 43 years. He cites Fischer to the effect that not a single instance of emphysema was found in 500 members of military bands, as published in 1902.

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[1] Journal American Medical Association, Mar. 19, 1904.

### GLASS BLOWERS' CATARACT.

Medical interest has rather been confined to the question of glass blowers' cataract, a description of which, however, is outside of the scope of the present discussion. The affliction is one of serious importance, especially with reference to workmen's compensation and as a medical problem in relation to the syphilitic infections. Since any and all diseases which impair physical efficiency or result in a diminution of disease resistance have an indirect bearing upon the frequency of pulmonary tuberculosis, the following reference to glass blowers' syphilis in the Medical Record (Feb. 11, 1888) is included:

Prof. N. De Smet, of Brussels, in commenting upon a case of syphilis occurring in the mouth of a glass blower, referred to several epidemics which have been reported as having occurred among artisans of this description. He said that only two plans for preventing these outbreaks had been devised, viz, giving a separate movable mouthpiece to each man, and instituting frequent, rigorous, and periodical inspection of the persons of the employees. The first plan is always declared by the workmen to be impracticable, from the loss of time which would be occasioned by fitting the different mouthpieces on the tubes.

The second would, of course, be resisted by the men, but he thinks their objections could be overcome by showing them the danger to themselves and their families which arises from the present system.

### MORTALITY OF GLASS BLOWERS—MEDICO-ACTUARIAL EXPERIENCE.

The mortality of glass blowers not using machinery and excluding foremen and superintendents was investigated by the Medico-Actuarial Association, with the result shown in Table 118.

TABLE 118.—MORTALITY FROM ALL CAUSES AMONG GLASS BLOWERS NOT USING MACHINERY, EXCLUDING FOREMEN AND SUPERINTENDENTS, BY AGE GROUPS.

[Medico-Actuarial Investigation.]

| Age at death. | Number exposed to risk one year. | Actual deaths. | Expected deaths. | Ratio of actual to expected deaths. |
|---|---|---|---|---|
| 15 to 29 years | 5,002 | 26 | 22.95 | 113 |
| 30 to 39 years | 4,216 | 30 | 22.75 | 132 |
| 40 to 49 years | 1,008 | 12 | 8.91 | 135 |
| 50 to 59 years | 144 | 2 | 2.83 | 71 |
| 60 years and over | 13 | ........ | .46 | ........ |
| Total | 10,383 | 70 | 57.90 | 121 |

The experience shows that the actual mortality of this class of workmen is 21 per cent in excess of the expected, the excess being most marked at ages 30 to 49.

**MORTALITY OF GLASS BLOWERS—INDUSTRIAL INSURANCE EXPERIENCE.**

The only available statistics of glass blowers' mortality from pulmonary tuberculosis are the data derived from the industrial insurance experience of the Prudential Insurance Co. of America for the period 1897 to 1914, which includes 546 deaths from all causes, of which 175, or 32.1 per cent, were from pulmonary tuberculosis.

TABLE 119.—PROPORTIONATE MORTALITY FROM PULMONARY TUBERCULOSIS AMONG GLASS BLOWERS, 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 glass blowers, 1897-1914, from— | | Per cent of deaths from pulmonary tuberculosis among— | |
|---|---|---|---|---|
| | All causes. | Pulmonary tuberculosis. | Glass blowers. | Males in registration area, 1900-1913. |
| 15 to 24 years | 51 | 23 | 45.1 | 27.0 |
| 25 to 34 years | 137 | 73 | 53.3 | 30.5 |
| 35 to 44 years | 115 | 36 | 31.3 | 23.4 |
| 45 to 54 years | 106 | 30 | 28.3 | 14.7 |
| 55 to 64 years | 52 | 8 | 15.4 | 7.9 |
| 65 years and over | 85 | 5 | 5.9 | 2.6 |
| Total, 15 years and over | 546 | 175 | 32.1 | 13.9 |

According to Table 119, the proportionate mortality from pulmonary tuberculosis is excessive at all ages, but especially so at ages 25 to 34, when of the deaths of glass blowers from all causes, 53.3 per cent are from pulmonary tuberculosis, against 30.5 per cent among males in the United States registration area. The table may be accepted as fairly conclusive, but, as said before, health and sanitary conditions vary considerably in the different branches of glass blowing, but no data are at present available which would permit of definite conclusions. It is, however, a safe assumption that carboy blowing, which requires much more strength than bottle blowing, is probably more injurious and involves an increased predisposition to pulmonary tuberculosis. How far the excessive liability to tuberculous diseases is increased by the dust factor can not be determined at the present time. The occupation group is one deserving of much more qualified medical and other technical consideration than it has heretofore received.

**MORTALITY EXPERIENCE OF THE GLASS BOTTLE BLOWERS' ASSOCIATION.**

The foregoing observations and conclusions are quite fully sustained by an analysis of the mortality of glass blowers, presented by the records of the Glass Bottle Blowers' Association of the United States and Canada for the period 1892 to 1908, inclusive, contained in the report of the United States Commissioner of Labor on the

Condition of Woman and Child Wage Earners in the United States, with special reference to the glass industry, Washington, 1911. The experience includes 898 deaths from all causes, of which 287, or 32.0 per cent, were from pulmonary tuberculosis. In addition, there were 8 deaths from other forms of tuberculosis, or 0.9 per cent of the mortality from all causes; 69, or 7.7 per cent, from pneumonia; and 28, or 3.1 per cent, from other diseases of the respiratory system. Combining the mortality from tuberculosis and nontuberculous respiratory diseases, the proportionate mortality from this group of causes in the mortality from all causes was 43.7 per cent. The mortality in detail, by divisional periods of life, is shown in the usual form in Table 120.

Table 120.—MORTALITY OF GLASS BLOWERS, GLASS BOTTLE BLOWERS' ASSOCIATION OF UNITED STATES AND CANADA, 1892 TO 1908.

| Age at death. | Deaths from all causes. | Deaths from pulmonary tuberculosis. | | Deaths from other tuberculous diseases. | | Deaths from pneumonia. | | Deaths from other respiratory diseases. | |
|---|---|---|---|---|---|---|---|---|---|
| | | Number. | Per cent. | Number. | Per cent. | Number. | Per cent. | Number. | Per cent. |
| 15 to 24 years | 48 | 24 | 50.0 | | | 5 | 10.4 | 2 | 4.2 |
| 25 to 34 years | 266 | 119 | 44.7 | 5 | 1.9 | 20 | 7.5 | 4 | 1.5 |
| 35 to 44 years | 272 | 93 | 34.2 | 3 | 1.1 | 27 | 9.9 | 7 | 2.6 |
| 45 to 54 years | 140 | 34 | 24.3 | | | 7 | 5.0 | 5 | 3.6 |
| 55 to 64 years | 86 | 9 | 10.5 | | | 3 | 3.5 | 3 | 3.5 |
| 65 years and over | 74 | 4 | 5.4 | | | 7 | 9.5 | 7 | 9.5 |
| Age unknown | 12 | 4 | 33.3 | | | | | | |
| Total, 15 years and over | 898 | 287 | 32.0 | 8 | .9 | 69 | 7.7 | 28 | 3.1 |

It would be outside of the purpose of the present investigation to enlarge upon the frequency occurrence of other causes, but it may be said in this connection, with special reference to alcoholism, that there were 7 deaths from this cause, or 0.78 per cent of the total, and 11 deaths from cirrhosis of the liver, or 1.22 per cent, which, however, can not be considered conclusive evidence regarding an excessive amount of gross intoxication among glassworkers, which is frequently assumed to be of relatively common occurrence. It is also suggestive that the mortality from pneumonia, which is often assumed to be increased in frequency by exposure to extreme heat and variable weather conditions, was not excessive in the experience referred to. The average age at death of all glass blowers was 41.4 years, and of those who died from pulmonary tuberculosis, 38.8 years.

SPECIFIC DISEASE LIABILITY OF GLASS BLOWERS.

The statistical analysis in the report referred to is amplified by extracts from reports on investigations into the hygiene of glassworkers in this country and Germany. According to an account of the diseases incident to the glass industry, in the Twenty-fourth Annual Report of the Bureau of Statistics of Labor and Industries of New Jersey for 1901, glassworkers are much exposed to unfavorable weather conditions, working, as they frequently do, in a temperature exposure of from 100° to 130°. It is said further, with reference to habits of life, etc., in the report of the United States Commissioner of Labor, that—

Irregularity in eating and sleeping, disregard of ordinary precautions, the habitual use of large drafts of ice water, are the prime factors in creating acute attacks of dyspepsia and indigestion, from which glassworkers suffer so much, and imprudent and unnecessary exposure aggravate and intensify diseases which attack the air passages. There is scarcely a glass blower to be found who does not suffer from some form of catarrh. Forethought and care exercised in guarding against the change from a high temperature to a low one would greatly improve the health conditions of men who work in the intense heat of the glassworks. When a workman leaves the high temperature of the factory, say 90° to 100°, in midwinter to face the temperature outside, say 10° to 12°, his underclothing wet with perspiration, without preparing himself thoroughly for the great change, he certainly invites disease to fasten upon his throat and lungs or give a dangerous chill to the circulatory system no matter how stalwart his frame or how robust his general health may be. The reaction is too sudden and severe.[1]

In contrast, it has been maintained by Mr. Denis A. Hayes, president of the Glass Bottle Blowers' Association of America, in an address before the American Academy of Political and Social Science, May, 1906, that—

It has been the common belief for years that glass blowing is an unhealthy occupation. Some insurance companies discriminate against the workers in this industry, but their action is based more upon suspicion than facts, because I doubt if glass blowing, so far as the work itself is concerned, is any more injurious than many other indoor occupations. There are, however, conditions which surround the work that are a menace to health and long life, but these unfavorable conditions can be and are being removed.[2]

Of interest also is the statement by Mr. Hayes that—

The sudden changes in temperature experienced by men in this condition may be resisted while youth and vigor remain, but, owing to the early age at which they go to work, their strength and vitality are not given a chance to fully develop or are almost entirely destroyed at an age when other men are entering the prime of life. Being deprived of schooling they can have very little knowledge of hygienic rules or laws, hence do not sufficiently know how to protect themselves against the conditions here described. The result is that early in life they become victims of rheumatism, catarrh, throat troubles, and tuberculosis. The latter disease especially is most dreaded by our members.[2]

[1] Report of U. S. Commissioner of Labor on Woman and Child Wage Earners in the United States, Vol. III, Glass Industry, pp. 254, 255.

[2] Idem, p. 257.

According to German observations by Dr. C. F. Schmidt, contributed originally to Weyl's Handbook of Occupational Hygiene, but translated for the report of the Commissioner of Labor on the glass industry, 1911, it is stated that—

As a rule, glass blowers are people of stalwart frame. Some have a pale but many a ruddy complexion, caused by the intense heat. They are generally spare, for they are obliged to undergo great physical exertion, and, in consequence of this exertion and the great heat, they perspire freely. The constant exercise makes the muscular development of the upper part of the body, especially the arms, exceptionally powerful, while they are sometimes observed to be bowlegged on account of continual standing.[1]

As glass blowers are forced to work in an atmosphere of a high temperature and are constantly exposed to the cool draft which rushes in through the open door of the factory, they are predisposed to colds. On one hand there are rheumatic inflammations, on the other catarrhal diseases of the bronchial tubes and of the lungs from which they suffer. Smoke often tends to produce bronchial catarrh, especially in the older factories where it is occasionally driven by unfavorable winds, directly from the openings of the furnaces, all through the factory. Since acute catarrhs of the larynx and bronchial tubes are often repeated, chronic bronchitis occasionally supervenes, from which pulmonary tuberculosis sometimes results.[2]

It was formerly believed that glass blowers often contracted emphysema of the lungs, and theoretically this seemed quite probable, since they are obliged continually to inhale a great volume of air and then by forced expiration to drive it out through the contracted glottis, by which means great demands are made upon the elasticity of the lungs. This opinion was refuted by Prettin and Leibkind. They examined 230 blowers from different glass factories who had followed this occupation for at least 10 years. Two hundred and eighteen of them were from 25 to 50 years of age, and 12 were from 51 to 62. One hundred and two had been blowing glass more than 10 years, and an equal number more than 20 years. Among the blowers under 40 years of age practically no emphysema was found. Of 54 blowers from 40 to 50 years old, only 2 had emphysema in a slight degree. Among the 12 oldest, there were but 3 cases of severe emphysema of the lungs. Of the 230 blowers, therefore, only 5 in all had emphysema, and even with these it was doubtful whether the emphysema was superinduced by the blowing or by other diseases of the lungs. But it was demonstrated by spirometric tests that the vital capacity of glass blowers' lungs is very large, for the spirometer indicated an average amounting to 3,350 cubic centimeters (183.25 cubic inches.)[2]

### PREDISPOSITION TO PULMONARY TUBERCULOSIS.

All of these observations reemphasize the earlier conclusion that glass blowers unquestionably are subject to an excessive mortality

[1] Report of U. S. Commissioner of Labor on Woman and Child Wage Earners in the United States, Vol. III, Glass Industry, p. 265.
[2] Idem, p. 267.

from pulmonary tuberculosis, largely in consequence of the continued and considerable inhalation of mineral dust. It is, therefore, of special importance that any and all measures concerning dust prevention should receive sufficient consideration, and that, as far as practicable, they should be adopted. With special reference to the possibilities of sanitary and other improvements, it is suggested by Dr. Schmidt that—

Since it has been demonstrated that pulmonary emphysema is not due to blowing, except in very rare instances, the necessity for a mechanical blower no longer appears so urgently requisite as it was formerly assumed to be. An apparatus has been invented by means of which glass masses are blown into shapes required by compressed air. By the use of this contrivance not only might the need of strenuous exertion in blowing be obviated, but the danger of syphilitic infection and of the transmission of tuberculosis might also be removed. But in most of the factories the pipe continues to be used, because, it is claimed, the inflation by this method is more uniform. The transmission of syphilis may be prevented by a simple device, namely, by the use of an individual mouthpiece for every blower. But this method is opposed by the blowers because by its employment they are hindered in their work. Regular examinations are also recommended, but the workmen rebel against such inquisitorial regulations. The attempt has been made to reduce the intense heat radiation by placing asbestos-coated iron curtains in front of the ovens. These curtains are raised by a lever so arranged as to be automatically set in motion by the weight of the workman's body. For lowering the temperature revolving fans have also been installed in proximity to the working place. These create an artificial breeze to cool the workmen. Blue or gray panes of glass placed before the openings of the furnace serve as a protection for the eyes.[1]

### POSSIBILITIES OF DUST PREVENTION.

Finally, on the question of the prevention of dust, it is said:

The prevention of dust presents the greatest difficulties, though a large part of it is held captive by means of water. In polishing with the sand blast the sand is so drawn up by the agency of a suction appliance devised by Gutmann that no dust can escape. The dangerous explosions of lamp cylinders are now prevented in a glass factory at Weisswasser by a mechanical apparatus by which the cylinder is heated in a narrow zone throughout its entire circumference, and then by a light blow with a sharp instrument it is cracked off. But in the grinding department even the simplest protective arrangements are often wanting, or are not employed because the work is retarded by them. Above all, sufficient ventilation should be provided for, and a scrupulous daily cleansing of the grinding rooms. In every room, too, there should be an adequate supply of cuspidors. By systematic instruction of the grinders the danger of tubercular infection may be minimized. Personal hygiene

[1] Report of U. S. Commissioner of Labor on Woman and Child Wage Earners in the United States, Vol. III, Glass Industry, p. 270.

would be promoted by the installation of bathrooms in the factories; and, in addition, good drinking water should be supplied.[1]

Most of the methods of dust prevention and other sanitary improvements are practical, if not in their entirety at least in part, and suggestive of much more extensive consideration in this country than has, heretofore, been the case.

### MECHANICAL GLASS BLOWING AND PRESSING.

Glass blowing and pressing by means of mechanical devices are of comparatively recent introduction. Entirely automatic bottle-blowing processes date from 1898, and the work in connection therewith practically dispenses with glass blowing in the generally accepted sense of the term. Such processes, however, are quite frequently carried on in conjunction with typical methods of glass blowing and related operations, so that in a general way the occupational hazards have remained much the same. There are no vital statistics of mechanical glass blowers and pressers, but it is quite probable that when carried on under proper sanitary supervision the use of machinery may prove distinctly advantageous to health and longevity. The blowing of window glass by machinery is of much more recent introduction and the process thus far has not become extensively developed. (See Scientific American, July 19, 1913.) Glass-making machines are of three important types, as described in the Report of the Bureau of Labor on the Condition of Women and Child Wage Earners in the United States, with special reference to the glass industry (Washington, 1911). The first type is the press machine, the second the blow machine, and the third the automatic machine which improves upon the simple blowing machine by using a self-feeding and self-pressing device. In all of these processes human labor is to a considerable extent dispensed with and no skilled glass workers are required, since machinists, in a restricted sense of the term, are sufficient for the purpose. One advantage of the automatic machine is that it tends greatly, according to the report referred to, to reduce the number of boys employed, and it tends further to raise the age of the boys that are employed, and older boys are usually preferred.

No statistical information is available as regards the possibly beneficial results to health in consequence of the universal use of glass-making machines and the practical elimination of glass blowing by hand. It, however, would seem to be a safe inference that in the absence of thoroughly efficient methods of sanitary supervision and control, with special reference to the dust hazard, the specific

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[1] Report of U. S. Commissioner of Labor on Woman and Child Wage Earners in the United States, Vol. III, Glass Industry, pp. 270, 271.

liability to pulmonary tuberculosis in the glass industry is not likely to be materially reduced as the result of the extensive and even universal introduction of glass-making machinery.

## DIAMOND CUTTERS.

Diamond cutting, although an employment of rather limited extent in the United States, is of interest and importance as an occupation with exposure to mineral dust. Hand cutting is very rare and machine cutting is at the present time the general rule in the trade, as carried on under American conditions. There has been a decided improvement in labor conditions as the result of the active efforts of the Diamond Polishers' Union, which has a membership of about 400 in New York City alone. The occupation has the advantage of being well paid, at least in many individual instances, and some of the cutters are reported to receive as much as $80 and polishers as much as $60 a week.

### PROCESSES OF MANUFACTURE.

The process of diamond cutting and polishing consists of two parts. After the stone has been cut it is taken to the polishing rooms, where the setter selects a suitable sized brass cup, called a dope, fills it with a mixture of lead and tin, and melts it in a gas flame. After working the solder to its proper shape, he places the diamond in the center, leaving only a very small part exposed. A mark is made on the solder before it becomes fairly set, and then the stone is passed on to the polisher. By the mark made on the solder the latter knows at once the exact run of the grain and the way it will polish to the best advantage. The polisher uses a circular disk composed of very porous iron, so that as the diamond is polished away in the form of dust it enters the pores of the iron, the result being that diamond cuts diamond.

According to Hirt, the first part of the process is exceedingly unhealthful. The bent position of the workman, the heat, and the danger of lead poisoning all contribute to make the occupation an unhealthful one. The principal bad features of the second part of the process are the dust inhalation and the straining of the eyes. While very little dust escapes into the air, the little, according to Hirt, is very bad in its effects, as the particles are angular, sharp, and, of course, very hard.

### MORBIDITY OF DIAMOND CUTTERS AND POLISHERS.

Arlidge in his observations upon the diamond cutters' trade remarks, however, that—

From our own observation of diamond cutting and polishing we can scarcely imagine any definite morbid result from the dust of the gem. It is far too precious to fritter away into dust by any coarse grinding likely to give off a tangible quantity of this substance, and we suspect that the recorded ill health of diamond workers is chiefly attributable to accidental circumstances connected with the charcoal furnaces formerly used; to overheated and badly ventilated workshops; and to dissipated habits among the employees. So far as diamond dust may possibly be thrown off in the polishing process, so far, doubtless, would it be an irritant to the respiratory organs by reason of the very sharp and angular character of its atoms.

Tracy comments upon the sanitary aspects of the employment as follows:

In diamond cutting the amount of dust created is small, and yet the occupation is a very injurious one. The "setter" prepares the diamond for the cutter by soldering it on the end of a copper rod with an alloy of 4 parts lead to 1 of tin. He does this with a charcoal fire, and is exposed to great heat, as well as to poisonous gases. The setters suffer from headache, tinnitus aurium, impaired digestion, and irregularity of the bowels. In Coster's factory, at Amsterdam, 73½ per cent of them were pale and emaciated, 57 per cent had palpitation, giddiness, præcordial distress, 56 chronic headache, 36 asthma, etc. The use of solder produces lead poisoning. Out of 90 examined, 30 showed traces of poisoning. In general, they are all sick men, and suffer from lung troubles. Nine per cent had phthisis. The cutters or polishers grind the gems on iron wheels covered with diamond dust and oil. The dust inhaled by them, though small in quantity, is enough to cause frequent chronic lung troubles. In Coster's factory, 52 per cent of them were thin and pale, 40 per cent asthmatic, 33.75 per cent suffered from headaches, etc.

### HEALTH-INJURIOUS RESULTS OF DIAMOND CUTTING.

The extensive development of the diamond industry in Holland, chiefly in Amsterdam, has been reported upon by United States Consul Frank W. Mahin, who points out that there are some 70 establishments in Amsterdam which cut and polish diamonds and employ more than 10,000 work people, of whom about 1,700 are cleavers and cutters and 4,700 polishers, the remainder being engaged about the offices and in other work. He explains the occupational process, in part, as follows:

Cleavers split the diamonds; cutters take off the rough and sharp edges and corners and make the general shape of the stone; polishers polish the stones and make their facets; turners turn the diamonds around in the apparatus which holds them, so that the facets can be made, every diamond worked in a first-class manner having from 58 to 64 facets; sawers saw stones which can not be cloven or which it is more profitable to saw; sometimes a stone is cleft and the parts are then sawed, but very small stones can not be sawed.

A more extensive technical account of the Amsterdam diamond industry has been contributed by Sir Thomas Oliver, in his report on Industrial Lead Poisoning, published by the United States Bureau of Labor Statistics (Bulletin 95), Washington, 1911. Upon the basis of his personal investigation he states that he found the workrooms overheated, owing to the large number of gas jets in use, and that the rooms generally were badly ventilated. "Work under these circumstances," he observes, "creates on the part of those following it an oversensitiveness to changes of temperature and a diminishing resistance to colds." Aside from a serious liability to lead poisoning, Sir Thomas Oliver's investigation failed to establish a special predisposition or liability to pulmonary tuberculosis. The occupation, however, has not been sufficiently investigated, but there are convincing reasons for believing that the dust factor in diamond cutting and polishing is of sufficient importance to prove inimical to health. Unquestionably important variations in liability are met with in the five principal groups of employment, viz, cleavers, polishers, turners, cutters, and sawers. Eyestrain is an important factor, and to the extent that any disease or physical disability tends to undermine health generally and reduces vital resistance. This factor, together with the liability to lead poisoning, is deserving of serious consideration. Although quite extensively developed in this country, chiefly through American branches of Amsterdam firms, there are no American vital statistics of this occupation, which, however, for the reasons stated, seems to require inclusion among unhealthy trades in which the mortality from pulmonary tuberculosis is quite probably above the normal.

## GENERAL CONCLUSIONS.

Diamond cutting is briefly referred to in Kober and Hanson's Diseases of Occupation and Vocational Hygiene, but chiefly with reference to the risk of lead poisoning. On account of the European war the industry has been quite extensively developed in the United States, and, according to the Scientific American Supplement (Oct. 7, 1916), New York instead of Amsterdam is now the center of the diamond industry. In a descriptive account of diamond-cutting methods in the article referred to it is said that in the process of cutting about 60 per cent of the weight of the rough stone is lost, but as far as practicable "every particle of waste material from the splitting and sawing of the stone is carefully saved for use in the sawing and other subsequent operations." This, of course, implies the possibility of a fair degree of diamond dust intermixture with the general atmosphere and the consequential mechanical injury to the lungs on account of the inhalation of the diamond-dust particles. It is suggested in this connection by Kober that "all polishing processes should be carried on by the wet process and guarded by hoods and efficient exhaust ventilation." Aside from necessary safeguards against lead poisoning, Kober recommends attention to general ventilation, adjustable workbenches, and improved working conditions as regards light, air, space, and heating. In the absence of more conclusive evidence, it is not apparent that the diamond-cutting industry as carried on in this country under modern conditions is distinctly injurious to health, or that it seriously predisposes to pulmonary tuberculosis, on account of the special liability to the risk of mineral and metallic dust inhalation.

# CHAPTER IV.—THE MINERAL INDUSTRIES (MINES, QUARRIES, ORE REDUCTION, AND SMELTING).

The mineral industries of the United States are of such enormous extent and variety that an adequate consideration of the health and mortality of the large number of persons employed therein would extend far beyond the scope of the present discussion of the mortality from respiratory diseases in dusty trades. In 1914 the approximate value of the mineral product of the United States, including both metallic and nonmetallic resources, exceeded $2,115,-000,000, and the number of persons employed in the different branches of the industry was in excess of 1,000,000. An almost infinite variety of products are mined, quarried, and subjected to ore dressing, smelting and refining processes equally varied and complicated in extent. Table 121 illustrates the principal divisions or main branches of the mineral industry, and for the group of persons employed in metal mining, in addition, the number and proportion of persons employed underground. The table has been derived from Technical Paper No. 129 of the United States Bureau of Mines.

TABLE 121.—NUMBER OF PERSONS EMPLOYED IN MINERAL INDUSTRIES OF THE UNITED STATES, IN 1914.

| Kind of mine, etc. | Total employed. | Number employed under-ground. | Per cent employed under-ground. |
|---|---|---|---|
| Coal mines | 763,185 | 639,334 | 83.8 |
| Copper mines | 44,686 | 31,265 | 70.0 |
| Gold and miscellaneous metal mines | 48,438 | 35,432 | 73.1 |
| Iron mines | 44,807 | 24,847 | 55.5 |
| Lead and zinc mines [1] | 10,935 | 7,609 | 69.6 |
| Miscellaneous mineral mines | 9,249 | 2,465 | 26.7 |
| Total, mines | 921,300 | 740,952 | 80.4 |
| Quarrying | 87,936 | | |
| Coke ovens | 22,313 | | |
| Smelting | 26,960 | | |
| Ore dressing | 14,501 | | |

[1] Mississippi Valley only.

## VARIED CONDITIONS OF EMPLOYMENT.

All general conclusions applicable to an industry of such varied extent must necessarily be of limited scientific value. Even with reference to well-defined groups, such as the subdivision of metal mining, or the broad division of coal mining into anthracite and bituminous, general conclusions must fall short of the required degree of scientific exactitude. As shown by the table, the proportion of men employed underground attains to 70 per cent in copper mining, while in iron mining the corresponding proportion is only 55.5 per cent. In the latter the process of open-cut mining or what is called stripping is quite generally employed. To a lesser extent, a similar method is employed in copper mining in the States of Utah and Nevada. Obviously, underground employment must by its nature be less healthy and predispose more to pulmonary tuberculosis than employment in the open, especially when carried on in connection with more or less health-injurious processes such as drilling, the use of pneumatic tools, etc. The number of specific employments in mines is much larger than is generally assumed to be the case, and the general use of the term "miners" in vital statistics is, broadly speaking, quite seriously misleading. Also the proportion of "miners" in the strict sense of the term varies considerably, according to the metal or mineral mined, and the term itself is becoming obsolete on account of the extensive use of machinery, rock drills, etc., by means of which the old-time pick and shovel miner has been replaced by machine miners, rock drillers, etc.

## LIMITATIONS OF OCCUPATIONAL STATISTICS.

Much has been written in general terms on the health of miners and other mine employees which, for the reasons stated, requires to be accepted with extreme caution. No very satisfactory progress has been made in the perfection of vital statistics to the extent that the relative health and mortality of specific employments under and above ground can be ascertained, especially with regard to the relative incidence of pulmonary tuberculosis and nontuberculous respiratory diseases. As elsewhere pointed out, the health-injurious conditions are frequently limited to a comparatively small group of underground employees, as best emphasized in the case of the rock drillers in the gold mines of the Transvaal. All general conclusions, therefore, understate the true liability of the persons directly employed in the most health-injurious occupations in the mining industry and all broad conclusions concerning the relation of the industry in its entirety or its principal branches must be considered inadequate for medical and public-health purposes, or as a basic consideration for protective labor legislation. The generally accepted official statistics on the health of mine employees relate to the main branches of the mining industry of the United Kingdom. Much useful, and, in a measure, even more conclusive information is available, in part, for the mines and other mineral industries of the European continent, South Africa, and the several States of the Australian Commonwealth, but nearly all of the available data at the present time have reference to the mining industry as a whole and not, as the usual titles of the official tables would imply, to "miners" within the more restricted sense of the term.

## COMPARATIVE MORTALITY OF ENGLISH MINERS.

The most recent English statistics, for the years 1900–1902, assign to certain branches of the mining industry a relatively favorable position in comparison with other more or less unhealthful occupations, chiefly with reference to dust exposure, as shown by the table following, derived from the Supplement to the 65th Report of the registrar general for England and Wales (London, 1908):

TABLE 122.—COMPARATIVE OCCUPATION MORTALITY STATISTICS, ENGLAND AND WALES, 1900 TO 1902.

[Data are for both occupied and retired.]

| Occupation. | Phthisis and diseases of the respiratory system. | | Phthisis | Diseases of the respiratory system. | Diseases of the circulatory system. |
|---|---|---|---|---|---|
| | Mortality figure. | Ratio. | Mortality figure. | | |
| **Agriculturist** | **171** | **100** | **85** | **86** | **96** |
| Ironstone miner | 266 | 156 | 126 | 140 | **94** |
| Carpenter, joiner | 276 | 161 | 150 | 126 | **120** |
| Coal miner | 285 | 167 | 89 | 196 | **134** |
| Wool, worsted—manufacturer | 320 | 187 | 159 | 161 | **164** |
| Baker, confectioner | 327 | 191 | 165 | 162 | **131** |
| Miller, cereal food manufacturer | 331 | 194 | 129 | 202 | **143** |
| Blacksmith, striker | 332 | 194 | 158 | 174 | **149** |
| Gas works service | 355 | 208 | 141 | 214 | **128** |
| Carpet, rug, felt—manufacturer | 359 | 210 | 180 | 179 | **161** |
| Bricklayer, mason, builder | 377 | 220 | 194 | 183 | **129** |
| Rope, twine, cord—maker | 381 | 223 | 207 | 174 | **137** |
| Cycle and motor manufacturer | 381 | 223 | 217 | 164 | **102** |
| Stone, slate—quarrier | 396 | 232 | 190 | 206 | **123** |
| Tinplate manufacturer, tinplate goods maker | 410 | 240 | 221 | 189 | **142** |
| Chemical manufacturer | 415 | 243 | 98 | 317 | **162** |
| Cotton manufacturer | 422 | 247 | 197 | 225 | **170** |
| India rubber, gutta percha—worker; waterproof goods maker. | 427 | 250 | 244 | 183 | **123** |
| Zinc—manufacturer, worker | 456 | 267 | 224 | 232 | **45** |
| Lead manufacturer, leaden goods maker | 474 | 277 | 165 | 309 | **224** |
| Coal heaver | 496 | 290 | 213 | 283 | **184** |
| Gunsmith | 498 | 291 | 244 | 254 | **151** |
| Brass, bronze—manufacturer, founder, finisher, worker | 500 | 292 | 272 | 228 | **161** |
| Nail, anchor, chain, and other iron and steel manufacturers | 503 | 294 | 187 | 316 | **173** |
| Wood turner, cooper, etc | 504 | 295 | 271 | 233 | **152** |
| Copper—manufacturer, worker; coppersmith | 519 | 304 | 162 | 357 | **139** |
| Furrier, skinner | 533 | 312 | 316 | 217 | **205** |
| Glass manufacturer | 551 | 322 | 283 | 268 | **177** |
| Chimney sweep | 556 | 325 | 284 | 272 | **153** |
| Lead miner | 598 | 350 | 324 | 274 | **162** |
| Brush, broom—maker; hair, bristle—worker | 609 | 356 | 325 | 284 | **173** |
| File maker | 712 | 416 | 387 | 325 | **198** |
| Potter; earthenware, etc., manufacturer | 758 | 443 | 285 | 473 | **219** |
| Cutler; scissors maker | 848 | 496 | 533 | 315 | **215** |
| Copper miner | 1,321 | 773 | 574 | 747 | **34** |
| Tin miner | 1,557 | 911 | 816 | 741 | **154** |

## RELATIVE FREQUENCY OF TUBERCULOUS AND NONTUBERCULOUS RESPIRATORY DISEASES.

Table 122 is limited to the mortality from phthisis, diseases of the respiratory system, and diseases of the circulatory system. The table presents a curious contrast in liability to phthisis and diseases of the respiratory system combined, for iron miners exhibit, relatively, the lowest mortality in the group, while copper and tin miners show the highest. Compared with the agriculturist, those employed in the mining industries show a distinctly excessive mortality from phthisis and diseases of the respiratory system considered as a group. Coal miners, however, exhibit a relatively favorable mortality from phthisis but a decidedly excessive mortality from nontuberculous respiratory diseases. As observed in the report referred to, with regard to the causes of death, "there is no question that as compared with the past, an increasing proportion of such deaths are referred to their true causes; but what of the very large number still returned as 'abscess of the lungs,' 'congestion of the lungs,' 'pleurisy,' 'hæmoptysis,' and from other lung diseases more or less indefinitely described?" It is explained in this connection that on the basis of supplementary inquiries, "a considerable number of the deaths so returned were ascertained to be tuberculous in origin, although the original certificates had contained no intimation to that effect." This factor of probable error, however, is for the present purpose not of serious importance, although no satisfactory explanation has been forthcoming as to the reasons for the distinctly higher mortality from bronchitis in England and Wales in comparison with the United States, which may possibly be of even more importance in the case of the obviously dusty trades. The high degree of frequency occurrence of nontuberculous respiratory diseases in the mineral industry has also not thus far received the required specialized medical consideration, except in so far as each and every important group of respiratory affections has been brought into precise correlation to recognized health-injurious processes in the Milroy lectures by Dr. Edgar L. Collis on "Industrial Pneumoconioses, with special reference to dust phthisis."[1] In the observations on this important hygienic aspect of the mineral industries it is said in the report of the registrar general, with special reference to the preceding table, that—

At the bottom of the list there are five industries, viz., filemakers, potters, cutlers, copper and tin miners, in which the combined mortality from phthisis and respiratory diseases (pulmonary disease) is

[1] These lectures have been reprinted in their entirety in "Public Health," the journal of the Society of Medical Officers of Health, London, 1915, issues of August, September, October, and November. The lectures includes illustrations, microphotographs, etc.

from four times to nearly ten times as high as that of agriculturists. How much of this excess is due to the presence of dust in the atmosphere, and how much to other unhealthy conditions of work it is at present impossible to determine. The circumstance is, however, noteworthy that in 1890–1892 also these industries had occupied almost equally unfavorable positions in the scale of dust-producing occupations. Among the remaining industries in the present list ironstone miners, carpenters, and coal miners appear to suffer least severely from "pulmonary disease," their mortality figure exceeding the standard for agriculturists by not more than from 56 to 67 per cent. The list contains 18 occupations (9 of which are among the least healthy of the series) in which the workers experience a higher mortality from phthisis than from other diseases of the lungs. Among agriculturists the mortality from phthisis is practically the same in amount as that from respiratory diseases, and among all occupied and retired males the excess of phthisis over respiratory mortality is only 6 per cent. In some of the 18 occupations referred to the difference between the mortality from these two causes is small, but among others it is much greater than among occupied and retired males generally, amounting in the case of cutlers to no less than 69 per cent. The list also contains 17 occupations in which the opposite is the case. In the latter category the most conspicuous instances are copper miners, potters, copper workers, iron and steel manufacturers, coal heavers, lead manufacturers, chemical manufacturers, millers, and coal miners, in all of which instances the workers die from nontuberculous disease of the lungs much faster than they do from phthisis.

These conclusions are in conformity to a considerable amount of trustworthy medical and other evidence suggestive of the practical importance and, in fact, urgent economic necessity of more qualified medical consideration of the incidence of nontuberculous respiratory diseases in the mineral industry. On this account it has seemed advisable for the present purpose to enlarge somewhat upon the mortality and morbidity aspects of the mineral industries, even though the large proportion of the so-called "pulmonary" diseases of miners and stone workers are in all probability nontuberculous.

## THE MINING INDUSTRY.

The health hazards of mining have for many years been the subject of scientific investigation in this and other countries. The extremely complex character of the industry, however, precludes the general application of many of the conclusions arrived at. For self-evident reasons, the more obvious accident hazards have, from the outset of mining operations, received more extended and technically qualified consideration. The deadly nature of many mine gases, aside from the risk of gas explosions, was made the subject of a scientific report as early as 1716, by Friedrich Hoffman and a rejoinder by Friedrich Andreae, amplified by medical and sanitary observations of value even at the present time.[1] During the intervening 200 years the mining industry has attained to truly enormous and world-wide importance, with a constantly increasing number of employees, either directly engaged in mineral production or in the subsequent conversion of metallic and nonmetallic substances. The progress which has been made in the scientific understanding of mining hazards to health and life is best emphasized in the most modern treatise on "Gas Poisoning in Mining and Other Industries," by John Blaister, M. D., and David Dale Logan, M. D., and the elaborate joint report of the Miners' Phthisis Prevention Committee of the Union of South Africa. It would be quite impracticable for the present purpose to discuss with the required brevity and sufficient thoroughness even the more important branches of the mining industry in their relation to health and mortality. The subject divides itself primarily into the mining of metallic and nonmetallic products, and is further subdivided according to essential variations in underground conditions, the mechanical and chemical properties of dust and gas exposure, methods of mining, and the use of safety precautions, chiefly in the direction of effective dust laying and the required use of respirators, particularly in dusty stopes. The predominating accident hazard, involving a considerable loss of life at the younger ages, materially impairs general conclusions regarding disease liability, since the effect of health-injurious conditions is obviously obscured by premature death in consequence of mine explosions, falls of roof, etc. During the year 1915 the fatality rate in American coal mines was 4.44 per thousand 300-day workers and in metal mines 3.89. Since the average age at death of mine employees in this country is approximately 32 years, the effect of such a fatality rate is to disturb seriously the proportionate mortality distribution from pulmonary tuberculosis and related diseases. The true menace of the dust hazard in mining operations subject to a considerable and continuous degree of dust inhalation is measurable only to an approximate degree, on account of the coincident and often more important mechanical accident hazard, which even far-reaching safety measures and precautions have not as yet reduced to relatively unimportant numerical proportion. The specific dust hazard in mining is much more serious in metal mining than in coal mining in that in the former the nature of the rock or gangue inclosing or containing the ore bodies is of decidedly greater hygienic importance than the metal dust when extracted by ordinary mining methods, or subsequently by processes of ore reduction, smelting, cyaniding, chlorination, etc. The hygiene of metal mining

[1] See "Friedrich Hoffmann über das Kohlenoxydgas," by Dr. Albert Neuburger; Leipzig, 1912. Also of interest and value in this connection is the treatise, in German, by Dr. Theodore Poleck, Berlin, 1867, entitled, "Die chemische Natur der Minengase und ihre Beziehung zur Minenkrankheit."

is, therefore, chiefly concerned with underground mining methods, which by their nature must be more unhealthful than open-cut excavations and quarrying, which, aside from other hygienic advantages, have the dust hazard in relation to health generally much reduced. The accident hazard in quarrying is also of lesser importance, and during 1915 the fatality rate was only 1.80 per thousand 300-day workers, against an average of 2.19 for the five-year period 1911–1915.[1]

The American mines and quarries, according to the returns of the United States Bureau of Mines for the year 1915, gave employment to 986,866 persons, of whom 734,008 were employed in coal mines, 152,118 in metal mines, and 100,740 in quarries. In addition thereto, in connection with metal mines and metallurgical plants, during the year 1915 the number of men employed was 18,564 at mills and ore-reduction works and 31,327 at smelters, etc. Of the workers in metal mines, during 1915, the number employed in copper mining was 47,174, in iron mining 39,391, in lead and zinc mining (Mississippi Valley only) 12,977, in gold, silver, and miscellaneous metal mining 45,312, and in the mining of nonmetallic minerals, 7,264. Regardless of the magnitude and nation-wide importance of the American mining industry, the available information regarding the health and disease liability of miners and the sanitary conditions of mines and mining communities is of a nature far from conforming to existing scientific and practical requirements. The most conclusive information regarding mining hazards in their relation to health, aside from the valuable and extended observations on miners' phthisis contained in the report of the interdepartmental committee on industrial diseases, is derived from British parliamentary reports, commencing with the classical investigations of the commissioners appointed to inquire into the condition of all mines in Great Britain, with reference to the health and safety of persons employed in such mines, issued in 1864, and the recent reports of a royal commission on metalliferous mines.[2] The results of these investigations amplify the scientific observations on "The Hygiene of Men Employed in Mines and Metallurgical Establishments," by Fuller, Meissner, and Saeger (Jena, 1895). Mining conditions and methods in this country, however, in fundamental essentials are so much at variance with those

[1] United States Bureau of Mines, Technical Paper 165, p. 7.

[2] The following are some of the more important parliamentary publications which are indispensable to the student of the subject of mine hygiene and problems relative thereto:

Report of Commissioners on the Condition of Mines in Great Britain with Reference to the Health and Safety of the Miners; Evidence and Appendices, London, 1864.

Royal Commission on Mines; Reports, with Evidence, Appendices, and Index; 8 Parts; London, 1907–1910.

Reports of an Enquiry into the Ventilation of Coal Mines, etc., by John Cadman, D. Sc., F. G. S., and E. B. Whalley; London, 1909.

Royal Commission on Metalliferous Mines and Quarries; Minutes of Evidence with Index and Appendices; Volumes I–IV, London, 1912–1914.

of Great Britain and the Continent of Europe that the subject requires to be investigated and reported upon in full detail in conformity to modern methods of scientific research. Our methods of shaft work, of driving adits and drifts, of stoping and rock drilling, ventilation, and the use of compressed air are sufficiently at variance with corresponding conditions and methods in other countries to require extended study for the purpose of ascertaining and determining the precise circumstances related to mining methods more or less injurious to health and life. Even the elementary considerations are far from having been thoroughly defined and become sufficiently well understood to eliminate the serious risk of inexperience with possibly disastrous results. In gold and silver mining, for illustration, the predominating metal in the United States is lead, which, because of its chemical qualities is hygienically of much greater importance than the precious metals, which are practically without pathological significance.[1]

Broadly speaking, all metal mining is essentially a process of rock extraction and the most important mechanical operation in modern mining consists of rock drilling, in connection with which vast quantities of more or less health-injurious dust are produced, the degree of injuriousness being dependent upon exceedingly important differences in the mechanical and chemical properties of the rock extracted. Variations in the type of drills, of which a large variety is in use, bear a direct relation not only to the quantity but also to the finely comminuted character of the dust created and the pathological consequences of continuous inhalation during the most active period of physical exertion in connection with mine work. These and other aspects of the metal mining and quarrying industry are emphasized in the general discussion of metallic and mineral dust, and particularly so in the separate consideration of the various branches of the stone industry, which, in broad outlines, as regards general conclusions, conforms to the more important special branches of mining. It, of course, is entirely immaterial for the present purpose whether the stone is quarried on account of its own intrinsic value and chiefly by blasting operations, or for the recovery of precious metals, chiefly by rock drilling and subsequent methods of ore reduction, smelting, cyaniding, etc. Quite different, of course, are the conclusions applicable to coal mining, where the product itself gives rise to an enormous amount of atmospheric pollution, which, however, in its effect upon the respiratory organs, with special reference to pulmonary tuberculosis, is apparently much less injurious than the corresponding degree of dust contamination resulting from underground mining processes for the recovery of copper, zinc, gold, and

[1] See Elements of Mining, by George J. Young; McGraw-Hill Book Co., New York, 1916.

other ores. Quite different also are the conditions in quicksilver mining, although the rock formation, in a general way, may conform to the rock quarried and extracted by drilling processes and the use of explosive substances in the mining of gold, silver, copper, etc. Quicksilver in its natural state rarely permits of being mined without very serious consequences to the health of miners, so that preference, as a rule, is given to the mining of cinnabar ore, which does not become injurious to health until subjected to subsequent reduction and refining processes.

In the hygiene of mining the dust problem is of fundamental importance, aside from the serious menace of finely comminuted coal dust as a cause of disastrous mine explosions. The health-injurious consequences of continuous and considerable rock dust inhalation are, fortunately, more generally recognized at the present time than in former years and reasonably effective methods are being made use of to reduce the dust hazard to a minimum. Since quartz dust is the most injurious form of dust exposure in deep mines, the pathological results of such exposure, as made evident by the increased frequency of miners' phthisis, have attracted most attention in South Africa, although correspondingly unsatisfactory conditions prevail in the deep mines of the central and western sections of the United States.[1]

## GOLD MINING IN SOUTH AFRICA.

The most conspicuous health-injurious effects of metal mining occur in connection with mining methods which require the use of underground drills, by means of which the rock substances are reduced to a highly comminuted condition. When the rock dust consists of practically pure quartz, as is the case in the South African gold mines on the Rand, the damage done to the lung tissue is so serious that the resulting condition of lung fibrosis terminates fatally within a comparatively short period, though generally as an important result of a superinduced tuberculosis. The typical form of lung disease common to miners subjected to the conditions referred to is known as "miners' phthisis," and the disease as such has a literature of its own. Modern high-power drills operated by compressed air have enormously increased the relative degree of air pollution in metal mines to the extent that the use of dust-allaying methods has become imperative as a more or less effective means of reducing the consequent mortality and morbidity of the men employed. The effective spraying of dusty stopes is, however, frequently quite difficult if not impossible when vertical drilling is necessary and unavoidable. In all such operations the compulsory use of respirators seems

[1] Of much practical value is the report of an investigation at Bendigo into the Prevalence, Causes, and Prevention of Miners' Phthisis, and the Ventilation of the Bendigo Mines, by Walter Summons, M. D., Melbourne, 1907. See also, pp. 336-342.

preferable, since in the operation of the power drills the men expose the mouth and the nostrils directly to the continuous stream of minute particles of silicious dust which, as abundantly shown by autopsy records and experimental evidence, proves exceedingly injurious to lung tissue, with a resulting predisposition to pulmonary tuberculosis.

### MINERS' PHTHISIS IN SOUTH AFRICA.

Within recent years a number of important contributions have been made to the subject of miners' phthisis, chiefly the report of a commission appointed under the provisions of the miners' phthisis allowances act, to inquire into the prevalence of miners' phthisis and pulmonary tuberculosis within the Union of South Africa, Cape Town, 1912. The reference to the workmen's compensation act is particularly significant in that it emphasizes the practical importance which is now being attached to miners' phthisis, more or less directly attributable to the occupation exposing miners to inherent occupational-disease dangers underground. The miners' phthisis act of South Africa of 1912 ranks as an epoch-making document and deserves most thoughtful consideration as a measure called for by perhaps the most health-destructive conditions met with in any industry, trade, or occupation throughout the world. The act makes provision for persons who have contracted miners' phthisis, and there is a frank recognition of the fact that the disease results in consequence of the employment and that the same is specifically cognizable as an occupational disease, separate and distinct from pulmonary tuberculosis contracted outside of the occupation. Joint contributions of employers and employees are required to be made, so that the entire responsibility for the disease is not made a burden upon the mining industry, in view of the fact that unquestionably a fair proportion of the existing amount of tuberculosis among miners employed is not directly attributable to the employment. Section II of the act reads that the minister shall at the commencement of this act frame a list of mines in the Union wherein the mineral dust produced by mining operations is in his opinion of such a nature as to cause miners' phthisis, and he may from time to time add or withdraw the names of mines from such list. This, in other words, separates the exceptionally dusty mines with obvious conditions predisposing to pulmonary tuberculosis from the mines not subject to this hazard and therefore not liable to assessment on account of the miners' phthisis fund. Subsection II, of section 14, provides that any employer or any number of miners, not being less than one-third of the miners so employed in any mine, may likewise petition the minister on the ground of the improved health conditions of the mine to exclude or remove that mine from the said list, and the minister shall thereupon order such investigation as he may deem fit and as a result of such investigation he may, if he thinks fit, remove such mine from said list, or reduce the amount of contribution payable in respect to said mine. This important provision directly encourages the sanitary improvement of mines to the extent that on the basis of ascertained evidence a previously proscribed mine may thereafter be included among the working places considered relatively harmless as regards exposure to health injurious dust. The act in its entirety has been reprinted in the Bulletin No. 9 of the International Labor Office, London, 1914.

### REPORT OF MINERS' PHTHISIS PREVENTION COMMITTEE.

The general report of the miners' phthisis prevention committee of the union of South Africa was published at Pretoria, under date of March 15, 1916. This report is unquestionably the most comprehensive and scientifically conclusive investigation of its kind ever made. The report includes a brief historical introduction, observations on the nature and general relations of miners' phthisis, a discussion of the principles of tuberculosis control, an outline of the general characteristics of the dust occurring in the silicotic lung, in mine air, and in streets, a descriptive account of the sampling of air and the determination of dust, a description of the principal operations giving rise to dust in mine air, amplified by methods of laying dust and preventing its formation or inhalation and the most suitable methods of laying dust produced by mine operation, including blasting, drilling, and transportation. In addition the report considers the problem of dust in crusher stations, the subject of ventilation, the drafting of model regulations, and the importance of a general survey of existing conditions more or less relating to health and longevity. The appendices to the report are exceptionally valuable and inclusive of practically every scientific aspect of mine sanitation and the related problem of dust control as a condition precedent to more or less effective methods of phthisis prevention. The statistical analysis of the returns from the miners' phthisis board by Dr. G. G. Maynard are most instructive and indicative of the broadening value of statistical methods in their practical application to sanitary and economic problems. The report and appendices constitute in a general way the scientific basis for similar investigations in every other country in which metal mining is an industry of relative importance.

### MINERS' MORTALITY IN RHODESIA.

The continued seriousness of the situation in Rhodesia is emphasized by a statement in the annual report of the Rhodesia Chamber of Mines for 1915 that the mortality from disease among native laborers was 21.94 per 1,000, aside from a mortality from accidents of 4.19 per 1,000. In Rhodesia as well as on the Rand the mortality from pneumonia continues to form an excessive proportion of the mortality from all causes, and the disease has properly been made the subject of a memoir published by the South African Institute for Medical Research, entitled "An Enquiry into the Etiology, Manifestations, and Prevention of Pneumonia Amongst Natives on the Rand, Recruited from Tropical Areas," by G. D. Maynard, Johannesburg, 1913. The same subject was subsequently investigated by Major General W. C. Gorgas, M. D., United States Army, whose report constitutes a source of much useful information, emphasizing the great practical value of sanitary improvements outside of the mines as well as in the work places underground, and the relatively greater value of such improvements in the case of native laborers in tropical regions on the Witwatersrand. The mortality from disease among native laborers employed in the mines of the Rand in 1915 was 16.47 per 1,000. The lesser figure for the Rand is explained by the nonemployment of tropical natives in the Transvaal. The data are suggestive in that they emphasize the importance of the race factor in the use of comparative vital statistics. During 1915 there were 991 deaths from all causes among the natives employed in Southern Rhodesian mines, of which only 48 deaths were attributed to phthisis, while 442 were attributed to pneumonia, and 21 to other diseases of the chest. It is practically certain that, on account of the extremely dangerous nature of the dust exposure underground in Rhodesian mines, a case of lung fibrosis is usually fatal before there is time for the development of a subsequent true pulmonary tuberculosis.

## PRACTICAL PREVENTIVE MEASURES.

Special and most commendable efforts have been made for a number of years by the mine owners of South Africa to control the problem of miners' phthisis through a miners' phthisis prevention committee, and good results have been achieved by means of dust-allaying methods which are deserving of much more consideration on the part of mine owners and managers in the United States than has thus far been the case. There has also been established a miners' phthisis sanatorium, with regard to which, during the month of September, 1915, a recommendation was made "That a separate institution should be provided for men suffering from tuberculosis plus silicosis, the present sanatorium being reserved for men suffering from silicosis only." It is in this direction of careful specialization that the best results are likely to be achieved in the course of time. The activities of the Transvaal miners' phthisis prevention committee are briefly reviewed in the Engineering and Mining Journal, June

17, 1916, with special reference to dust allaying. It is pointed out that blasting produces enormous quantities of dust and that much may be done to reduce the quantity produced by intelligent methods of supervision and control. It is conceded that the dust produced during blasting operations is very fine and most injurious and that "its inhalation should be avoided at any cost." It is agreed that machine drilling with water produces a smaller quantity of dangerous dust than blasting, but that the amount is still very large and is liable to be inhaled over a much longer period than air contaminated by blasting. It is, therefore, recommended that "by the use of water applied in a proper manner with suitable devices, the dangerous dust can be diminished to a small fraction of that produced when dry—in fact, to less than 1 per cent of the original quantity, when it is comparatively innocuous." Special emphasis is placed upon the imperative necessity of using proper devices for the allaying of the dust and the urgency of constant vigilance in their application, which, it may be said, is as yet inadequately recognized by mine managers and superintendents in this country. Attention is directed to a notice posted at all the Rand mines by the chamber of mines, reading in part as follows:

*Effects of dust allaying on the number of dust particles breathed per minute.*

| | Millions of dust particles. |
|---|---|
| Blasting: | |
| Five minutes after blasting cut, no water spray [1] | 2,450 |
| After using water spray for 30 minutes in drive | 10 |
| Drilling with 3¼-inch piston drills: | |
| Collaring dry [1] | 125 |
| Collaring wet | 57 |
| Drilling dry [1] | 330 |
| Drilling with wet jet in hole | 12 |
| Watering with cup | 28 |
| Hammer drills without water feed: | |
| Collaring dry [1] | 64 |
| Collaring wet | 8 |
| Drilling dry [1] | 18 |
| Drilling with wet jet in hole | 9 |
| Hammer drills with efficient water feed: | |
| Collaring | 3 |
| Drilling | 6 |
| Crusher houses: | |
| Dusty conditions | 31 |
| Dust well laid | 2 |
| General: | |
| Dust-laden air entering drive after blasting | 1,770 |
| Mine air after standing over Sunday | 4 |
| Street dust (excluding visible) on a dusty day | 2 |

(The figures given are the number of millions of particles of dust of 1/2000 of an inch and less in diameter breathed per minute.)

[1] Work under these conditions is prohibited by law.

### MINERS' PHTHISIS IN NEW SOUTH WALES.

One of the most important or scientifically conclusive investigations into the prevalence, nature, causes, and prevention of miners' phthisis was made in 1906 under the auspices of the Bendigo Hospital Committee and at the cost of the trustees of the Edward Wilson estate, by Walter Summons, M. D., including a report on the ventilation of the Bendigo mines. This investigation, following a fairly comprehensive statistical study, considers the symptoms, the pathology, the etiology, and the prognosis of miners' phthisis and the more obvious prophylactic measures, amplified by a brief summary and practical recommendations. The statistical investigation covers a period of 30 years and the statistical facts presented are of a sufficiently startling character to suggest the practical value of the inclusion of Table 123.

TABLE 123.—ANNUAL DEATHS AMONG BENDIGO MINERS, DETERMINED IN 5-YEAR PERIODS, AND ESTIMATED AS PER 10,000 LIVING AT ALL AGES.

| Year. | Miners' phthisis (tuberculosis). | Chronic bronchitis. | Acute pneumonia. | Total lung diseases. | Fatal mining accidents. | All other causes. | Total deaths. |
|---|---|---|---|---|---|---|---|
| 1875-1879 | 48.5 | 8.0 | 20.5 | 77.0 | 28.5 | 74.3 | 179.8 |
| 1880-1884 | 56.9 | 13.1 | 17.0 | 87.0 | 32.8 | 70.6 | 190.4 |
| 1885-1889 | 80.0 | 39.3 | 20.6 | 139.9 | 31.3 | 111.3 | 282.5 |
| 1890-1894 | 84.6 | 34.4 | 16.9 | 135.9 | 28.4 | 120.2 | 284.5 |
| 1895-1899 | 102.4 | 35.6 | 27.4 | 165.4 | 21.9 | 130.4 | 317.7 |
| 1900-1904 | 100.8 | 23.0 | 21.3 | 145.2 | 14.7 | 96.5 | 256.3 |
| 1905-1906(½) | 129.6 | 34.6 | 27.4 | 191.6 | 9.2 | 69.2 | 270.0 |

The table indicates a very marked increase in the death rate from pulmonary diseases, especially tuberculosis, and largely subsequent to the year 1880, when the detrimental effects of machine drilling had become manifest. As observed in the report by Dr. Summons, "Since their coming into general use, the increase in the death rate has been progressive and during the last 18 months it has been so excessive that the outlook is indeed fraught with the gravest forebodings." The further conclusion is advanced that "The detrimental influence of quartz mining, though directly acting on a section of the adult males only, is felt by the whole community of the mining center," for, as brought out in the report, the death rate of Bendigo was twice the normal rate for the State of Victoria. An interesting comparison is made with the mortality from respiratory diseases in other countries and for more or less corresponding periods of time, as follows:

*Comparative mortalities from respiratory diseases per 10,000 living.*

| | Rate. | |
|---|---|---|
| Adult, males, Victoria, 1903-1905: | | |
| Phthisis | 20.8 | |
| Pneumonia | 12.1 | |
| Other respiratory diseases | 10.0 | |
| | | 42.9 |
| Occupied males, England and Wales, 1890-1892 | | 58.0 |

| | Rate. | |
|---|---|---|
| Bendigo miners, 1905–1906 (½): | | |
| Phthisis | 129.6 | |
| Pneumonia | 27.4 | |
| Bronchitis | 34.6 | |
| | | 191.6 |
| Tin miners, Cornwall, 1900–1902 | | 182.0 |
| Coal miners (England) 1890–1892 | | 58.0 |
| Ironstone miners (England) 1890–1892 | | 46.0 |

According to the statement above the mortality from lung diseases of the quartz miners at Bendigo and of the tin miners at Cornwall is far in excess of the corresponding mortality, for illustration, of English coal and ironstone miners and the adult male population of the State of Victoria and England and Wales. In amplification of the general discussion the report includes an analysis in detail of 2,068 deaths of miners in the Bendigo district and of 750 miners in the Eaglehawk district. On account of its value, the table is included:

TABLE 124.—MORTALITY OF BENDIGO MINERS FROM JANUARY, 1875, TO JUNE, 1906.

| | Number of deaths. | Per cent. |
|---|---|---|
| BENDIGO CITY (EXCLUSIVE OF EAGLEHAWK). | | |
| Pulmonary diseases: | | |
| Phthisis (tuberculous) | 661 | |
| Bronchitis | 230 | |
| Pneumonia | 174 | |
| Total | 1,065 | **51.5** |
| Nonpulmonary diseases: | | |
| Cardiac disease | 176 | |
| Senility and asthenia | 142 | |
| Abdominal diseases | 86 | |
| Cancer | 76 | |
| Nervous disease | 66 | |
| Typhoid fever | 64 | |
| Vascular diseases | 39 | |
| Renal disease | 37 | |
| Diseases of urinary tracts | 15 | |
| Septic infections | 15 | |
| Rheumatism | 6 | |
| Hydatids | 4 | |
| Alcoholism | 3 | |
| Other diseases | 25 | |
| Total | 754 | 36.5 |
| Violent deaths: | | |
| Fatal mining accidents | 193 | |
| Other accidents | 41 | |
| Suicides | 15 | |
| Total | 249 | 12.0 |
| Total, Bendigo City | 2,068 | 100.0 |
| EAGLEHAWK. | | |
| Pulmonary diseases: | | |
| Phthisis (tuberculous) | 240 | |
| Bronchitis | 50 | |
| Pneumonia | 57 | |
| Total | 347 | 46.3 |
| Nonpulmonary diseases (inclusive of accidental deaths other than those caused b mining) | 316 | 42.1 |
| Fatal mining accidents | 87 | 11.6 |
| Total, Eaglehawk | 750 | 100.0 |
| Total for district | 2,818 | |

Aside from the statistical investigation, a fairly extensive amount of clinical material was subjected to qualified analysis. In the aggregate 192 cases, embracing all the stages of the disease, were considered. The details are given in full in the report for both tuberculous and nontuberculous cases. The results are summarized in the statement that—

The clinical histories of the above and other cases show the disease is most insidious in its onset, and, as a rule, only after years of work do definite symptoms present themselves. By this time, however, damage to the lungs has taken place, and the condition is irremediable. The early symptoms are frequently recurring coughs and mild attacks of bronchitis, in which the ciliated epithelium of the bronchial tubes is destroyed, and thereby greater facilities are afforded for the absorption of the dust particles. The general health is good, or the feelings of malaise so slight as not to interfere with the men's capacity for work. The primary irritating cause continues, and the bronchial tubes are progressively more and more damaged. This condition may last for years, and the only symptoms are those of a frequently recurring or of a continuous bronchitis.

The dust particles inhaled are, for the most part, caught in the mucus of the respiratory passages, and spat out again, giving rise to what is popularly called the "black spit." Even years subsequent to working underground, the expectoration may have at times a bluish black discoloration, especially when there is a caseation and necrosis of the lung tissue. Even without any infection with the tubercle bacillus, the expectoration may be profuse and muco-purulent in character, which, on microscopic examination, is found teeming with staphylococci and many putrefactive organisms. In other instances the dyspnoea may be extreme, but the patient has practically no spit, or some only first thing in the morning.

Sooner or later, however, the miner notices he becomes more readily short of breath than formerly, especially so if he has any bronchitis; and this is characteristic of attacks of bronchitis to which the miners are liable—that they become much more dyspnoeic than ordinary patients with bronchitis. The breathlessness increases *pari passu* with the amount of harm done to the lung, till, finally, though constitutionally his health is good, the man is compelled to cease working; and at this stage, even while resting, there is wheezing with prolonged expirations, while on the slightest exertion there are marked stridor and hurried breathing. This dyspnoea is unassociated with any signs of cardiac incompetence, and, therefore, is purely respiratory. In no case was the interference with respiration so extreme as to cause cyanosis.

This rather technical explanation is an admirable contribution toward a more precise and conclusive definition of a case of pure fibrosis, as separate and distinct from a case of unquestionable tuberculous infection. The physical signs of the disease are frequently quite confused, but the chest expansion is generally below the average, for according to the investigation, "mensuration showed the average expansion in 30 cases to be 1½ inches, one inch or less being all some patients could manage." By auscultation, however, the greatest knowledge was gained of the lung condition, for according to Dr. Summons—

The usual evidence of bronchitis, emphysema, and fibroid lung was universal, and, prior to the full development of these conditions, much alteration in the respiratory murmurs was noted, as diminution, prolongation of expiration, raised pitch, and different grades of bronchial breathing. Creaking sounds, perceptible both on inspiration and on expiration, and cardio-respiratory murmurs along the left cardiac border and in the region of the apex beat—notably a series of short puffs synchronous with the heart beat, and equally well heard on expiration as on inspiration, with crackles and fine pleural friction—in this region are common.

Irrespective of extreme care in physical examination, or on inspection, or by means of percussion and auscultation, or even the use of the fluorescent screen, the conclusion is reached by Dr. Summons that while the main symptoms are those of a chronic and obstinate bronchitis, "there are no distinctive signs by which one can say that this is a miner's lung, but all point to a chronic irritation of the lung and pleurae, and the results, in addition to being nonremedial, are, to a greater or less extent, steadily progressive."

The question is taken up as to the length of time in which these symptoms develop. It is stated that—

As a rule men, when first taken on, are employed in shoveling and trucking, and it may be some years before the miner is promoted to work with a rock drill. The earlier work involves the inhaling of a certain quantity of dust, but to nothing like the extent that work with a machine in dry country rock does without the beneficial effect of a dust-laying water jet or spray. Under these circumstances a strong, healthy man, going home after his shift with merely a slight cough, may show no detrimental effect to his health for many years. Others, on the contrary, rapidly develop serious symptoms. All men, however, do not become victims. In one mine, for example, two men, aged 67 and 71 years, respectively, were found working as mates, and each did a fair day's work. They were not native born, and had not worked altogether in the Bendigo mines.

The value of an examination of the sputum is emphasized in the statement that while the physical signs in some cases were those only of a simple fibrosis, the sputum examination showed abundant bacilli. The symptoms are more or less at variance with those of ordinary phthisis, for it is said that—

Haemoptysis is rare, but in one case it was the final ending. This may be understood when it is recognized that the dust irritation sets up a peribronchitis and a periarteritis at the same time, with the slow production of much fibrous tissue. With excavation of the lung these tough, fibrous cords resist the necrotic process, or they are destroyed so slowly that in nearly all cases the blood is clotted and organized before the vessel wall is destroyed. The dyspnoea is, as would be expected, quite out of all proportion to the tuberculous involvement of the lung. This is even the case when there has been no evident respiratory embarrassment prior to the superadded tuberculous infection. Pneumothorax seems to be extremely uncommon. In many of the chests examined at autopsy it would be an impossible condition, as the pleural cavities were totally obliterated by adhesions.

The foregoing observations have been quoted at length in view of the increasing importance of concrete and conclusive diagnosis of miners' phthisis in States in which the principle of workmen's compensation on account of occupational injuries, in the broadest sense of the term, may be adopted. The most thorough inquiry in the State of Victoria found it extremely difficult to fix the onset of tuberculous infection. On the basis of 204 autopsies of cases of miners' phthisis, 95, or 47 per cent, of the cases presented abundant evidence of tuberculosis. It is pointed out that out of the difficulty to determine accurately the prevalence of tuberculosis several questions arise, and the question is asked, "Is there a type of case starting in the usual way, and progressing as a pure fibrosis, with recurring attacks of bronchitis and pleurisy, which, going on and on, finally brings about heart failure and death, without any superadded bacterial infection? And what is the cause of death in the lung diseases to which the miners are liable?"

In reply to the second question the conclusion is advanced that at the present time "all Bendigo miners dying of their respiratory diseases die of tuberculosis." This statement was based on the final ending of 27 almost consecutive cases. Reference is made to a report on miners' phthisis by the Transvaal Medical Society in 1903, according to which "It is not common to find the typical physical signs of tubercular phthisis present, and this observation, together with the confirmatory fact that out of a series of over 30 sputa from cases of disease of the lung of miners examined only two or three were found to contain tubercle bacilli, leads us to conclude that, while in some cases a true tubercular phthisis may coexist or may be superadded, the conjunction is only seen in a minority of cases."

An article by Sir Thomas Oliver in the British Medical Journal is referred to in the statement that "In some instances tubercle bacilli are detected, in others not at all. Since during life no tubercle bacilli are found in the expectoration, and after death none are found in the lungs, it is apparent that in Rand miners' phthisis we have an illustration of a true pneumoconiosis—that is, of a lung that has been irritated by dust, and in which, while the changes become progressive and ultimately lead to death, the malady from first to last can be nontuberculous."

Dr. J. S. Haldane's conclusion on the health of Cornish miners is quoted, however, to the effect that "We thus have, as the gross results of the investigation, that out of 23 cases 17 were definitely shown to be tubercular, and further analysis of the cases shows that in 12 cases a history of the men having worked machine drills was obtained and of these 8 were tubercular." Again, "9 of the men examined had worked in the Transvaal and of these 6 were tubercular." Dr. Summons therefore concludes that—

The inference to draw from these almost contradictory opinions, and the evidence obtained from the cases at Bendigo, is that the tubercular infection depends entirely on local conditions. If the disease is rare in the community, the chance of infection is diminished, and vice versa. Every infected case, however, whether miner or nonminer, if his sputum contains bacilli, is a danger to others, and unless precautions are adopted the percentage of tubercular cases will increase.

A useful clinical classification, therefore, is—

(1) A pure fibrosis of the lungs, nontuberculous in origin, and which is a silicosis.

(2) The mixed type, with a tuberculous infection in a fibroid lung.

As regards the pathology of miners' phthisis, the discussions by Dr. Summons are in a large measure based upon a number of exceptionally interesting autopsies and supplementary scientific research, summarized in the statement that—

The essential pathology of miners' phthisis is thus seen to be a fibrosis of the lungs, with an associated chronic irritation of the bronchial tubes, consequent upon which coarse, emphysematous changes ensue, and sooner or later infection with the tubercle bacillus takes place, with the resulting formation of tubercles, caseation, and formation of cavities. The tuberculous process is altered somewhat from the fact that the tissue affected is not normal but fibrotic lung tissue.

The inorganic constituents of a Bendigo miner's lungs were examined by Mr. Gustav Ampt at the Melbourne University, with the following result:

TABLE 125.—ANALYSIS OF INORGANIC CONSTITUENTS OF A BENDIGO MINER'S LUNGS.

| Constituent. | Weight (grammes). | Per cent of total ash. |
|---|---|---|
| Silica | 5.3127 | 40.52 |
| Alumina | 4.3851 | 33.45 |
| Ferric oxide | 1.2914 | 9.85 |
| Lime | .0471 | .36 |
| Magnesia | .1645 | 1.25 |
| Phos. pentox | .4263 | 3.25 |
| Constituents found | 11.6271 | 88.68 |
| Total ash | 13.1101 | |
| NaCl, $Na_2O$, $K_2O$, $SO_3$, by difference | 1.4830 | 11.32 |

Table 125 is briefly interpreted as follows:

The silica constituent of a Bendigo miner's lungs was 40.52 per cent of the total ash content, in contrast to the ash content of a normal lung given in the same report as only 13.4 per cent. It is explained in this connection that the lung analyzed was in but a moderately advanced stage of silicosis, but that the proportion of silica shows adequately the importance of the part it plays in the abnormal lung condition. The presence of alumina to the extent of 33.5 per cent of the ash content is equally abnormal and in large measure accounts for the fibrosis. The conclusion is therefore advanced by Dr. Summons that—

Silica dust is therefore to be considered the cause of nontuberculous miners' phthisis. It is constantly found in their lung tissue, enveloped by fresh fibrous tissue formed in consequence of its presence; and, even after many years, presents the same appearance as when it was inhaled. On incineration it was regained from the lungs, and by chemical analysis shown to be of the same nature as the country rock of the Bendigo mines. Without the dust no lung disease is prevalent, hence it, and it alone, is the sole cause of miners' phthisis (nontuberculous), and it can safely be asserted that, with the absolute prevention of dust, the lung disease would almost cease to exist. The other sources of air vitiation, as noxious fumes, are adjuvant causes, but of themselves do not produce sufficient detriment to health to bring about lung disease.

Miners' phthisis (nontuberculous) is thus a typical example of a disease brought about by the mechanical action only of dust particles, without absorption of them, and with no poisoning of the system generally. It is a disease of purely local origin, and continues as such till tuberculosis, with its specific bacillus, is superadded and poisons the body with its toxines, and, in addition, produces alteration in the nature of the pathological changes in the lungs.

## OFFICIAL INVESTIGATIONS IN THE UNITED STATES AND NEW SOUTH WALES.

There has not, unfortunately, been a correspondingly clear and concise recognition of the dust hazard in the mining industries of this country, with the possible exception of the zinc and lead mines of southwestern Missouri, where the conditions have been subjected to a joint investigation on the part of the United States Bureau of Mines and the United States Public Health Service. An earlier official investigation in the State of Montana proved practically inconclusive, because of the nonuse of the required technical information. Most of the conclusions involved in a discussion of health hazard in mining represent scientific problems of an exceptionally complex nature, with reference to which experimental evidence is frequently of considerable practical value. Such investigations, for illustration, as have been made by Prof. Beattie, of Liverpool, upon the effects of stone dust, and with some reference to coal dust, prove the practical usefulness of research of this kind. The results of an exhaustive investigation into the health of metal miners are presented in the reports of the royal commission on metalliferous mines and quarries, presented to both Houses of Parliament during the years 1912–1914.[1]

An equally important official investigation was made during 1914 by the royal commission on the mining industry at Broken Hill, in the State of New South Wales, which includes important observations on improved methods of ventilation, the possibilities of temperature reductions in hot mines, etc. Another important investigation was made in 1910 by the royal commissioner of Western Australia on pulmonary diseases amongst miners, including a considerable amount of new evidence and some very interesting statistics on the frequency of lung diseases among miners and in the mining districts generally.[2]

## ACCURACY OF DEATH CERTIFICATION.

All of the available evidence confirms earlier conclusions, based largely upon official mortality statistics and insurance experience, that the death rate of miners, considered as a group, is generally distinctly above the average, but that during recent years there has been a material improvement, particularly among coal miners in the principal coal-producing countries of the world. Practically all of the official investigations, however, have been limited to the general occupational aspects of the mining industry, and insufficient attention has been given to employments in detail, with the possible exception of the South African inquiries, in which rock drillers were differentiated from mine employees generally. The available evidence is more or less conflicting, particularly on account of the existing confusion in medical terminology. Death certificates are frequently filled out in a superficial manner and the diagnosis is rarely confirmed by autopsy findings. Extreme caution is therefore necessary

[1] Royal Commission on Metalliferous Mines and Quarries; Vol. I. Minutes of evidence, London, 1912; Vol. II, Minutes of evidence, London, 1914; Vol. III, Minutes of evidence, London, 1914; Vol. IV. Second report, London, 1914.

[2] Report of the Royal Commission on the Mining Industry at Broken Hill, State of New South Wales, Sydney, 1914. This report and evidence makes a volume of nearly 900 pages and the evidence includes nearly 25,000 questions and answers. There has been no equally exhaustive investigation in any other country in which the metal-mining industry is of equal importance. The main questions considered are the reduction of the temperature in mine working to 75 degrees Fahrenheit, the compensation of mine employees in all cases of industrial sickness or accident, the improved ventilation of mines, the authorization of officials of industrial unions to visit the mines, the control of foreign immigration, and finally the best means of securing a diminution in the frequency of mine accidents. The title of the earlier investigation is "Report of the royal commission on pulmonary diseases amongst miners, together with appendices and minutes of evidence," published at Perth, Western Australia, October 4, 1910. This report includes the results obtained by the actual physical examination of working miners and a considerable amount of experimental and pathological evidence.

in the interpretation of the statistical data, which, as a general rule, fail to differentiate the several important forms of respiratory diseases.

### MINERS' PNEUMOCONIOSIS AND ANTHRACOSIS.

Under the general term "Pneumoconiosis" Sir Thomas Oliver, in Allbutt and Rolleston's System of Medicine, presents a most interesting discussion of miners' lung diseases, in which separate consideration is given to coal miners' phthisis or anthracosis, the diseases of metal miners, the lung diseases of slate quarriers and dressers, of those engaged in ganister mining and ganister crushing, and in slag crushing, and gold miners' phthisis, or silicosis, aside from the diseases incident to a number of related employments, such as millstone building and French buhrstone dressing, which also involve considerable and continuous exposure to health-injurious mineral dust. Concerning coal miners, Sir Thomas Oliver observes that the conditions under which the industry is carried on have so materially improved during recent years that the employment may now be considered a healthy occupation, and he states that coal miners, as a class, suffer less from phthisis than men in other occupations, and that coal miners' phthisis, or anthracosis, is on the decline in the United Kingdom. He observes that—

> Although colliers occasionally suffer from cough, shortness of breath, an abundant black and at times purulent expectoration, and show progressive emaciation, the lungs after death being found black and excavated, and on section exuding an inklike fluid on pressure, it is more than probable that, owing to the improved conditions of work in the mines, the disease is not a pure pneumoconiosis due to dust, but a mixed tuberculous malady, the bacillary infection of which has been caught not in the pit but in the home or elsewhere.

How far these conclusions apply to American coal miners has not been determined. The results of such investigations as have been made are inconclusive, and the evidence is generally of a superficial character. Nor are there reasons for believing that even in the United Kingdom coal miners suffer less from pulmonary tuberculosis than men employed in many other occupations, when the required correction is made for the determining influence of the liability to accidental death. The majority of coal miners' accidents occur at ages under 40, when the proportionate mortality from pulmonary tuberculosis in industrial employments is generally excessive. There are, however, no reasons for assuming that the frequency of pulmonary tuberculosis in coal mining is anywhere near as common as in metalliferous mines, in which it varies, of course, quite widely according to the nature of the dust inhaled.

### DIFFERENTIAL DIAGNOSIS OF MINERS' PHTHISIS.

Medical opinion, as well as autopsy evidence, is quite conclusive that true phthisis or pulmonary tuberculosis is not a common disease among coal miners. As stated in the Index of Differential Diagnosis, edited by Herbert French—

> Miners' phthisis is a particular variety of fibrosis due to the inhalation of irritating particles, especially amongst workers at certain occupations. Coal miners seldom get it; although their lungs become packed with carbon—anthracosis—these particles do not seem to inflame the tissues. Knife grinders suffer from it—siderosis—so do workers in certain limestone quarries, rock-drilling, gold mines, and diamond mines—silicosis. The chief point in the diagnosis is the history as to occupation; there is much doubt as to whether these conditions are not really of a chronic tuberculous nature, and tubercle bacilli should be looked for in all these cases. The hæmoptysis is far less frequent and less abundant than it is in ordinary cases of phthisis.

### QUESTIONABLE OCCUPATIONAL STATISTICS.

It is therefore quite clear that the correct interpretation of the statistical evidence depends largely upon the completeness and accuracy of death certification, which, it is generally agreed, is frequently far from satisfactory in mining regions. The emphasis placed upon the occupation in the previous reference suggests the practical importance of more extensive special occupational investigations than have heretofore been made. Unfortunately, the scientific value of the available mortality statistics is materially impaired by the superficial, indefinite, or even obviously inaccurate description of the exact employment of the deceased. The previous occupation is rarely referred to, although the occupation at death may have been followed only for a comparatively short period of time. Reference may be made to a suggestive illustration in the monograph on industrial pneumoconiosis, or dust phthisis, by E. B. Collis, which shows a vertical section from the lung of a man who had first been an ironstone miner in England, then a gold miner in the Transvaal, then an ironstone miner in England, and again a gold miner in the Transvaal for five years, but who finally became an insurance agent in England eight years previous to his death from pulmonary tuberculosis.

### RELATIVE FREQUENCY OF MINERS' PHTHISIS.

Sir Thomas Oliver was the first to direct attention to the occurrence of a theretofore unknown form of fibroid phthisis in England, contracted during prolonged employment in the gold-mining industry of the Transvaal. Men in whom the condition was observed, upon returning to the lead and tin mines of Cornwall, exhibited symptoms and terminal results quite out of the ordinary for that section of the English mining field.

In the absence of a thoroughgoing past occupational inquiry the initial diagnosis, at least, would often be erroneous. As a result of Sir Thomas Oliver's observations and the public discussion following, the South African Government appointed a commission which in a report published in 1912 stated that out of 3,462 persons examined 31.6 per cent were found to be affected with miners' phthisis, but among machine drillers 47.5 per cent were found to be victims of the disease, while among those who had never done machine drilling the proportion was only 21.0 per cent. It is pointed out in this connection by Frank Shufflebotham, M. A., in one of the Milroy lectures on the "Hygienic aspect of the coal-mining industry in the United Kingdom," that although 31.6 per cent of the men examined were suffering from phthisis at the time of the examination, it was estimated that 90 per cent of the workers would eventually contract the disease. It was also ascertained that among European miners pulmonary tuberculosis existed to the extent of 3.6 per cent among those who were not affected by pneumoconiosis and that of those so affected 10 per cent were tuberculous. The evidence was therefore quite conclusive that pulmonary tuberculosis was a disease contracted subsequently to the so-called fibroid phthisis, which, in other words, is a nontuberculous disease of the lungs.

## DISEASE LIABILITY OF ROCK DRILLERS.

The evidence obtained by the miners' phthisis commission of the Transvaal, limited, of course, to miners on the Rand, according to Sir Thomas Oliver, amply demonstrates that—

Of 4,403 miners working underground in the gold mines of Witwatersrand, 1,200 were medically examined on behalf of the commission; of this number 187, or 15.4 per cent, were certified by the examining doctor to be suffering from miners' phthisis, and a further 88 were suspected. The average age at death of Transvaal gold miners at the time of the war was 35.5 years. Most of the men who died from phthisis were rock drillers, in whom, as a class, the disease prevailed to the extent of 91.98 per cent. The average length of time rock drillers follow their occupation is 6.49 years. It is noteworthy that out of 9.3 males who died from disease of the chest in the Johannesburg hospital 50 per cent were miners. The most dangerous dusty processes in the gold mines are the blasting and boring of the rock, but a considerable quantity of dust is raised also during the shoveling of the débris. A cubic foot of air, taken close to rock-drilling machines boring dry holes, was found to contain 0.185 grain of dust on one occasion and 0.083 grain on another; so that miners working in these atmospheres ran the risk of inhaling 2.38 grains of dust per hour. It is not contended, however, that the whole of this dust reached the lungs of the miners; most of it, caught by the ciliated epithelium, would be arrested in the mucus of the trachea and bronchial tubes, and finally expelled.

### PATHOLOGICAL CONSIDERATIONS.

The morbid anatomy of miners' phthisis or silicosis varies, naturally, in important essentials from true tuberculosis, it being stated in part by Sir Thomas Oliver that—

The hardness and solidity of the lung in pneumoconiosis are due to excessive fibrosis and to the deposition of gritty particles of stone in stone miners' phthisis, of steel and stone in steel grinders' phthisis, and of silica in miners' phthisis. The particles of grit in the lungs have been examined physically and chemically, and have been found to correspond exactly with the particles of dust that float in the atmosphere of the mine or factory where the patient had worked.

With special reference to the results of microscopical examinations of miners' lungs, it is said that—

Although in anthracosis or coal miners' phthisis the lung is perfectly black, the fibro-connective tissue is not so much increased as in some other forms of pneumoconiosis; a condition which proves that carbon per se is but slightly irritating in its effects. When a coal miner's lung shows pronounced fibrosis it is generally an indication that the individual has worked in a coal seam which contained a quantity of stone; it is the stone dust in the coal, not the coal itself, which in the case of colliers' phthisis is the cause of the fibrosis, for the lungs of men who have worked in soft coal or at charcoal burning and who have inhaled the smoke from lamps, may be laden with carbon particles without much evidence of fibrosis and without the invasion of pulmonary phthisis, as is often seen in the bodies of miners who have been accidentally killed and who had never had any symptoms of lung disease.

The relative degree of the contamination of the air in coal mines by stone dust must naturally be subject to very wide variations, according to the overlying or underlying geological strata, inclusive of coal seams. It is a safe assumption that under given conditions the proportion of stone dust intermixed with coal dust must be sufficiently injurious, particularly during drilling operations when the overlying so-called slate is removed. Much of the drilling, in other words, is in stone rather than in coal, although, of course, in the overwhelming majority of coal mining operations the bore holes are entirely in the coal seam. The information is therefore of quite a conflicting character, largely because of the nonrecognition of the complexity of the problem under consideration. Obviously a general analysis of the mortality of miners is, therefore, as far from conclusive as a corresponding general analysis would be of the stone industry, on account of the wide variations in working conditions and, consequently, the results to health and longevity.[1]

[1] Textbooks on coal mining fall lamentably short of the required consideration of matters of health, sanitation, and accident prevention. During recent years much useful information in matters of detail has been contributed to technical publications, especially the Coal Age and the Engineering and Mining Journal.

### PNEUMOCONIOSIS AND TUBERCULOSIS.

For practical purposes, however, chiefly in connection with the successful solution of problems in workmen's compensation having to do with the inclusion of occupational diseases, the precise relation of pneumoconiosis and tuberculosis is of much importance. As has been said by Sir Thomas Oliver in this connection:

One party maintains that some of the structural changes met with in the lungs of persons who have worked in dust are tuberculous, and that pneumoconiosis is only the fibroid form of ordinary pulmonary tuberculosis. My own experience does not lead me to accept this conclusion. Pneumoconiosis is in its inception nontuberculous; it may even run its course and end fatally without ever becoming tuberculous. In at least two necropsies which I made on the bodies of Rand miners the lungs were quite free from naked-eye and microscopical evidence of tuberculosis. The absence, during life, of fever, of sweating, and of emaciation, and the presence of a bronzed appearance of the skin, combined with a degree of breathlessness quite out of proportion to the physical signs of the disease in the chest, all indicate that the disease is different from pulmonary tuberculosis. Yet in a considerable proportion of the patients the disease of the lungs becomes tuberculous; whether the percentage of such cases is as low as 47, as some pathologists maintain, or as high as 70, as others assert, the number of cases of miners' phthisis which become tuberculous is not so great after all, considering the length of time the illness lasts and the numerous opportunities for tuberculous infection. The records of any large infirmary show that evidence of pulmonary tuberculosis, latent or active, is forthcoming in nearly 70 per cent of all bodies examined after death. The presence of tuberculosis in from 47 to 70 per cent of cases of pneumoconiosis has given rise to the opinion that all cases are tuberculosis, but this conclusion is not borne out by the clinical data, nor by the results of naked-eye and microscopical examination of the diseased structures. As the disease progresses the patients run the risk of tuberculous infection, the onset of which is shown by sweating, rise of temperature, presence of bacilli in the sputum, rapid emaciation, a change in the symptoms, and by an alteration in the general conditions of the patient for the worse, as indicated by the more rapid course of the disease to a fatal termination.

The observations have been given in full on account of their practical importance and the recognized high authority of the writer, who, as said before, was the first to recognize the occurrence of true miners' phthisis in English miners returning from the Transvaal. Sir Thomas Oliver differentiates completely the two forms of pneumoconiosis: (1) the purely nontuberculous form and (2) that complicated with tuberculosis. He quotes the results of an investigation made by a committee of the Transvaal Medical Society to the effect that "while in some cases a true tubercular phthisis may coexist or may be superadded, the conjunction is only seen in a minority of cases." It would therefore appear that most of the deaths attributed to miners' phthisis are, in fact, caused by nontuberculous lung diseases, complicated to only a very limited extent by a superadded true pulmonary tuberculosis. In the investigation of the royal commission on the ventilation and sanitation of mines in West Australia much the same conclusion was arrived at, to the effect that "Some of the cases investigated were of the purely tubercular type, but in the majority there had apparently been fibrosis of the lung followed by tubercular infection of the damaged lung." And Sir Thomas Oliver quotes Prof. D. J. Hamilton in the statement that "coal miners' phthisis is not a tuberculous process but has more the character of an asceptic slough due to the altered condition of the organ. In the case of the stonemason's lung, on the contrary, a complication with tubercle, at the time of death, or for some time before it, is frequently met with, accompanied by the expectoration of tubercle bacilli." The correct ascertainment of either condition is frequently quite difficult, even on the part of an experienced medical practitioner. Bacilli are rare and so-called giant cells are only occasionally observed. All the evidence, however, may be summed up in the statement that when pulmonary tuberculosis is actually present in the lungs of persons who have died of pneumoconiosis, "the fibrosis is the result of a primary irritation induced by dust, and that the pulmonary tuberculosis is secondary and accidental."

## MORTALITY OF MINERS AND QUARRYMEN—UNITED STATES REGISTRATION AREA.

The most recent American vital statistics of miners and quarrymen are limited to the two years 1908 and 1909, no subsequent analysis of the data having been made by the division of vital statistics of the United States Census Bureau. The mortality of miners and quarrymen is combined, so the statistics are, therefore, of rather limited usefulness. In the aggregate there were 10,800 deaths from all causes, of which 948, or 8.8 per cent, were from pulmonary tuberculosis. The details of the mortality, by divisional periods of life, are given in Table 126:

TABLE 126.—PROPORTIONATE MORTALITY OF MINERS AND QUARRYMEN 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 deaths from all causes. |
| 15 to 24 years | 1,491 | 88 | 5.9 |
| 25 to 34 years | 2,184 | 151 | 6.9 |
| 35 to 44 years | 2,122 | 235 | 11.1 |
| 45 to 54 years | 1,869 | 214 | 11.4 |
| 55 to 64 years | 1,430 | 168 | 11.7 |
| 65 years and over | 1,657 | 88 | 5.3 |
| Age unknown | 47 | 4 | 8.3 |
| Total, 15 years and over | 10,800 | 948 | 8.8 |

The table should be interpreted with extreme caution, in view of the fact that the miners in the United States registration area are chiefly coal miners, but in a general way the table confirms the conclusion that the recorded mortality from pulmonary tuberculosis among miners and quarrymen, considered as a group, is relatively low at all ages and at specified ages, reaching a maximum of 11.7 per cent at ages 55 to 64. The age distribution of the deaths is in itself significant in that the maximum mortality falls upon ages 35 to 64, in contrast to the usually excessive proportion of deaths from pulmonary tuberculosis in dusty trades at ages 15 to 34. The table indicates that the apparent mortality from pulmonary tuberculosis among miners and quarrymen in all probability includes a considerable number of deaths from miners' phthisis, or nontuberculous lung diseases. This conclusion in part is confirmed by the relatively high mortality from asthma, bronchitis, and other respiratory diseases.

### MORTALITY OF MINERS FROM NONTUBERCULOUS RESPIRATORY DISEASES.

Combining all nontuberculous respiratory diseases, the proportion of deaths from this group of causes among United States miners and quarrymen was 12.1 per cent, having been, respectively, 0.7 per cent from asthma, 0.8 per cent from bronchitis, 7.8 per cent from pneumonia, and 2.8 per cent from other respiratory diseases. Combining the mortality from tuberculous and nontuberculous lung diseases, it is shown that 20.9 per cent of the deaths from all causes among miners and quarrymen were attributable to these two groups of causes, in comparison with 29.8 per cent as shown by the Prudential experience, and 32.7 per cent by the statistics for England and Wales.[1]

### MORTALITY OF MINERS AND QUARRYMEN—INDUSTRIAL INSURANCE EXPERIENCE.

The Prudential industrial mortality statistics regarding miners are practically limited to coal mining and quarries, but, in so far as the data may prove useful, they are included in the present discussion in the combined form for mines and quarries, including 4,819 deaths from all causes, of which 533, or 11.1 per cent, were from pulmonary tuberculosis. The details of the mortality, by divisional periods of life, are shown in Table 127:

[1] The Metropolitan Co.'s statistics have reference only to white coal miners aged 15 years and over. Out of 1,557 deaths from all causes, 91, or 5.8 per cent, were from tuberculosis of the lungs; 161, or 10.3 per cent, from pneumonia (all forms); and 49, or 3.1 per cent, from acute and chronic bronchitis. Information for other nontuberculous respiratory diseases is not available in detail.—(See Bulletin No. 207, United States Bureau of Labor Statistics on "Causes of Death by Occupation," Washington, March, 1917.)

TABLE 127.—PROPORTIONATE MORTALITY OF MINERS AND QUARRYMEN, FROM PULMONARY TUBERCULOSIS, INDUSTRIAL EXPERIENCE OF PRUDENTIAL CO., 1897 TO 1914,[1] 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 | 561 | 48 | 8.6 |
| 25 to 34 years | 563 | 92 | 16.3 |
| 35 to 44 years | 650 | 106 | 16.3 |
| 45 to 54 years | 1,043 | 142 | 13.6 |
| 55 to 64 years | 1,163 | 105 | 9.0 |
| 65 years and over | 839 | 40 | 4.8 |
| Total, 15 years and over | 4,819 | 533 | 11.1 |

[1] Miners and workers at coal and lead and zinc mines cover the period 1907 to 1914 only.

The comparatively low proportionate mortality from pulmonary tuberculosis in the Prudential experience is confirmed in a general way by the corresponding statistics for the United States registration area, but throughout the proportions are higher, which in part may be explained by adverse selection, and in part by the practical limitation of the table to actual miners rather than men employed in the mining industries. The United States registration data have reference rather to all employments in connection with mines and quarries, while the Prudential statistics are more strictly limited to miners and quarrymen within the technical sense of the term.

### EXCESSIVE FREQUENCY OF NONTUBERCULOUS RESPIRATORY DISEASES.

In contrast to a relatively low proportionate mortality from tuberculous disease, the proportionate mortality from nontuberculous respiratory diseases was relatively high, or 18.7 per cent of the mortality from all causes, which compares with only 12.1 per cent for the mortality of miners and quarrymen in the United States registration area. The same conclusions apply here, with more strict occupational limitations in the Prudential statistics, which exclude a considerable proportion of persons employed in the mining industries who work under practically noninjurious conditions as regards dust exposure and predisposition to tuberculous or nontuberculous lung diseases. In view of the fact that each important branch of the mineral industry is separately considered in the following discussion it would serve no useful purpose to here repeat the data, which it may be said, however, in a general way are confirmed by the official English statistics and the corresponding official statistics for the United States. The differences in the results are attributable to widely varying conditions of employment in the mining industries, the variable degree of disease exposure as affected by territorial considerations, and adverse occupational selection in industrial insurance experience, etc.

## GOLD AND SILVER MINING.

The term "gold and silver mining" comprehends several important and widely different methods of ore extraction. The precious metals, as such, are of no hygienic importance. Gold and silver as extracted by the ordinary processes of deep mining constitute but a minute fraction of the ores, which, however, frequently contain a relatively large proportion of lead. The rock itself is generally a silicious quartz which, during the process of rock drilling, seriously contaminates the atmosphere underground, often with disastrous results to the miners' lungs. The term "gold and silver mining" is, therefore, of importance only in so far that mining for the purpose of extracting the precious metals, is, as a general rule, inseparable from exposure to more or less health-injurious silicious dust. Many gold and silver mines, as measured by the metallic content of the ore, are more accurately described as lead mines. Most of the gold is obtained by deep-mining methods, but a fair proportion is recovered by means of placer mining, hydraulic mining, dredging, etc. In these latter processes the dust exposure is of decidedly less importance, since most of the operations are carried on in the open. No extended official inquiry has ever been made in this country into the health and mortality of gold and silver miners, although the industry, for many years, has been one of relatively large economic importance. According to the report of the U. S. Bureau of Mines for 1915, the number of men employed in connection with gold and miscellaneous metal mines, other than iron, copper, lead, and zinc, was 45,312. The industry is chiefly concentrated at the present time in Alaska, California, and Colorado. In all of the States the underground conditions vary considerably on account of important differences in the chemical and mechanical properties of the rock dust inhaled during drilling and other underground operations. It is only within recent years that the dust hazard has been clearly recognized, and among other suggestive indications of a tendency toward an improvement in underground conditions, reference may be made to the following tentative rules and regulations of the California Industrial Commission:

### SECTION 41.—ELIMINATION OF ROCK DUST.

(*a*) No operator or person in charge of any underground mine shall cause to be drilled or bored by machinery a hole or holes in any working place in ground that causes dust from drilling, unless said machinery is equipped with a water jet or spray, or other means equally efficient to prevent the escape of dust; *Provided*, That when water jets or sprays are used, water free from pollution with organic or other noxious matter, shall be furnished.

(*b*) No person or persons shall drill or bore a hole in said working places without using said appliance for the prevention of dust.

(*c*) Every mine operator shall equip all chutes from which dusty ore or rock is taken with a sprinkler or other device with which to effectively dampen said ore or rock, to prevent the escape of dust into the air during removal; *Provided*, That whenever in the opinion of the chief inspector the installation of said device in any property is impracticable, he shall have the power to exempt such property.

(*d*) Whenever a sprinkling device is installed at any chute for the purpose of preventing the escape of dust, it shall be so placed that it can be operated by the workmen loading cars from such chute.

(*e*) Every ore house where dusty rock or ore is sorted shall be supplied at all times with suitable clean water, which shall be used for the purpose of sprinkling said ore or rock to allay the dust.

Of interest also in this connection is a resolution adopted by the board of directors of the National Association for the Study and Prevention of Tuberculosis in 1911, reading as follows:

Whereas the royal commission, appointed by the governor general of Australia to inquire into the subject of miners' lung diseases, has ascertained a truly alarming state of affairs resulting from the extensive use of rock drills underground, not provided with spraying apparatus to diminish the production of health-injurious dust; and

Whereas a large proportion of our mining population is exposed to conditions quite similar to those reported upon adversely in the Australian Commonwealth; and

Whereas the actual extent of the occurrence of lung diseases among metal miners in the United States is at present unknown.

*Resolved, by the board of directors of the National Association for the Study and Prevention of Tuberculosis*, That we recommend to the President and the Congress of the United States that a thorough investigation into the whole subject of sanitary conditions surrounding metal mining underground, with special reference to diseases of the lungs, be made by the United States Bureau of Mines, the Public Health and Marine-Hospital Service, and the appropriate State authorities.

The effect of this resolution has been that both the Public Health Bureau of the Federal Government and the Bureau of Mines have commenced tentative investigations into the sanitary condition of mines and the health of miners, and with regard to zinc and lead mines of southwestern Missouri a preliminary report has been made, as referred to elsewhere in some detail.

In the absence of trustworthy vital statistics and the results of a sufficient number of physical examinations of underground employees in gold and silver mines, no definite conclusions can be advanced at the present time. The most useful data are the results of exhaustive investigations in South Africa, Western Australia, and New South Wales, elsewhere referred to. The problem, however, will unquestionably require more qualified consideration in the future, in view of the probability that miners' phthisis, or miners' lung diseases, whether tuberculous or nontuberculous will, in course of time, be brought within the scope of the workmen's compensation law. On the Witwatersrand, in South Africa, where miners' phthisis is a veritable scourge among both the white and the native employees, compensation is paid under restricted conditions, and according to a discussion in the Engineering and Mining Journal for January 2, 1915, up to the end of January, 1914, as much as £1,163,000 ($5,659,-740) had been granted in awards. Serious difficulties, chiefly on the ground of malingering, have been experienced in the administration of the act, partly attributable to the medical difficulty of the necessary precise diagnosis of silicosis. In consequence of the act, however, the conditions underground inimical to health and life are gradually being brought under sanitary and medical control. It is said in the article referred to, which is a discussion on phthisis conditions on the Rand, by A. Cooper Key, editor of the South African Mining Review, that "Medical members of the committee had not formed any definite opinion as to the relation between the amount of dust and the occurrence of the disease. They could not say that with such an amount as even 5 milligrams per cubic meter a man could not certainly contract miners' phthisis." Evidence gradually accumulating proved conclusively that the dust found in the silicotic lung after death was of extraordinary fineness, so that, in other words, only the very fine dust in the mine was most likely to be inhaled and to reach the lungs. Methods of dust control along the line of dust reduction seem not to guarantee a relative freedom from liability to miners' phthisis, for it is said that "with all the precautions taken, the 5 milligrams now remaining may be doing as much injury as the 50 or more before." The dust found in the lungs on postmortem was so fine that "50 particles in a row would be about as thick as a hair." These observations suggest the very important conclusion that it would not seem advisable that "mines, proved to be practically free of dust, should be removed from the list of contributors (to the compensation fund), as it was doubtful if they were not still causing phthisis." Time and subsequent experience alone can prove whether it would be safe to relieve a carefully managed mine, on the basis of dust standards, from the duty of making contributions to the compensation fund.[1]

### LEAD AND ZINC MINING.

The available information regarding lead and zinc mining in the United States is practically limited to the mining districts of the Mississippi Valley, where, according to the returns of the Bureau

[1] The comparative statistics of mortality from accidents and violence and disease, according to race, as reported by the Transvaal Chamber of Mines in its annual report for 1916, are of much interest and value

of Mines for 1914, the number of men employed in lead and zinc mines was officially reported as 10,935, of whom 7,609, or 69.6 per cent, worked underground. Of the zinc produced in the United States, 38.26 per cent during 1913 was obtained in Missouri, 19.23 per cent in Colorado, and 10.56 per cent in Montana. In Missouri zinc and lead mining is practically an identical industry, but in some of the more western States the recovery of lead is chiefly in connection with the mining for precious metals. Of the United States lead production during 1913, out of a total of 436,000 tons, 152,430 tons, or 35 per cent, came from Missouri; 137,802 tons, or 31.6 per cent, from Idaho; and 71,069 tons, or 16.3 per cent, from Utah. Aside from Colorado, where the production during 1913 was 42,840 tons, the production in the remainder of the United States is comparatively unimportant. It is explained in the annual report of the United States Geological Survey on the mineral resources for 1913 that the product of refined lead can with difficulty be apportioned according to the sources of ore, owing to the fact that lead refiners treat smelted products whose origin may, as in custom refining, be unknown to them, the identity of the ore and thus its original source being preserved only so far as the smelter. The mines of the Mississippi Valley were originally worked exclusively for lead, but since 1860 the production of zinc ore has predominated, which makes a separate consideration of each metal in this important mining area practically impossible. In Idaho, however, for illustration, most of the ores mined are strictly lead ores even though the object of the mining is the recovery of the precious-metal content.

in this connection, but they must be used with exceptional care on account of the probable effect of the war on the death rate and selection of the men employed during the last two or three years.

*Mortality of mine employees in the Transvaal.*

[Rate per 1,000 employed—white and colored.]

| Year. | White. | | | Colored. | | |
|---|---|---|---|---|---|---|
| | Accident and violence. | Disease. | Total. | Accident and violence. | Disease. | Total. |
| 1906 | 4.7 | 12.3 | 17.0 | 4.9 | 29.1 | 34.0 |
| 1907 | 5.6 | 12.2 | 17.8 | 4.4 | 27.3 | 31.7 |
| 1908 | 4.7 | 13.9 | 18.6 | 4.1 | 29.1 | 33.2 |
| 1909 | 4.9 | 12.3 | 17.2 | 5.2 | 27.6 | 32.8 |
| 1910 | 3.8 | 11.4 | 15.2 | 4.5 | 29.7 | 34.2 |
| 1911 | 4.3 | 12.9 | 17.2 | 4.1 | 28.9 | 33.0 |
| 1912 | 3.0 | 14.9 | 17.9 | 4.1 | 24.2 | 28.3 |
| 1913 | 3.6 | 13.5 | 17.1 | 3.9 | 22.9 | 26.8 |
| 1914 | 3.9 | 11.8 | 15.7 | 3.4 | 15.1 | 18.5 |
| 1915 | 3.0 | 15.0 | 18.9 | 3.2 | 16.5 | 19.7 |
| 1916 | 3.6 | 15.6 | 19.2 | 3.4 | 13.7 | 17.1 |

Most of the official inquiries into the health conditions of this group of mine employees have been limited to lead mining, chiefly, however, with reference to the United Kingdom. As subsequently to be stated, the only important exception to this conclusion applies to the lead and zinc mines of southwestern Missouri, where a fairly thorough investigation has during recent years been made by the United States Bureau of Mines in cooperation with the United States Public Health Service. All official investigations in this and other countries are apparently in agreement that the health of lead miners is distinctly below the average for the mining industry as a whole. This unfavorable condition is not merely with reference to the special liability to lead poisoning, but much more so with reference to general underground conditions. Greenhow, in one of the earlier investigations into the several mining districts of England and Wales, brought out clearly the injurious nature of the lead miner's employment, and proved that the predominating cause of death was then, as now, to be attributed to pulmonary disease, chiefly, as far as determined, pulmonary tuberculosis. Parry, in his treatise on "The risks and dangers of various occupations," especially in connection with lead, copper, and tin miners, observed that of the various forms of metalliferous mining, these are all attended by a very high rate of mortality from chest diseases caused by the dust inspired. He concludes—

> Perhaps the chief reasons of the high mortality of those engaged in these mines, when compared with coal miners, are, firstly, that the mines from their nature are more difficult to drain and ventilate than are coal mines; secondly, from the fact that the dusts are metallic and poisonous, and composed of sharp, angular, irritating particles; and, thirdly, that explosives are used in these mines, which generate poisonous gases and cause the formation of large numbers of minute stony atoms. They, however, do possess one advantage over coal mines—they seldom produce explosive and poisonous gases, and can therefore be worked safely without lamps. In lead mines the ore chiefly mined is galena, a sulphide of lead, and the dust of this occasionally, though not commonly, gives rise to lead poisoning. Dust is also produced during blasting operations, and whilst the various strata of limestone, sandstone, and shale, especially the latter, are being cut through. The importance of the perfect ventilation of these mines from the health point of view can hardly be overestimated; the comparison of the deaths from lung trouble in the workers in two mines, one of which is properly, the other improperly ventilated, amply proves the advantages accruing from the removal by ventilation of the dusty atmosphere. In tin and copper mines the dust is produced, again, during the blasting operations and whilst cutting through the various rocks. Nothing need be added to what has already been said above on lead mining.

The risk of lead poisoning is usually of importance only during the initial mining operations. With increasing depth the risk, on account of alterations in the nature of the ore, rapidly diminishes until cases become extremely rare. This, at least, has been the experience in the Coeur d'Alene District of Idaho, where years ago lead poisoning was relatively common among lead miners but where now it is seldom met with. Foreign observations seem to lead to much the same conclusion, for, as observed by Sir Thomas Oliver in his "Diseases of Occupation":

Lead miners do not in this country suffer from lead poisoning, but as the mines are badly ventilated, are often wet, and entrance into and exit from them can only be effected by means of ladders the men suffer in their general health and from rheumatism. In the dales of Durham house accommodation near the lead mines is difficult to obtain. Consequently many of the men have long distances to walk from and to home. At the end of a day's work, when heated and fatigued, they are thus exposed in winter to the cold winds that sweep along the valleys. Bronchitis and lung diseases claim a large number of victims. The deadliest enemy is tuberculosis. Formerly, when lead mining was more of an industrial success than it is to-day, the men were housed in barracks close to the mines and returned to their homes at the week ends. These barracks were overcrowded and badly ventilated and were hotbeds of tuberculosis. In the sleeping rooms not only was the air space insufficient and the beds too close to each other, but the windows were never opened, and miners who were the subjects of bronchial catarrh and tuberculous lung disease simply expectorated on the floor of the dormitories. Overcrowding, the breathing of foul air and of the dust-laden atmosphere of the sleeping rooms favored the spread of tuberculosis. As a consequence of these and of exposure to severe weather, also inattention to "colds on the chest," lead miners, although living in healthy districts, have succumbed to phthisis in much larger number than other persons living in the same district.

Obviously the social and economic condition of the industry has an important bearing upon the health problem aside from the health-injurious conditions underground, which more or less predispose the miner to pulmonary tuberculosis and nontuberculous respiratory diseases. According to the English occupational mortality statistics, out of 373 deaths of occupied and retired lead miners from all causes only 1 death was attributed to lead poisoning. In marked contrast the same official returns show that out of 162 deaths from all causes among persons employed in lead manufacture, including the making of leaden goods, 9 deaths, or 5.6 per cent, were from lead poisoning. The evidence would therefore seem to be quite conclusive that the special risk of lead poisoning in lead mining is at present quite negligible, although, as previously pointed out, important exceptions occur in the case of new lead-mining districts. It may be said in this connection that, according to Sir Thomas Oliver's "Diseases of Occupation"—

The lead miner does not suffer from plumbism, owing to the fact that the ore contains lead in almost a pure metallic state; but at the

Broken Hill mines in Australia the ore contains lead in the form of carbonate, and several of the miners there have died from saturnine encephalopathy, or the cerebral type of lead poisoning attended by convulsions.

These observations, of course, have no reference to the liability to plumbism in lead smelting and refining, which is usually carried on as a separate industry. Lead poisoning, however, is of practical importance in a consideration of the liability to pulmonary tuberculosis, in that the opinion is held by qualified authorities that the former disease distinctly predisposes to the latter, or that, in other words, those liable to lead poisoning suffer an increased liability to pulmonary tuberculosis.[1]

The only conclusive data regarding the mortality of zinc and lead miners in the United States are limited to the industrial insurance statistics for the mining districts of southwestern Missouri. In Table 128, which, though limited to 96 deaths from all causes, is nevertheless extremely suggestive of an excessive proportion of deaths from pulmonary tuberculosis, equivalent to 49 per cent, against 13.9 per cent for males in the United States registration area.

TABLE 128.—PROPORTIONATE MORTALITY FROM PULMONARY TUBERCULOSIS AMONG LEAD AND ZINC MINERS, INDUSTRIAL EXPERIENCE OF PRUDENTIAL CO., 1907 TO 1914, COMPARED WITH THAT OF ALL MALES IN THE UNITED STATES REGISTRATION AREA, 1900 TO 1913, BY AGE GROUPS.

| Age at death. | Deaths of lead and zinc miners, 1907 to 1914, from— | | Per cent of deaths from pulmonary tuberculosis among— | |
|---|---|---|---|---|
| | All causes. | Pulmonary tuberculosis. | Lead and zinc miners. | Males in registration area, 1900 to 1913. |
| 15 to 24 years | 15 | 5 | 33.3 | 27.0 |
| 25 to 34 years | 29 | 17 | 58.6 | 30.5 |
| 35 to 44 years | 26 | 16 | 61.5 | 23.4 |
| 45 to 54 years | 15 | 8 | 53.3 | 14.7 |
| 55 to 64 years | 8 | 1 | 12.5 | 7.9 |
| 65 years and over | 3 | | | 2.6 |
| Total, 15 years and over | 96 | 47 | 49.0 | 13.9 |

[1] The white lead industry might appropriately have received some consideration in connection with this discussion, but as far as known the employees in this industry are not exceptionally subject to pulmonary tuberculosis or nontuberculous respiratory diseases. During recent years far-reaching sanitary and other improvements have been introduced into the American white lead industry, with the result that the frequency of lead poisoning has been much reduced. In some plants the disease has practically been eliminated. Some of the larger establishments have been entirely reconstructed and, as far as practicable, in conformity to modern sanitary standards. There is, however, unquestionably a considerable amount of dust exposure, and a strictly scientific inquiry would be desirable. Such an investigation with special reference to the health of employees is rather difficult on account of the fact that the labor turnover is considerable since the labor force consists largely of foreigners and negroes. Health-injurious conditions, therefore, common to foreign white-lead plants where employment is more permanent are probably relatively rare in this country for the reasons stated.

Out of 96 deaths from all causes the extraordinary number of 47, or 49 per cent, are caused by deaths from pulmonary tuberculosis, in contrast to the expected proportion of 13.9 per cent. At ages 35 to 44, however, the proportionate mortality attains to 61.5 per cent, in contrast to the expected proportion of 23.4 per cent.

The investigation by Messrs. Lanza and Higgins was in consequence of a continued agitation for an inquiry into a truly alarming state of affairs. Various efforts made to abate the causes of the trouble resulted in the formation of the Jasper County (Mo.) Antituberculosis Society, which subsequently, on the basis of statistical information and the reports of visiting nurses, brought much important information to public attention. The general opinion in Jasper County, it is stated in the report referred to, seemed to be that "lung diseases became more prevalent after the beginning of active mining in the so-called sheet ground, in the early eighties, and that the flint dust from drilling and other mine operations is largely responsible for this condition." Both the records of the State board of health and the Jasper County Antituberculosis Society had established an unusual prevalence of tuberculosis in that county and southwestern Missouri. According to the report, after allowing for differences of opinion, inaccuracies, errors, and exaggerations—

An impartial investigator can not but conclude that when working conditions in any locality are such as to expose the workers to a hard, flinty, insoluble rock dust, and when among those workers there is a high death rate from pulmonary tuberculosis, that there is a definite connection between the dust and the disease, and that the dust is largely responsible for the disease—not entirely responsible for all pulmonary disease, but a prime factor in its causation.

In support of this conclusion attention is directed to the high proportionate mortality from pulmonary tuberculosis in Jasper County, including Webb City and Joplin, where 14.8 per cent of the deaths from all causes were from pulmonary tuberculosis, and in St. Francois County, another lead and zinc mining center, where the proportion was 11.8 per cent. These proportions are for 1911, but even higher figures were shown for 1913, as brought out by Table 128, which includes some comparative data for other sections of Missouri.[1]

[1] The health-injurious conditions in the Joplin district are, however, in all probability, not limited to underground mining. There has apparently been no qualified and extensive inquiry into the health aspects of employment in ore dressing. For a strictly scientific account of ore dressing methods in the Joplin district see a series of articles by James L. Bruce, general manager, Continental Zinc Co., Engineering and Mining Journal, February–March, 1912. Mr. Bruce directs attention to the fact that the ore mills are poorly housed; that the winter season is short, with only a few extremely cold snaps, and that consequently little consideration is given to the adequate protection of the machinery, which, of course, applies also to the inadequacy of the protection for the men. How far defective methods of mill construction affect the exposure of the employees to health-injurious conditions in the four fundamental operations of crushing, coarse concentration, fine concentration, and the disposition of waste has not as yet been determined.

TABLE 129.—PROPORTIONATE MORTALITY FROM PULMONARY TUBERCULOSIS IN SPECIFIED COUNTIES OF MISSOURI DURING 1913.

| County. | Population (1910). | Total number of deaths. | Deaths from pulmonary tuberculosis. | | |
|---|---|---|---|---|---|
| | | | Number. | Per 100,000 population. | Per cent of total deaths. |
| Jasper (including Webb City and Joplin) | 89,673 | 1,324 | 206 | 229.7 | 15.5 |
| St. Francois | 35,783 | 518 | 68 | 190.0 | 13.1 |
| Greene (including Springfield) | 63,831 | 847 | 63 | 99.2 | 7.4 |
| Jackson (including Kansas City) | 283,522 | 4,487 | 396 | 139.6 | 8.8 |
| St. Louis (city) | 687,029 | 10,972 | 987 | 143.6 | 9.1 |
| Buchanan (including St. Joseph) | 92,920 | 1,364 | 108 | 116.2 | 7.9 |

Table 129, derived from the report of the Bureau of Mines, is amplified by more extended data for the lead and zinc producing counties of Missouri, for the five years of 1911–1915. To make the data as complete as possible the eastern section is also included.

TABLE 130.—MORTALITY FROM PULMONARY TUBERCULOSIS AND NONTUBERCULOUS RESPIRATORY DISEASES IN THE LEAD AND ZINC PRODUCING COUNTIES OF MISSOURI, 1911 TO 1915.

*Eastern section.*

| County. | Production in tons. | Pulmonary tuberculosis. | | Respiratory diseases. | |
|---|---|---|---|---|---|
| | | Deaths. | Rate per 100,000 population. | Deaths. | Rate per 100,000 population. |
| Franklin | 116 | 136 | 91.7 | 171 | 115.3 |
| Jefferson | 3,363 | 177 | 123.9 | 167 | 116.9 |
| Madison | 86,933 | 97 | 165.9 | 65 | 111.2 |
| St. Francois | 1,246,374 | 290 | 146.7 | 312 | 157.8 |
| Washington | 17,284 | 102 | 154.7 | 96 | 145.6 |
| Total | 1,354,070 | 802 | 130.8 | 811 | 132.2 |

*Western section.*

| | | | | | |
|---|---|---|---|---|---|
| Creen | 6,870 | 402 | 119.2 | 541 | 160.4 |
| Rural | | 115 | 78.0 | 173 | 117.3 |
| Springfield | | 287 | 151.3 | 368 | 193.9 |
| Jaspar | 1,188,091 | 984 | 215.1 | 682 | 149.1 |
| Rural | | 390 | 170.3 | 312 | 136.2 |
| Joplin | | 387 | 237.0 | 269 | 164.7 |
| Webb City | | 207 | 317.6 | 101 | 154.9 |
| Lawrence | 7,825 | 161 | 126.4 | 196 | 153.9 |
| Newton | 47,605 | 169 | 124.4 | 183 | 134.7 |
| Ozark | 1,694 | 61 | 102.7 | 30 | 50.5 |
| Total | 1,252,085 | 1,777 | 159.0 | 1,632 | 146.1 |

*Total mining area and remainder of State.*

| | | | | | |
|---|---|---|---|---|---|
| Mining area | 2,606,155 | 2,579 | 149.0 | 2,443 | 141.2 |
| Balance of State | 185 | 19,470 | 129.4 | 21,924 | 145.7 |

According to this table, the general death rate from pulmonary tuberculosis in the mining sections of Missouri, as regards lead and zinc ores, was 149.0 per 100,000 of population during the five-year period under review. For the eastern counties considered as a group the rate was 130.8 against 159.0 for the western counties. The mortality from nontuberculous respiratory diseases was also definitely higher in the western counties, or 146.1 against 132.2 for the eastern counties; but in the remainder of the State the rate for this group of diseases was somewhat higher, or 145.7.

Considered by individual counties, however, it is shown that in St. Francois County, which is the chief center of production, the mortality from pulmonary tuberculosis was above the average for the eastern counties. The rate for pulmonary tuberculosis was 146.7 and for nontuberculous respiratory diseases 157.8. There can be no question of doubt, therefore, that the mining industries of this county are primarily responsible for this excess in the mortality from both tuberculosis and the nontuberculous respiratory diseases in St. Francois County.

In the western mining area the pulmonary tuberculosis death rate was highest in Webb City, or 317.6 per 100,000 of population. It was next highest in Joplin City, or 237.0 In the rural portion of Jaspar County the rate was only 170.3. How far the excessive rates for Joplin and Webb City are the result of local hospital admissions and the nonassignment of deaths to the original place of residence can not be stated. For Jaspar County as a whole the rate was 215.1, a rate not reached by any other county in the mining area. Of special importance is the relatively low rate of 124.4 for Newton County, although this area is a considerable center of production.

The nontuberculous respiratory diseases prevail also to an excessive degree in Joplin and Webb City, or respectively, 164.7 and 154.9 per 100,000 of population, against an average of 146.1 for the western mining area as a whole. The highest rate prevailed in Springfield, Green County, although this particular section is not a center of production. The tuberculosis death rate of Springfield, however, was slightly below the average for the western area, or 151.3, while for Green County as a whole the rate was only 119.2.

Assuming that the rate for the nonmining areas of the State may be considered as a fairly trustworthy index of normal conditions, it is suggestive that out of the 10 counties in the zinc and lead mining areas only 4 should show rates distinctly and even decidedly above this average. This would suggest that the pulmonary tuberculosis problem in its relation to lead and zinc mining is very much localized and that therefore thoroughly specialized investigations should prove productive of good results. The same conclusion applies to the mortality from nontuberculous respiratory diseases, for which the rate was above the average for the nonmining areas in only 4 out of the 10 counties. There is no well-defined correlation, however, between a definite degree of excessive incidence of pulmonary tuberculosis and a correspondingly high mortality from nontuberculous respiratory diseases in the zinc and lead producing counties of Missouri.

The preceding data suggest the practical value of further and more strictly scientific investigations into the problem of miners' phthisis in the zinc and lead producing counties, not only of southwestern Missouri, but also in the eastern mining area. The investigation should include a careful inquiry into the mechanical and chemical properties of the zinc and lead areas of the different mining areas, which should not be difficult in view of the excellent reports which have been made on the geology of the lead and zinc producing counties by the United States Geological Survey. The investigation by the Bureau of Mines while limited in plan and scope is a useful indication of research work into a much neglected aspect of the mining industry in this country.

Preliminary to the investigation in southwestern Missouri a physical examination was made of miners. Only 93 were examined, but of this number 64 showed plain and definite evidence of pulmonary disease. Of the 64 sick employees 22 had stopped work on account of their health, the remaining 42 being still at work underground. Of the 64, 39 had the classical symptoms of pulmonary tuberculosis, including night sweats, cough, hemorrhage, loss of weight, and fever. With reference to the results of the examination it is said that "the figures can not be considered as showing the percentage of tuberculosis among miners generally in the county, as those who applied for examinations probably had symptoms which made them suspect they had the disease." There is no doubt some force in this conclusion, and a much larger number of physical examinations would be required for a final determination as regards the true incidence of the disease among the lead and zinc miners of southwestern Missouri. Such an investigation should be made with a due regard to age, length of mine employment, work actually performed, and some additional observations regarding possible previous employment in other mining regions. A. J. Lanza, M. D., in a subsequent report on miners' consumption in southwestern Missouri, in the journal of the Missouri State Medical Association, St. Louis, 1916, is briefly reported as having presented the results of a series of physical examinations of 720 miners, of whom 433, or 60.1 per cent, exhibited definite signs of lung injury, and of this number 103 had also ascertainable tubercle bacilli in their sputum. The most prominent symptom observed was dyspnea on exertion, or, in other words, shortness of breath. It is said in continuation of the statement referred to, that—

A summary of the symptoms and the physical signs gives us three distinguishing features of miners' consumption. First, a gradually increasing dyspnea, with pain in the chest and diminished expansion; second, an absence of physical signs, or an absence of apparently adequate physical signs; third, the appearance of good health. While the sputum may serve to clear up the diagnosis occasionally, it is on a knowledge of the patient's occupation that the diagnosis largely depends. The disproportion between symptoms and signs distinguishes between miners' consumption and tuberculosis; the degree of dyspnea observed in the former would in tuberculosis be compatible only with far-advanced cases with ample physical signs. Even where a tuberculous infection is grafted on a silicosis, the resulting clinical picture may not, and often does not, resemble ordinary tuberculosis.

The conclusion may, therefore, be advanced that underground employment in the zinc and lead mines of southwestern Missouri unquestionably predisposes in a most serious manner to pulmonary tuberculosis; but the question may be raised whether in the investigations referred to the true form of miners' phthisis or nontuberculous fibroid lung disease was precisely differentiated from the true form of pulmonary tuberculosis, since even in the cases referred to, out of 433 miners showing definite signs of lung injury, only 103, or 23.8 per cent, were found to present definite bacillary evidence of the disease. The reports thus far published are, however, inconclusive on this point.

Special consideration was given to temperature and humidity and to causes of dust production, chiefly, apparently attributed to the so-called blowing of dry holes, the dust caused by "squibbing" and bowlder popping, by drilling, shoveling, and other operations. Most of the dust was naturally found at the working faces, and only a relatively small number of men were found to be exposed to the most dusty atmospheric conditions. The report is a promising indication of future research work in a most important direction. Fairly extensive scientific tests were made of the nature of the dust inhaled, and the quantitative conditions of exposure, the results of the entire investigation being summed up in the following conclusions:

1. The death rate from pulmonary diseases is unusually high among the miners of the Joplin district.

2. Poor housing, exposure, alcoholism, the use of common drinking receptacles, and overwork all tend to spread infection and lessen the power of the miner to resist disease, but the prime factor in causing pulmonary trouble is the rock dust in the mines.

3. Rock dust in the sheet-ground mines, although not made in great quantity as compared to mines with more restricted working places, is harmful to the miner for two reasons: (*a*) Because he is exposed to it practically during his entire shift, and (*b*) because the

dust is made up chiefly of particles of insoluble flinty chert with splintered and knifelike edges.

4. This rock dust is produced by the blowing of dry holes, squibbing, bowlder popping, drilling without water, shoveling, tramming, roof and pillar trimming, and the dumping of the bucket at the surface.

5. By observing certain precautions rock dust in the mines can be almost entirely abated.

6. There are certain abuses connected with the piece system of work that demand attention and correction as far as practicable.

On the basis of the foregoing conclusions the following recommendations were presented, and it may be said that some of these have subsequently been carried into effect, either through the cooperation of mine owners and employees or through legislative enactment:

1. The following means should be employed for the abatement of rock dust in the mines:

(*a*) Provide a water supply for every working face by the laying of a separate water line.

(*b*) Where drills are operated without water, attach to the hose leading to the face a 5 or 6 foot length of pipe with a nozzle from one-eighth to one-fourth inch in diameter. Make and enforce such regulations as will insure the use of this water spray for the purpose of wetting drill holes, the face, and the broken rock about the face. For the purpose of washing drill cuttings from drill holes this hose may be attached to the long pipes now in use for blowing out drill holes.

(*c*) Where there is in use some type of drilling machine that provides for water passing through the core of the drill steel into the drill holes, make and enforce regulations that will insure the spraying of the face and broken rock for short periods at such times as the drill may not be in operation. For this purpose the water hose must be uncoupled from the drilling machine unless separate water connection is provided.

(*d*) Make and strictly enforce rules against squibbing and bowlder popping while the shift is underground and against the blowing of dry holes at all times.

(*e*) Improve ventilation by the opening of new shafts whenever practicable.

2. Do away with common drinking cups and kegs and water pipes which allow the miner to bring his lips in contact with the orifice. Substitute the well-known sanitary drinking fountain when practicable or have miners bring their own water supply in individual containers.

3. Do not employ as shovelers men under twenty years of age.

4. Through cooperation among the operators provide a maximum daily tonnage for shovelers, so that they can not injure their health through overwork.

5. Provide a warm, dry, and clean place in which the miners may change their clothes.

6. Through intensive educational campaigns in the public schools and among the miners themselves disseminate information as to the

harmful effects of insanitary practices and conditions, such as crowded living quarters, overwork, exposure, dissipation, the breathing of air polluted by powder fumes and rock dust, and the use of common drinking devices.

Thus far there has been no correspondingly extensive inquiry into the health conditions of other mining districts in this country; but in course of time, no doubt, such investigations will be made through the cooperation of the Bureau of Mines, the United States Public Health Service, and local mining and health authorities.

Aside from the foregoing observations of methods and means of dust prevention, it seems appropriate to include a brief but exceptionally instructive article on a new method of dust arresting during drilling and boring, from the Coal Age for September 26, 1914:

Much attention is being paid at present to the avoidance of free or floating dust during drilling or boring in stone, coal, or other materials. One method of attacking this problem is by directing a spray of water onto the part where drilling is in progress, but this is not always possible, unless a supply of water is easily available.

An alternative arrangement which has been introduced by Holman Bros., of Camborne, England, under the patents of M. T. Taylor, consists of providing the drilling or boring machine with a means of arresting and collecting the dust so that it can not permeate the air.

The boring tool is provided with a cup or receptacle slipped over the shank and having a soft-edged mouth, which accommodates itself to the rock surface when pressed against it. The soft edging at the mouth of the receptacle is secured by a sponge collar or gasket. At the lower part of the receiver a nozzle is arranged, from which the dust is led away through a hose into bags or a water trough. A gland closed at the lower end by a rubber washer fits around the drill. The machine when it commences to bore compresses a spiral spring, which butts against the cup receiver and forces it against the rock surface and the dust on coming out of the hole, being unable to make its escape because of the soft edging, passes away through the dust-collecting duct into the receptacle provided.

The whole arrangement is extremely simple, and easily applied. Its simplicity of application is a strong point in its favor, inasmuch as the average miner is prone to give but little attention to his physical condition if such attention involves any extra trouble in the operation of his equipment. It is to be hoped that with the introduction of dust-allaying devices, miners' phthisis, of which so much has been heard in recent years, will be done away with, or at least effectively curbed.

It may also be said in this connection that a comparatively simple and inexpensive method of dust control has been devised by Mr. Thomas E. Mitchell, and an illustration of the method as employed in the Leonard mine, of Butte, Mont., is given in the monthly bulletin of the American Museum of Safety for March, 1914. The dust, according to this method, is accumulated in a canvas bag, and, with reasonable efficiency, is prevented from contaminating the atmosphere in otherwise exceptionally dusty stopes, to the material advantage of the workmen. All such methods, of course, must as yet be considered tentative, and the practical solution of the question of dust control in underground mines remains a problem for the future.[1]

### COPPER MINING.

In copper mining the health-injurious conditions, with special reference to pulmonary tuberculosis and nontuberculous respiratory diseases, are much the same as in gold and silver mining. The copper content of the ore represents but a small fraction of the rock extracted, and, as far as known, the metal itself is not, in the condition as mined, injurious to health. The number of men employed in copper mining in 1914, according to the report of the Bureau of Mines, was 44,686, the chief centers of production being in Arizona, Michigan, and Montana. In Utah and Nevada most of the copper mined is obtained by other than underground mining methods, chiefly in the form of stripping, which, of course, involves a much lesser degree of dust exposure. For this reason the comparative mortality of copper miners from pulmonary tuberculosis and nontuberculous lung diseases, varies quite considerably in the two States of Utah and Montana. In the latter State most of the copper ore is derived from very deep mines, where the sanitary problem is frequently seriously complicated by exceptional conditions of temperature and humidity. No thorough investigation has thus far been made into the health and mortality of copper miners in this country, but it is practically certain that at least a preliminary inquiry will be made in this direction by the United States Bureau of Mines in the near future.[2] The only available statistics are with reference to the mortality of miners in the Butte district of Montana, obtained by means of a special analysis of 1,614 death certificates recorded in the city of Butte during the period 1907 to 1914. The results of this analysis, first exhibited by The Prudential Insurance Co. of America on the occasion of the Fifteenth International Congress on Hygiene and Demography, but brought down to date for the present purpose, are shown in Table 131.

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[1] Of practical value in this connection is a recent publication of the Bureau of Mines on the dust problem in the iron and steel industry, with illustrations of methods of dust analysis, etc. See Technical Paper 153, entitled "Occurrence and Mitigation of Injurious Dusts in Steel Works," by J. A. Watkins; Washington, 1917.

[2] In this connection the "Yearbook of the Bureau of Mines" for 1916 gives information as follows:

In May, 1916, the Bureau of Mines, in cooperation with the Public Health Service, undertook, in the mines of Butte, Mont., an investigation into health hazards, particularly silicosis. It was thought that the investigation would closely parallel that carried into effect in the Joplin region, but as the investigation has developed its scope has necessarily widened, and it is probable that before definite conclusions can be reached careful study must be made not only of dust conditions and of methods of allaying the dust, but also of problems of ventilation, heat, humidity, etc., which appear to have a direct bearing on health conditions in general as well as on silicosis. There are approximately 40 large mines in Butte, many of which have men working to depths as great as 3,300 feet, and there are approximately 15,000 miners in the district. Progress reports are being made from time to time, and a final report will be made on completion of the investigation.

TABLE 131.—MORTALITY FROM RESPIRATORY DISEASES AND FROM ALL CAUSES AMONG COPPER MINERS OF MONTANA, 1907 TO 1914, BY AGE GROUPS.

[Data are based on an original office investigation, including a transcript of all death certificates indicating deaths of miners in Butte, Mont., through the cooperation of the local board of health.]

| Age at death. | Deaths from— | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Tuberculosis of lungs. | | Pneumonia. | | Other respiratory diseases. | | All respiratory diseases. | | All causes. | |
| | Number. | Per cent of deaths from all causes. | Number. | Per cent of deaths from all causes. | Number. | Per cent of deaths from all causes. | Number. | Per cent of deaths from all causes. | Number. | Per cent of deaths from all causes. |
| 15 to 24 years | 9 | 8.0 | 9 | 8.0 | 1 | 0.9 | 19 | 17.0 | 112 | 100.0 |
| 25 to 44 years | 323 | 38.6 | 126 | 15.1 | 42 | 5.0 | 491 | 58.8 | 836 | 100.0 |
| 45 to 64 years | 260 | 46.7 | 86 | 15.4 | 61 | 11.0 | 407 | 73.1 | 557 | 100.0 |
| 65 years and over | 18 | 17.3 | 13 | 12.5 | 25 | 24.0 | 56 | 53.8 | 104 | 100.0 |
| Age unknown | 1 | 20.0 | 1 | 20.0 | | | 2 | 40.0 | 5 | 100.0 |
| Total, 15 years and over | 611 | 37.9 | 235 | 14.6 | 129 | 8.0 | 975 | 60.4 | 1,614 | 100.0 |

It is shown by this analysis that the proportion of deaths from pulmonary tuberculosis among the copper miners of Butte, Mont., is decidedly excessive.[1] It is of special significance that the proportionate mortality from this disease should be highest at ages 45 to 64. The data suggest that in all probability deaths are reported as due to pulmonary tuberculosis which, in fact, are more properly attributable to nontuberculous so-called miners' phthisis, or true silicosis. The proportionate mortality from pulmonary tuberculosis among the copper miners of Butte, Mont., increases very rapidly from 8 per cent at ages 15 to 24, to 38.6 per cent at ages 25 to 44, and to 46.7 per cent at ages 45 to 64. Even at ages 65 and over the proportion is as high as 17.3 per cent. In addition to the mortality attributed to pulmonary tuberculosis, the mortality from pneumonia is exceptionally high. The proportion of deaths from this cause increases from 8 per cent at ages 15 to 24 to 15.1 per cent at ages 25 to

[1] An analysis of the general mortality of Silver Bow County, Mont., for the period 1911–1915, showed the following results:

For the city of Butte the death rate from pulmonary tuberculosis was 215.8 per 100,000 of population and from nontuberculous respiratory diseases 242.0. The facts were almost precisely the opposite for Silver Bow County, exclusive of the city of Butte (that is, only the rural portion), in which the death rate from pulmonary tuberculosis was 352.8 per 100,000 and from nontuberculous respiratory diseases 202.0. For the county as a whole the pulmonary tuberculosis rate was 227.3 and the mortality from nontuberculous respiratory diseases was 229.6. For the remainder of the State of Montana the mortality rate from pulmonary tuberculosis was only 75.4 and from nontuberculous respiratory diseases 112.4.

The data are, therefore, entirely conclusive that the mortality from both pulmonary tuberculosis and nontuberculous respiratory diseases is decidedly excessive in the city of Butte and in the surrounding territory comprising the remainder of Silver Bow County. The relation of this excess to the mining industry can not be questioned by anyone familiar with local industrial conditions.

44, remaining at about the same proportion, or 15.4 per cent, during the age period 45 to 64, and falling to 12.5 per cent at ages 65 and over. Aside, however, from pneumonia, there is an additional high proportionate mortality from other respiratory diseases, which reaches the maximum at ages 65 and over, or 24 per cent. Combining all forms of respiratory diseases, whether tuberculous or nontuberculous, it is shown by the table that at ages 15 to 24 the proportion of deaths from this group of causes in the mortality from all causes among the copper miners of the Butte district was 17 per cent, at ages 25 to 44 it was 58.8 per cent, increasing to a maximum of 73.1 per cent at ages 45 to 64, and attaining to 53.8 per cent at ages 65 and over. It seems, therefore, quite safe to conclude that this unusual condition is directly attributable to the exceptionally health-injurious nature of the dust inhaled during the underground mining operations in the Butte district, although with regard to pneumonia it should be said that climatic conditions, drinking habits, etc., have also an important bearing upon the question under consideration. The elevation of Butte, Mont., is 5,500 feet above sea level, and, as elsewhere observed, in localities at a high altitude the mortality from pneumonia is practically certain to be above the normal.[1] The question of altitude, however, is of quite secondary importance, for whenever the necessary sanitary improvements have been introduced into mining methods, housing, etc., and when the earlier conditions of riotous living have disappeared, the incidence of pneumonia will be substantially diminished. This has been the case throughout the western States, but especially in the mining camps of Butte, Mont., Leadville, Colo., and certain sections of Idaho and Nevada.

The problem is therefore more complicated than would appear to be the case upon preliminary consideration. No strictly scientific study has been made of the disease problem in connection with copper mining, but conditions in this respect are known to vary widely in the chief centers of copper production. Conclusions applicable to the copper-mining district of Butte would unquestionably be inapplicable in a measure to the copper-mining territory of northern Michigan. To a lesser extent differences in conditions are met with in the copper-mining States of Utah and Arizona.

The morbidity and mortality problems in copper mining obviously demand more qualified scientific consideration. The general mortality statistics may be more or less misleading on account of serious defects in death certification. Unfortunately, autopsies are very rare, and the clinical diagnosis of pulmonary tuberculosis is, as a general rule, not confirmed by the necessary bacteriological evidence. The

[1] See in this connection Professional Paper 74, United States Geological Survey, entitled "Geology and Ore Deposits of the Butte District, Montana," by Walter Harvey Weed; Washington, 1912.

problem of nontuberculous respiratory diseases in the mining districts is, in all probability, of equal if not even more serious importance than true pulmonary tuberculosis. The relative frequency of pneumonia and other nontuberculous respiratory diseases in the Butte mining district suggests strongly a definite connection between unusual employment conditions and a rapidly fatal form of acute infectious respiratory diseases. Maynard, in his work on "The Manifestations and Prevention of Pneumonia among the Natives on the Rand, Recorded from Tropical Areas," shows conclusively that most of the morbidity occurs during the first few weeks, and even days, after arrival. A somewhat similar experience has been had on the Isthmus of Panama, though, of course, without reference to mining. Gorgas, in his recommendations as to sanitation concerning employees of the mines on the Rand, made to the Transvaal Chamber of Mines, points out in this connection that pneumonia varies greatly in the different mines and among different classes of natives, and in accordance with other circumstances which do not admit of being discussed in detail on this occasion. Pneumonia, he observes, "is a disease in man due to infection by a particular organism—the pneumococcus. Individuals and races differ widely in the degree in which this organism affects them. The liability is most serious in the case of native races not previously exposed to the pneumococcus, and even slight colds, sore throat, etc., may be followed by fatal results." The bearing of these observations upon the problem of miners' phthisis and pulmonary tuberculosis is obvious. In other words, the mortality of miners may be, and occasionally is, materially increased by special conditions, chiefly such as result from exposure to other than infectious diseases, aside, however, from fatal accidents, which tend to disturb materially the proportionate mortality from specified causes.

The occurrence of chronic interstitial pneumonia, introduced by stone dust, has been discussed in a contribution to the Journal of the American Medical Association, under date of June 13, 1900, by Dr. William Winthrop Betts, of Salt Lake City, based apparently on extended metal-mining experience in Nevada and Utah. After describing a number of cases in detail Dr. Betts gives some important facts regarding the rapidly fatal course of the disease among men employed for even a comparatively short time in the mills of the mining companies at De Lamar, Nev. He observes that "almost every town in Nevada and southern Utah has had its victim, for it is a fact that neither the company nor the men realized their danger until the deaths began to occur." The conclusion in this case was based upon a number of autopsies and a chemical and microscopical analysis of the tissues of the lungs and bronchial glands. The chemical examination of the lungs indicated the presence of pure silica to the amount of 2.8 per cent in the lung tissue and 3.8 per cent in the glands. Betts therefore advanced the conclusion that "the cases were more properly regarded as chronic interstitial pneumonia, which consists in the gradual substitution, to a greater or less extent, of connective tissue for normal lung"; and he concludes, further, that "The different conditions under which these changes occur are so varied that a proper classification is difficult, but the interstitial changes play a very important rôle in all chronic lung troubles. There is no sharp line of demarcation between fibrous phthisis and other forms of chronic pulmonary phthisis, and there are instances of fibrous phthisis which can not be distinguished from cirrhosis of the lung from other causes." Summarizing his conclusions, he states that, in the light of the clinical history of the cases under observation, and the results of autopsy examinations, including microscopical and chemical analyses, he has no hesitancy "in speaking of them as chalicosis pulmonum, or chronic interstitial pneumonia." The paper is an exceptionally valuable one, and the observations are amplified by a long list of individual cases of men who had died subsequently to their employment with continuous exposure to irritating dust, at an average age of only 30 years, although the average height was 5 feet 8½ inches and the average weight 170 pounds, which would suggest otherwise exceptionally favorable physical conditions. The average working time previous to the onset of the disease was only 14 months, and the average intervening period between the termination of work and death was only 10 months, or an aggregate exposure to conditions exceptionally injurious to health of only two years. (See also, p. 430 et seq.)

## IRON MINING.

The iron-ore mining industry is of enormous extent throughout the United States, but it is chiefly concentrated in the four States of Minnesota, Michigan, Wisconsin, and Alabama. Of the aggregate output during 1915 the proportion of ore mined in these three States was 93 per cent. Iron minerals are differentiated by the United States Geological Survey as sulphides, oxides, carbonates, silicates, etc., of which only the oxides and the carbonates are used in the iron and steel industry, except a relatively small quantity of by-product from sulphide ores used in acid manufacture. It is explained that the ores of iron are generally classified as follows:

1. Hematite (locally known as red hematite), specular ore, gray ore, etc.
2. Brown ore, locally known as brown hematite, bog ore, limonite, etc.
3. Magnetite, generally known as magnetic iron ore.
4. Iron carbonate, locally known as spathic iron ore, siderite, etc.

Of these four varieties hematite ore constituted 94 per cent of the American output for 1915, or precisely 52,227,324 tons out of a total quantity of 55,526,490 tons. Brown ore constituted only 2.7 per cent of the total, or 1,488,709 tons; and magnetite 1,807,002 tons, or 3.3 per cent. The carbonate product is very small, amounting to only 3,455 tons in 1915. Most of the hematite ore—46,944,254 tons out of a total of 52,227,324 tons—is mined in the Lake Superior district. Most of the brown ore is mined in the Appalachian States and most of the magnetite ore in the Adirondack district of the State of New York.[1]

The methods of mining vary according to the nature of the ore mined, geological formations, and other conditions, but the major portion of the product is obtained by open-pit mining, although underground iron mining involving all the usual underground processes is not at all rare. In open-pit mining the dust exposure is obviously much less than in underground mining, so that for this reason alone the health of iron miners should, in a general way, be less seriously affected by the occupation than that of gold, silver, copper, lead, zinc, and other miners, who are chiefly and almost exclusively employed underground. The number of iron miners in the United States is returned by the Bureau of Mines for the year 1914 as 44,807, of whom 24,847, or 55.5 per cent, work underground, which compares with 73.1 per cent for gold, silver, and miscellaneous metal mines, and 70 per cent for copper mines. The fatality rate in iron mining in 1914 was relatively high, or 3.3 per thousand, which compares with 3.7 for gold and miscellaneous metal mines, and 3.69 for copper mines. No qualified investigation has been made into the health and mortality of iron miners considered separate and distinct from the mining industry in general, and on account of the extensive development of open-pit mining methods in the United States the conclusions of Arlidge and others, based largely upon underground iron mining in England and on the Continent, are of doubtful applicability to American conditions. Iron ores in England are called ironstone, and the ore is mined from considerable depths, while in the United States iron ore, particularly the red hematite, is mined more largely from shallow excavations in the nature of open quarries than by mining methods properly so called. It is therefore regrettable that there should be no conclusive vital statistics of iron miners for this country, although a sufficiently extensive experience has been had in the principal mining districts which, if subjected to qualified analysis, should prove useful for the purpose. The Port Henry iron mines in the State of New York, for illustration, have been in operation since 1849, but thus far no

[1] See New York State Museum Bulletin 119 (Education Department Bulletin 423, Albany, N. Y., April, 1908), entitled "Geology of the Adirondack Magnetic Iron Ores," by David H. Newland.

qualified medical inquiry has been made with regard to the relation of iron mining in this country to health and longevity. There are, however, no reasons for believing that the metallic content of iron ore has an important bearing upon the health aspects of the industry, since the relative frequency of fibroid phthisis and true pulmonary tuberculosis are more directly determined by the nature of the ore mined, which of course is chiefly composed of mineral matter and from which the metallic substances are extracted by subsequent processes of smelting and refining.

Subject to the foregoing considerations it has not seemed advisable to omit from this discussion the vital statistics of ironstone miners for England and Wales, which, however, do not require an extended analysis. Table 132 shows the mortality of ironstone miners in England and Wales (occupied only) for the three years, 1900 to 1902, by divisional periods of life, and Table 133 shows the mortality from other respiratory diseases, but without reference to age.

TABLE 132.—PROPORTIONATE MORTALITY OF IRONSTONE MINERS (OCCUPIED ONLY) FROM PULMONARY TUBERCULOSIS, 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. | Deaths from all causes. | Deaths from pulmonary tuberculosis. | |
|---|---|---|---|
| | | Number. | Per cent of deaths from all causes. |
| 15 to 24 years | 36 | 8 | 22.2 |
| 25 to 34 years | 70 | 16 | 22.9 |
| 35 to 44 years | 69 | 15 | 21.7 |
| 45 to 54 years | 105 | 17 | 16.2 |
| 55 to 64 years | 135 | 18 | 13.3 |
| 65 years and over | 148 | 3 | 2.0 |
| Total, 15 years and over | 563 | 77 | 13.7 |

TABLE 133.—PROPORTIONATE MORTALITY OF IRONSTONE MINERS FROM NONTUBERCULOUS RESPIRATORY DISEASES, ENGLAND AND WALES, 1900 TO 1902.

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

| Cause of death. | Deaths from nontuberculous respiratory diseases. | |
|---|---|---|
| | Number. | Per cent of deaths from all causes. |
| Bronchitis | 36 | 6.4 |
| Pneumonia | 43 | 7.6 |
| Other nontuberculous respiratory diseases | 20 | 3.6 |
| Total | 99 | 17.6 |
| Accidents | 81 | 14.4 |

According to Table 132, the proportionate mortality from pulmonary tuberculosis is relatively low among ironstone miners—13.7 per cent for all ages and 22.9 per cent for ages 25 to 34. The number of deaths under observation is, however, rather small for safe conclusions. As shown in Table 133, the mortality from nontuberculous respiratory diseases is 17.6 per cent, the proportion of deaths from bronchitis being 6.4 per cent, from pneumonia 7.6 per cent, and from other respiratory diseases 3.6 per cent. These proportions would be slightly modified by the inclusion of the retired, but it would serve no useful purpose to enlarge upon this aspect of the problem under consideration, since most of the comparative statistics in the present discussion have reference only to the occupied, or, in other words, the mortality considered represents the occupations at death, and, broadly speaking, as a rule, excludes the mortality of men previously occupied in given occupations, or subsequently occupied in less harmful occupations, or retired on account of invalidity or old age.

The relatively high mortality from nontuberculous respiratory diseases suggests the inclusion of Table 134, showing the mortality of ironstone miners from bronchitis, pneumonia, and other respiratory diseases in detail by divisional periods of life.

TABLE 134.—PROPORTIONATE MORTALITY OF IRONSTONE MINERS (OCCUPIED ONLY) FROM NONTUBERCULOUS RESPIRATORY DISEASES, 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. | Deaths from all causes. | Deaths caused by nontuberculous respiratory diseases. | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Bronchitis. | | Pneumonia. | | Other. | | Total. | |
| | | Number. | Per cent. | Number. | Per cent. | Number. | Per cent. | Number. | Per cent. |
| 15 to 24 years | 36 | | | 2 | 5.6 | | | 2 | 5.6 |
| 25 to 34 years | 70 | | | 5 | 7.1 | 4 | 5.7 | 9 | 12.9 |
| 35 to 44 years | 69 | 1 | 1.4 | 5 | 7.2 | 4 | 5.8 | 10 | 14.5 |
| 45 to 54 years | 105 | 9 | 8.6 | 17 | 16.2 | 5 | 4.8 | 31 | 29.5 |
| 55 to 64 years | 135 | 12 | 8.9 | 9 | 6.7 | 3 | 2.2 | 24 | 17.8 |
| 65 years and over | 148 | 14 | 9.5 | 5 | 3.4 | 4 | 2.7 | 23 | 15.5 |
| Total, 15 years and over | 563 | 36 | 6.4 | 43 | 7.6 | 20 | 3.6 | 99 | 17.6 |

The foregoing statistics are of special interest in comparison with the corresponding data for English coal miners, which are distinctly more favorable for pulmonary tuberculosis, but less favorable for nontuberculous respiratory diseases, particularly bronchitis. As brought out by the discussion of the mortality of coal miners, the proportion of deaths from bronchitis among them in the English experience was 9.5 per cent against 6.4 per cent for ironstone miners.

How far these observations and conclusions apply to the underground mining of the United States can not be determined at the present time. No insurance data are available, chiefly because of the fact that the operations of the industrial insurance companies in the principal iron-mining districts are of rather limited extent. There are also reasons for believing that many iron miners return themselves merely as "miners" in the statement relating to their occupation and that they are subsequently classified under the mining industry in general.

A small group of iron mines of rather limited production has been in operation for many years in New Jersey, and the results of an investigation by the New Jersey Bureau of Labor in 1890 with reference to trade life and occupational disability may briefly be referred to. The investigation included 1,269 miners of all ages, of whom 43.1 per cent had entered the employment at ages under 16 years. Of the 1,269 only 39, or 3 per cent, had attained to the age of 61 and over, and 79, or 6.2 per cent, were of the age period 51 to 60. The proportion of foreign born was 60.4 per cent, but it is practically certain that at the present time this proportion is larger. The average number of years at work was 16.0, varying, of course, according to the ages attained. At ages 61 and over the average previous duration of mine employment was 42.8 years. But conclusions based upon such data require for practical purposes to be utilized with extreme caution, in that a number of factors enter into the calculation which can not be adequately explained with the required brevity. It is much the same problem in trade life as in life generally, that the average age at death is not the mathematical equivalent of the average age of the living, on the one hand, nor of the expectation of life on the other. The effects of the employment on health are indicated by the proportion of those beginning to decline in physical strength, which for the present purpose may be considered the equivalent of physical good health. The proportion at ages under 26 beginning to decline was 1.1 per cent, increasing with age, as follows: At ages 26 to 30 the proportion beginning to decline was 1.5 per cent; at ages 31 to 40 it was 2.3 per cent; at ages 45 to 50 it was 3.4 per cent; at ages 51 to 60 it was 48.1 per cent; and at ages 61 and over it was 74.4 per cent. At the younger ages, that is, under 50, the numbers beginning to decline were relatively so small as not to justify any very definite conclusions, but the data apparently sustain the point of view that no materially health-injurious results were experienced below the ages of 51. Above this age, of course, other factors and conditions would materially affect general health and physical strength, so that the proportion beginning to decline is not in its entirety chargeable against the industry of the entire number considered, 1,269, the number beginning to decline being 90, or 7.1 per cent. The average duration of work previous to decline was 21.8 years. The New Jersey investigation with reference to the average duration of trade life and the ascertained period of physical decline strongly suggests the practical possibility of further research in this much neglected direction. The data indicate in a general way that iron mining in the State of New Jersey was not seriously injurious to health or the obvious cause of an early impairment in physical strength and ability to work.

The health conditions of American iron miners were investigated by the United States Immigration Commission, and reported upon in a general survey of the iron-ore mining industry, chiefly with reference to the States of Minnesota, Michigan, and Alabama. The working conditions were inquired into with reference to mining methods and class of labor employed in the several systems of mining on the Mesabi Range, the hours worked per day, the regularity of employment, wage payment, mining accidents, hospital and medical service, company accident insurance, etc. The ores on the Vermillion Range, which are all of the hematite class, are in all instances very hard, and "underground mining is necessary to remove the ore, which lies often at a great depth below the surface, some of the shafts having been pushed over a thousand feet underground." Two systems of underground mining are employed, known technically as the "overhand stoping" and the "caving" methods, which can not be conveniently explained with the required brevity. The differences in underground mining methods are of more direct importance, however, with reference to accident liability than to health and mortality. It is pointed out in the report referred to that "the ore is so hard at places that percussion drilling has been displaced by the introduction of diamond drills for use in making blast borings." In marked contrast to the conditions on the Vermillion Range the open-pit method of mining prevails extensively on the Mesabi Range. The open-pit system, or mining by steam shovels in open-surface cuts, consists, as explained in the report, "in removing the glacial drift or 'overburden' which covers the ore beds, varying from a few feet to about 80 feet in thickness, by the use of steam shovels and then securing the iron ore by the same methods." Quoting from a special monograph on the Mesabi Range by the United States Geological Survey, it is said further, with reference to mining methods, that—

When the surface of the ore or a part of it is stripped, standard-gauge railroad tracks are built out on the ore deposit and steam shovels make a cut through the ore. In this first cut the ore is either thrown to one side or is loaded on cars brought on a paralleled track. After the first cut the shovel is set over against the bank and another slice is taken off and loaded onto the cars run into the cut already made. When by a series of slices or cuts the bank or bench or level is carried back far enough, work is begun as before on a lower level, and in time this is followed by cuts on third and fourth levels, carving the deposit into a series of banks or terraces at several levels, against any or all of which steam shovels may work, giving access to a great variety of ores and making possible a large output in a short time.

These extracts are sufficient for the purpose of emphasizing the practical difficulties of averaging iron-mining conditions so as to make general vital statistics concerning iron miners useful for scientific purposes. It is self-evident that conclusions based upon iron miners, so called, working largely above ground and employed chiefly in open-cut blasting operations or the management of steam shovels, etc., can not be made to apply to miners working continuously underground with an exposure of dust and other conditions quite similar to underground mining methods in the extraction of gold, silver, copper, lead, and other ores. The so-called "milling" process as practiced on the Mesabi Range may here be referred to, the same being explained in the report of the Immigration Commission to consist "in the sinking of a shaft on the edge of the ore body from which a tunnel is run in under the ore and connected with a vertical, funnel-shaped hole from under the surface, through which the ore is 'milled' down into the tramcars placed under the opening under the tunnel. After being loaded at the bottom of the funnel-shaped hole, the cars are run out to the bottom of the shaft, where the ore is dumped into skids or elevators and raised to the surface and unloaded into the tipple, where it is loaded into the cars ready for shipment." It is properly pointed out that the so-called "milling" process employs some of the features of both the open-pit and underground methods of mining. For these and many other reasons it is self-evident that general statistics concerning iron mining are quite likely to be inconclusive and possibly seriously misleading.

Aside from the foregoing the problem is seriously complicated by the extensive employment of foreign labor in the iron-mining industries of the Lake Superior districts and of Negro labor in iron mining in Alabama. Within recent years, according to the report of the Immigration Commission, a considerable displacement has occurred in the quality of labor employed in iron mining, the displacement being referred to as "progressive," in that one race or group of races has entered the region and taken up the work offered in the lower occupations, the race or races already holding such positions having moved up in the scale of occupation leaving the field to the newcomers. This statement is quite suggestive in that it indicates a comparatively short average trade life or trade exposure, quite at variance with the relatively long average ascertained for the iron mines of New Jersey. It is said in the report of the Immigration Commission that—

The Scandinavians and the other northern European races have given way to the Finns and Slovenians, and in the open-pit mines the Finns and Slovenians have given way to the south Italian, Montenegrins, Croatins, and other southern European races. In the underground mines the common labor and mining is chiefly done by Finns and Slovenians because the races from the southern countries can not stand the heavy physical work required in this kind of mining. Here, too, is found the same upward movement, for formerly the English (Cornishmen) and Scandinavians were in the lower occupations in the underground properties. At present the south Italians, Serbians, Montenegrins, and Croatians are performing the most menial work and are the races who are now at the foot of the scale of occupations. It is a matter of conjecture on the ranges as to who will push these races up or whether they will remain the common laborers of the region.

Inquiry was made into the prevalence of diseases on the ranges, but more with reference to outside sanitary conditions than to occupational exposure. The most common diseases on the ranges, however, were ascertained to be pulmonary tuberculosis and typhoid fever, and to a lesser extent smallpox and venereal diseases. With regard to pulmonary tuberculosis it is said that the disease is most prevalent among the Finns and the Swedes, and is chiefly imported. There is no reference to a possible connection between disease occurrence and occupational conditions, above or below ground, but there is no evidence that this aspect of the iron-mining industry was made the subject of a special investigation.

### COAL MINING.

The coal-mining industry of the United States during 1914 gave employment to about 763,000 persons, chiefly in the States of Pennsylvania, West Virginia, Ohio, and Illinois. The fatality rate in American coal mining is relatively high, or 3.22 per 1,000 employed for the year 1914, which, however, was below the average for the preceding decade. Largely in consequence of the persistent efforts of the United States Bureau of Mines, in cooperation with State mine inspectors, mine owners, and mine employees, a gradual improvement has been brought about in the conditions affecting both the calamity hazard and the individual liability of miners to fatal accidents and serious injuries. Thus far, however, no extended consideration has been given to the sanitary aspects of the industry, with reference both to conditions underground and on the surface, including the hygiene of mining towns, which is often decidedly unsatisfactory. The fatality rates vary widely in the different mining fields, largely in consequence of variations in underground conditions, which also, though probably to a lesser degree, affect the health of employees.

Whether one form of coal dust is distinctly more injurious to health than another has not been accurately determined. The dust itself is frequently pure carbon, but there are many important exceptions where the dust is considerably intermixed with other mineral and even metallic impurities.

In coal mining a relatively large proportion of the employees are not engaged in mining operations proper, the term "miner" being generally limited, in accordance with State certificates, to men who drill holes and blow down the coal by explosives, and to the mine laborers who assist the miners in drilling the holes and loading the loose coal into mine cars. As stated in an article in the Coal Age (1915), of 96,991 men returned as employed in connection with the anthracite coal industry of Pennsylvania. 44,346 were returned as miners, and 33,973 as mine laborers. It has also been stated that there are nearly 100 different positions or specified employments in the coal-mining industry, with an exceedingly confusing terminology, including many occupations, such as carpenters, machinists, electricians, etc., which are identical with employments carried on above ground and without reference to the mining industry. Most of the coal, of course, is mined in the proper sense of the term, underground, but within recent years some coal stripping operations have been developed, which give employment to an increasing proportion of men. Primitive methods of mining by pick and shovel have largely been replaced by coal-cutting machinery, which has apparently resulted in an increase in the dust contamination of the atmosphere. The problem is further complicated by the exceptionally large proportion of foreign-born laborers usually without previous mining experience and frequently of an intellectual status materially below the average American standard. Conformity on the part of this class of labor to exacting sanitary requirements is naturally enforced with difficulty even in the best-managed mines. On account of the extensive use of coal-cutting machinery the technical requirements for underground work are apparently less at the present time than in former years, so that the term "miner," with special reference to coal, has lost much of its former restricted significance. The far-reaching improvements in labor conditions, however, the shorter hours, the higher wages, the better conditions of housing, etc., have gone far toward causing an improvement in general health and a reduction in the general mortality, although underground conditions have remained practically about the same. The increasing dust hazard as a cause of disastrous dust explosions has been recognized by conservative mine managers, and many effective improvements have resulted in consequence of attention to economic considerations without specific reference to sanitary necessities. Physical selection has unquestionably operated distinctly in favor of a low death rate since for self-evident reasons the physically impaired or otherwise weak or infirm could not be employed at arduous labor underground.[1] According to Dr. F. J. Butler, of Wilkes-Barre, who testified before the Anthracite Coal Commission of 1902, he had in many cases found on post-mortem that lungs affected by miners' asthma were so heavily charged with dust particles that they sank when immersed in water, while the healthy lungs, by way of contrast, he took occasion to point out, would float without difficulty. Dr. John O'Malley, of Scranton; Dr. F. P. Lenahan, of Wilkes-Barre; and Dr. R. H. Gibbons, of Scranton, presented evidence on the basis of extended experience in mining communities, to the effect that special diseases prevailing among coal miners were miners' asthma, catarrh, consumption, rheumatism, and anemia. Miners' asthma was attributed in part to the inhalation of powder smoke, coal dust, and vitiated air. According to Dr. O'Malley, the mucous membrane of the lungs becomes saturated with coal dust and acts as an irritant, causing muscular contraction of the lungs. On post-mortem the lungs were found to be as black as anthracite coal. Rheumatism was common and the pneumonia observed to exist in many cases was evidently a factor in diminishing disease resistance generally.

In a brief discussion of foreign vital statistics in the Journal of the American Medical Association for December 6, 1902, in commenting upon the very limited American data, it is pointed out that in a general way "the statistics are distinctly favorable to the miners." The editorial includes a quotation from Newsholme's Vital

[1] It may seriously be questioned whether the general assumption that coal miners are a physically selected class is strictly in conformity to the facts. There has been no extended scientific inquiry into the subject, and, as far as known, the only available data are those derived from the ordinary mortality experience of The Prudential Insurance Co. Whether even these data are entirely conclusive may be questioned, in view of the fact that they relate only to coal miners who have died, and not to the living population. The data, however, would seem to be strictly comparable with the corresponding information for printers, presented elsewhere in this discussion. The data in detail are given in the table below, and are indicative of the physical inferiority of insured coal miners at ages 35 to 64, inclusive, in the manner that the height or weight, and the relative weight, of this class is, without exception, below the average for all males:

*Coal Miners—Males.*

[Prudential Ordinary Experience, 1886 to 1915.]

| Age at entry. | Number. | Average height (inches). | All males. | Average weight (pounds). | All males. | Relative weight (pounds per inch). | All males. |
|---|---|---|---|---|---|---|---|
| 15 to 24 years | 97 | 67.8 | 68.1 | 146.7 | 144.7 | 2.16 | 2.12 |
| 25 to 34 years | 201 | 68.4 | 68.3 | 157.6 | 154.5 | 2.30 | 2.26 |
| 35 to 44 years | 240 | 67.5 | 68.1 | 155.1 | 160.2 | 2.30 | 2.35 |
| 45 to 54 years | 205 | 67.8 | 67.9 | 157.1 | 162.8 | 2.32 | 2.40 |
| 55 to 64 years | 31 | 67.0 | 67.8 | 151.4 | 162.7 | 2.26 | 2.40 |
| 65 years and over | 1 | 67.0 | 67.9 | 165.0 | 161.8 | 2.46 | 2.38 |
| Total | 775 | 67.8 | 68.1 | 155.1 | 156.6 | 2.29 | 2.30 |

Statistics to the effect that coal miners in Derby and Nottinghamshire stand high in the list as to expectation of life, being only surpassed by farmers, agricultural laborers, teachers, etc., but in Lancashire their status is quite different, and that the variations in the death rate are in all probability due to other causes than the employment. Attention is directed to the fact that one of the principal diseases among coal miners in the United Kingdom is bronchitis, while the corresponding frequency of phthisis is relatively slight. In conclusion it is said that, taking it altogether, the facts collected from all sources seem to indicate, what could hardly have been expected, that the occupation of coal mining was neither relatively nor absolutely unhealthy, as compared with other means of gaining a livelihood. It has its inconveniences and hardships, and is exposed to special dangers from accidents, but these can be minimized by proper care, appliances, and legal regulations. The special diseases to which miners are liable seem to be largely preventable, and greater care in changing from the equable atmosphere of the mine to the extremes of heat and cold outside would probably reduce the proportion of respiratory affections, such as asthma, etc., that are now claimed to be incident to the occupation. The official statistics of miners as a class include so large a number of different occupations that, as elsewhere shown with reference to community mortality data, the special facts of a particular group of exceptionally unhealthy employments may be obscured.[1]

Of the total number of men employed in American coal mines, 83.8 per cent work underground; of this proportion the actual number of men employed at the breast of the mine, where the dust hazard is serious, is about 73 per cent. Mining conditions, as said before, are subject to an unusual degree of variation, as to whether, for illustration, the mining is by hand or by machinery; as to whether the dust is anthracite or bituminous; as to the character of the underlying and overlying strata, etc. That pulmonary tuberculosis is relatively less common among coal miners than among metal miners admits of no question of doubt. The important differences are chiefly attributable to the mechanical and chemical properties of the dust inhaled. It has frequently been maintained that the dust in coal mines has germicidal properties antagonistic to the development of pulmonary tuberculosis, but the evidence at present available is not conclusive. In a letter to the Journal of the American Medical Association, December 16, 1905, Dr. M. C. Carr, of Duquoin, Ill., states that, on the basis of an experience of 25 years in one of the largest coal-mining towns in southern Illinois,

[1] For a descriptive account of the principal employments in coal mines see discussion of "Fatal Accidents in Coal Mining," by F. L. Hoffman, Bulletin No. 90, U. S. Bureau of Labor, Washington, 1910.

in his opinion "bituminous coal miners while actively engaged in their occupation are practically immune from tubercular infection."[1] For the purpose of ascertaining the consensus of qualified medical opinion on the subject, he sent out a letter to some 600 practicing physicians in the coal-mining towns of Illinois, Indiana, Ohio, Pennsylvania, and West Virginia, and out of some 200 replies received about 75 sustained the point of view that "during active service in his occupation the bituminous coal miner is immune (to tuberculosis), wholly or in part." The conclusion is obviously a very broad generalization, and merely referred to here as an indication of the superficial nature of most of the inquiries which have thus far been made with reference to an exceedingly important question in occupational hygiene. It is self-evident that as a general principle men would not be found to suffer from pulmonary tuberculosis while actively employed, for, as elsewhere shown in the case of a life insurance agent with eight years' experience, the disease had been contracted during prolonged previous experience in mining in England and the Transvaal. (See p. 345.) If the previous mining experience had been ignored, the conclusion apparently would have been sustained by the evidence that the disease had been contracted in the pursuit of one of the most healthy outdoor employments.

According to the general vital statistics for England and Wales the mortality from pulmonary tuberculosis in that country is distinctly less than in the United States, while the mortality from bronchitis in its various forms is seriously excessive.[2] These facts must be taken into account in interpreting such terms as miners' asthma and miners' bronchitis, which is frequently quite indistinguishable from ordinary bronchitis, although usually recognized without difficulty in the more advanced stages of the disease. Ogle, in an address before the Seventh International Congress of Hygiene (Vol. X, p. 22), placed on record his conclusions, resting upon perhaps the largest available amount of statistical evidence, that—

> Now that coal dust should be less injurious to the lungs than the dust of stone or metal is readily intelligible for, as Hirt has pointed out, the particles of coal when examined under the microscope are found to be, comparatively speaking, rounded off and free from

---

[1] A large amount of extremely valuable information on the technical aspects of coal mining in the State of Illinois has been made available through the coal-mining investigations of the State Geological Survey under a cooperative agreement between the Engineering Experiment Station of the University of Illinois and the United States Bureau of Mines. These investigations include, for illustration, a chemical study of Illinois coal (1916), a descriptive account of coal-mining practice in every mining district of the State, a general account of coal mining, and the different coal seams, etc.

[2] The essential facts of the comparative mortality from tuberculosis and nontuberculous respiratory diseases are concisely set forth in a series of charts presented by The Prudential Insurance Company of America to the Royal Sanitary Institute of Great Britain and to the Henry Phipps Institute of Philadelphia. Miniature reproductions of these charts are available on application to the company.

sharp points and angles such as characterize the flint dust in a china factory. This, however, clearly would only explain why coal miners are less subject to these diseases than workers in metal and stone, and not why they are scarcely more subject to them, taken together, than agricultural laborers, nor why their mortality from phthisis alone is very little above that of fishermen, who have been taken as the standard of comparison, because of their healthiness. The figures given in my table, supported as they are by the consentient evidence of all those who have personal experience of the diseases of miners, leaves no possible doubt that for some reason or other coal miners are much less liable to phthisis than most other workmen, and that, even as regards lung diseases generally, their liability is by no means so great as is usually supposed.

Louis, in a more recent contribution to Oliver's Dangerous Trades, has advanced similar conclusions, observing that "It may first of all be stated that mining is a distinctly healthy occupation." He remarks further that—

There are no doubt several circumstances that contribute to the general healthiness of the miner's occupation; in the first place, mining is hard work, and men whose constitutions are not tolerably sound, and whose physiques are not fully up to the average, will either select some less arduous occupation at the outset, or will find themselves, if they began life as miners, unable to continue at the work. On the other hand, the work, though arduous, requires steady, though only moderate exertion, and does not expose the worker to the abnormally violent strains, exerted through brief periods, that characterize some other occupations. Again, the hygienic conditions are, as far as the coal mine at least is concerned, far more favorable than in most other occupations. The miner works in a good atmosphere, ample ventilation being a prime necessity for insuring the safety of the coal miner, in an equable temperature, free from the extremes of heat and cold, he is not exposed to the inclemencies of the weather, and his working place is usually dry.

The foregoing observations, according to Louis, can not, however, be made to apply to metalliferous mines, where "the conditions of work are far less favorable in every respect," and where the mortality is therefore higher. He directs special attention to the so-called "kirving" or undercutting of the coal, as being particularly unhealthy in that the miner has to lie on his side on the floor of the coal seam, swinging his pick with a peculiar sideways stroke over his head, till he has cut out a narrow groove some 3 feet deep below the overhanging mass of coal. The health-injurious effects, however, are chiefly with reference to the causation of miners' nystagmus. This method of mining is rather uncommon in the United States where coal cutting by machinery is now the general practice. While in this position, Louis states, by way of further explanation, "the coal miner is bound to inhale a considerable amount of fine coal dust, which has an irritating effect upon the lungs," and he includes a brief analysis of the mortality of coal miners by causes, according to which 16.2 per cent of the deaths were from accidents, 10.7 per cent from phthisis, 12.4 per cent from bronchitis, and 10.9 per cent from pneumonia. As a method of relief he suggests the use of mechanical coal cutters, which, of course, as is well known, are used almost universally in the United States. By way of contrast Louis directs attention to the higher mortality of metal miners, including the men employed in the Cornish tin mines, the method of which is considered typical of metal-mining methods in Great Britain. Phthisis, he observes, is extremely fatal among this class of employees, and bronchitis is also excessively common. Of the mortality during 1890–1892, 5.8 per cent of the deaths were caused by accident, 29.9 per cent by phthisis, 13.5 per cent by bronchitis, 5.4 per cent by pneumonia, and 7.1 per cent by other diseases of the respiratory system.

### MORTALITY OF MINERS IN THE UNITED KINGDOM.

On account of its numerical importance in the United Kingdom, the official vital statistics of the mining industry for the three years. 1900–1902, are of exceptional value, although their application to American conditions is naturally more or less restricted. Out of an aggregate of 637,590 men employed in the mining industry, 609,402 were employed in coal mining, 16,765 in ironstone mining, and the remainder in the mining of copper, tin, and lead. The metalliferous mining industries are, therefore, of relatively small importance. The comparative death rates of the different branches of the mining industry, compared with those of occupied and retired males represented by 100 for each divisional period of life are shown in Table 135.

TABLE 135.—MORTALITY OF MINERS COMPARED WITH THAT OF OCCUPIED AND RETIRED MALES, GREAT BRITAIN AND IRELAND, 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.]

| | 15 and under 20 years. | 20 and under 25 years. | 25 and under 35 years. | 35 and under 45 years. | 45 and under 55 years. | 55 and under 65 years. | 65 years and over. |
|---|---|---|---|---|---|---|---|
| Occupied and retired males | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| Mining industry | 130 | 100 | 82 | 75 | 82 | 108 | 121 |
| Coal miner | 130 | 100 | 81 | 73 | 81 | 107 | 121 |
| Ironstone miner | 125 | 67 | 85 | 64 | 66 | 82 | 81 |
| Copper miner | 380 | .......... | 232 | 211 | 113 | 148 | 93 |
| Tin miner | 61 | 123 | 212 | 250 | 205 | 194 | 148 |
| Lead miner | 250 | 107 | 117 | 118 | 94 | 144 | 176 |

Supplementing these interesting statistics of the mortality from all causes, Table 136 exhibits the mortality from specified causes. Unfortunately the more important nontuberculous diseases of the respiratory system are not specifically returned.

TABLE 136.—MORTALITY OF MINERS COMPARED WITH THAT OF OCCUPIED AND RETIRED MALES, GREAT BRITAIN AND IRELAND, 1900 TO 1902, BY CAUSES OF DEATH.

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

| | All causes. | Influenza. | Alcoholism and disease of the liver. | Cancer. | Phthisis. | Diseases of the nervous system. | Diseases of the circulatory system | Diseases of the respiratory system. | Bright's disease. | Accident, with plumbism. | Suicide. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Occupied and retired males | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| Mining industry | 89 | 92 | 51 | 78 | 53 | 83 | 91 | 113 | 63 | 207 | 58 |
| Coal miner | 88 | 88 | 51 | 78 | 48 | 84 | 92 | 111 | 66 | 208 | 58 |
| Ironstone miner | 74 | 104 | 58 | 75 | 67 | 51 | 64 | 79 | 23 | 200 | 32 |
| Copper miner | 166 | ....... | 105 | 50 | 307 | 80 | 23 | 422 | ........ | ........ | ...... |
| Tin miner | 212 | 104 | 28 | 101 | 436 | 84 | 105 | 419 | 143 | 92 | 32 |
| Lead miner | 120 | 121 | 58 | 97 | 173 | 69 | 111 | 155 | 54 | 127 | 32 |

In explanation of the preceding two tables it is said in the official report that—

In the mining industry as a whole the death rate of men under the age of 20 years exceeds by 30 per cent the standard for occupied and retired males. At ages 20 to 25 the mortality is normal, but from ages 25 to 55 it is below the standard, being in defect by no less than 25 per cent at ages 35 to 45. After the age of 55 the mortality of miners is again in excess. In the main working period of life the comparative mortality figure is 896, or 11 per cent below the standard, notwithstanding the excessive mortality from accident, which is more than twice the normal. Miners appear to suffer more heavily than the average from diseases of the respiratory system, but on the other hand the mortality from phthisis is little more than half the standard, as is also that from alcoholism and liver disease and from suicide. The mortality from influenza, cancer, diseases of the nervous and circulatory systems, and Bright's disease is likewise below the standard.

It may be stated in this connection that during the later triennial period under review the mortality of miners declined approximately 20 per cent in comparison with a corresponding decrease of 16 per cent in the mortality of occupied males generally. The decline affected all principal causes excepting cancer. With special reference to coal miners it is said that they constitute nine-tenths of the entire mining population, but that in view of the wide variations in local mortality rates the conditions should be considered in detail for the six principal coal mining districts.[1] The local mortality rates from both disease and accident are shown in Table 137.

[1] For observations on the mortality from cancer with special reference to malignant lung diseases, see "Mortality from Cancer Throughout the World," by F. L. Hoffman, Newark, N. J., 1915, p. 56 et seq.

TABLE 137.—MORTALITY FIGURES FROM DISEASE AND FROM ACCIDENT AMONG COAL MINERS, IN SPECIFIED LOCALITIES OF GREAT BRITAIN.

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

| | Total mortality. | Disease. | Accident. |
|---|---|---|---|
| All coal miners: | | | |
| 1900-1902 | 846 | 723 | 123 |
| 1890-1892 | 1,068 | 905 | 163 |
| Coal miners in Lancashire: | | | |
| 1900-1902 | 1,006 | 875 | 131 |
| 1890-1892 | 1,236 | 1,057 | 179 |
| Coal miners in Monmouthshire and South Wales: | | | |
| 1900-1902 | 951 | 782 | 169 |
| 1890-1892 | 1,322 | 1,041 | 281 |
| Coal miners in Staffordshire: | | | |
| 1900-1902 | 846 | 728 | 118 |
| 1890-1892 | 1,100 | 943 | 157 |
| Coal miners in West Riding: | | | |
| 1900-1902 | 783 | 684 | 99 |
| 1890-1892 | 1,051 | 920 | 131 |
| Coal miners in Durham and Northumberland: | | | |
| 1900-1902 | 763 | 658 | 105 |
| 1890-1892 | 894 | 783 | 111 |
| Coal miners in Derbyshire and Nottinghamshire: | | | |
| 1900-1902 | 675 | 595 | 80 |
| 1890-1892 | 841 | 737 | 104 |

According to this table, there has been a decline in the liability to accident in every coal-mining district and also a corresponding decline in the mortality from disease. Aside from an increase in the mortality from cancer in every mining district, there has also been an increase in nervous diseases and an increase in urinary diseases in the districts of Lancashire and in the West Riding of Yorkshire.

These tables are self-explanatory and require no further consideration. Table 136 shows an apparently low degree of susceptibility to pulmonary tuberculosis, while indicating a high proportionate mortality from nontuberculous respiratory diseases combined. There are convincing reasons for believing that a corresponding analysis of trustworthy American statistics for carefully selected coal-mining districts would yield approximately similar results; in other words, the mortality problem in the coal-mining districts is primarily one of nontuberculous respiratory diseases rather than of pulmonary tuberculosis. The acceptance and practical use of any and all of these observations and conclusions are subject to a very cautious interpretation of the statistical data, in view of the relatively high mortality from accidents at the most important divisional period of life.

The English statistics have not been subjected to the required critical analysis to bring out the remarkable degree of divergence in the local frequency rates of tuberculous and nontuberculous respiratory diseases. Sir Thomas Oliver in his most recent discussion on "Dust diseases of the lungs" in Kober and Hanson's Diseases of Occupation and Vocational Hygiene (New York, 1916), observes that, "so far as coal miners' phthisis is concerned, it may be stated that a collier who develops anthracosis may live for years and be little inconvenienced by his malady," but "this applies only to the man who has worked in soft coal. It is otherwise if the coal has been of a hard, gritty, and stonelike nature." It is only within the last few years that trustworthy comparative data have been made public regarding the microscopic analysis of coals in the different coal fields, and the results are quite conclusive that the chemical and mechanical properties of the dust vary considerably and particularly as to the proportion of mineral and even metallic impurities. General conclusions with regard to the mortality and disease liability of coal miners with special reference to pulmonary tuberculosis and nontuberculous respiratory diseases, therefore, should be made use of with extreme caution, for what may be true of the industry in general may be far from true for particular coal fields, where special conditions affecting health and life may vary decidedly from the normal. In some coal samples, for illustration, the proportion of fixed carbon may be as high as 90.75 per cent (Ehrenfeld mine, Cambria County, Pa.) or as low as 49.95 per cent (San Coulee mine, Cascade County, Mont.).[1] Similar variations are met with in the proportion of sulphur which is commonly present in coal in the form of iron pyrites, either in large lumps and bands or finely disseminated particles. Sulphur may also be present in combination with lime and magnesia as sulphates. The presence of other mineral and even metallic impurities may so completely modify the chemical and mechanical properties of fine coal dust as to produce widely different pathological effects on the lungs of miners subject to its continuous inhalation.

It is only upon the ground of the preceding considerations that the wide range in the mortality rates from pulmonary tuberculosis and nontuberculous respiratory diseases in the more important coal fields for which the information has been made available can be explained. The official English statistics are for six representative coal fields, and the results are shown in detail in the following series of tables, commencing with the consolidated table for all coal miners, but differentiating occupied miners only and occupied and retired miners (the term miners being used in the general sense as equivalent to all employees in the mining industry) for the six mine fields of Durham and Northumberland, Lancashire, West Riding, Derbyshire and Nottinghamshire, Staffordshire, and Monmouthshire and South Wales. The tables include, aside from the proportionate mortality data for pulmonary tuberculosis, the mortality from accidents, and each table is followed by an additional

[1] See Bulletin 22, U. S. Bureau of Mines.

table showing in detail the nontuberculous respiratory mortality by divisional periods of life.

TABLE 138.—PROPORTIONATE MORTALITY FROM PULMONARY TUBERCULOSIS AMONG COAL MINERS (OCCUPIED ONLY), ENGLAND AND WALES, 1900 TO 1902, 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 | 2,332 | 430 | 18.4 |
| 25 to 34 years | 2,522 | 467 | 18.5 |
| 35 to 44 years | 2,645 | 364 | 13.8 |
| 45 to 54 years | 3,295 | 331 | 10.0 |
| 55 to 64 years | 3,866 | 198 | 5.1 |
| 65 years and over | 4,195 | 49 | 1.2 |
| Total, 15 years and over | [1] 18,855 | 1,839 | 9.8 |

[1] Including 2,806 deaths from accident, which are 14.9 per cent of the total deaths.

TABLE 139.—PROPORTIONATE MORTALITY FROM NONTUBERCULOUS RESPIRATORY DISEASES AMONG COAL MINERS (OCCUPIED ONLY), ENGLAND AND WALES, 1900 TO 1902, BY AGE GROUPS.

| Age. | Deaths caused by nontuberculous respiratory diseases. | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Bronchitis. | | Pneumonia. | | Other. | | Total. | |
| | Number. | Per cent. | Number. | Per cent. | Number. | Per cent. | Number. | Per cent. |
| 15 to 24 years | 7 | 0.3 | 170 | 7.3 | 22 | 0.9 | 199 | 8.5 |
| 25 to 34 years | 33 | 1.3 | 270 | 10.7 | 32 | 1.3 | 335 | 13.3 |
| 35 to 44 years | 79 | 3.0 | 309 | 11.7 | 63 | 2.4 | 451 | 17.1 |
| 45 to 54 years | 246 | 7.5 | 368 | 11.2 | 125 | 3.8 | 739 | 22.4 |
| 55 to 64 years | 596 | 15.4 | 322 | 8.3 | 174 | 4.5 | 1,092 | 28.2 |
| 65 years and over | 839 | 20.0 | 175 | 4.2 | 157 | 3.7 | 1,171 | 27.9 |
| Total, 15 years and over | 1,800 | 9.5 | 1,614 | 8.6 | 573 | 3.0 | 3,987 | 21.1 |

According to Tables 138 and 139 the average proportion of deaths from pulmonary tuberculosis in the mortality of coal miners of England and Wales (occupied only) is 9.8 per cent, and the combined mortality from nontuberculous respiratory diseases is 21.1 per cent, chiefly attributable to bronchitis (9.5 per cent) and pneumonia (8.6 per cent). These proportions are extremely suggestive in that it is shown that the actual mortality from each of the three principal diseases, i. e., pulmonary tuberculosis, bronchitis, and pneumonia, is almost the same. In the United States this is true for pulmonary tuberculosis and pneumonia but not for bronchitis. Nor does this conclusion hold true, as subsequently shown, for some of the more important mining districts, which emphasizes the conclusion that the general mortality of coal miners from all forms of respiratory diseases is materially modified by special local conditions.

Table 140—PROPORTIONATE MORTALITY FROM PULMONARY TUBERCULOSIS AMONG COAL MINERS (OCCUPIED AND RETIRED), ENGLAND AND WALES, 1900 TO 1902, 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 | 2,349 | 436 | 18.6 |
| 25 to 34 years | 2,597 | 489 | 18.8 |
| 35 to 44 years | 2,768 | 379 | 13.7 |
| 45 to 54 years | 3,443 | 344 | 10.0 |
| 55 to 64 years | 4,320 | 232 | 5.4 |
| 65 years and over | 6,128 | 70 | 1.1 |
| Total, 15 years and over | [1] 21,605 | 1,950 | 9.0 |

[1] Including 2,876 deaths from accident, which are 13.3 per cent of the total deaths.

Table 141.—PROPORTIONATE MORTALITY FROM NONTUBERCULOUS RESPIRATORY DISEASES AMONG COAL MINERS (OCCUPIED AND RETIRED), ENGLAND AND WALES, 1900 TO 1902, BY AGE GROUPS.

| Age at death. | Deaths caused by nontuberculous respiratory diseases. | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Bronchitis. | | Pneumonia. | | Other. | | Total. | |
| | Number. | Per cent. | Number. | Per cent. | Number. | Per cent. | Number. | Per cent. |
| 15 to 24 years | 7 | 0.3 | 172 | 7.3 | 22 | 0.9 | 201 | 8.6 |
| 25 to 34 years | 33 | 1.3 | 275 | 10.6 | 36 | 1.4 | 344 | 13.2 |
| 35 to 44 years | 80 | 2.9 | 316 | 11.4 | 66 | 2.4 | 462 | 16.7 |
| 45 to 54 years | 254 | 7.4 | 377 | 10.9 | 130 | 3.8 | 761 | 22.1 |
| 55 to 64 years | 666 | 15.4 | 342 | 7.9 | 188 | 4.4 | 1,196 | 27.7 |
| 65 years and over | 1,201 | 19.6 | 245 | 4.0 | 200 | 3.3 | 1,646 | 26.9 |
| Total, 15 years and over | 2,241 | 10.4 | 1,727 | 8.0 | 642 | 3.0 | 4,610 | 21.3 |

Tables 140 and 141 furnish an answer to the question frequently raised as to how far the recorded mortality of coal miners is modified by the factor of occupational elimination, in that it is well known, of course, that a fair proportion of coal miners discontinue the employment on the first signs of lung injury and seek employment mostly outdoors in more healthy occupations. This conclusion, it is true, has been opposed by Wainwright and Nichols in their observations on pulmonary anthracosis, but no evidence has been forthcoming that in a general way the conclusion is unsound that a considerable proportion of men in nondusty trades have not been previously employed in the mining industry. The most recent English statistics have, therefore, been made to include the occupied and retired, or in other words, the men previously employed in coal mining and now retired from the occupation. This, of course, does not bring out the full force of the preceding observations, in that men actively engaged in other pursuits, though formerly coal miners, would be enumerated under the occupation followed irrespective of the length of trade life. The number of deaths from all causes in the preceding table is increased to 21,605, over 18,855 for occupied coal miners only. The increase in the main naturally concerns only ages 55 and over. The proportionate mortality from pulmonary tuberculosis is modified from 9.8 per cent for the occupied only to 9 per cent for the occupied and retired, but in contrast the mortality from bronchitis is increased from 9.5 per cent for the occupied only to 10.4 per cent for the occupied and retired. In a general way the inclusion of the retired may, however, be said not to affect materially general conclusions based upon the data for the occupied only, except in so far as the most advanced age groups are concerned.

### MORTALITY OF MINERS IN THE NORTHUMBERLAND COAL FIELD.

For consideration in detail of the mortality from pulmonary tuberculosis and nontuberculous respiratory diseases among coal miners in the principal mining districts, the data for the Durham and Northumberland districts are given in the two tables following:

TABLE 142.—PROPORTIONATE MORTALITY FROM PULMONARY TUBERCULOSIS AMONG COAL MINERS (OCCUPIED ONLY) IN THE DURHAM AND NORTHUMBERLAND DISTRICT, 1900 TO 1902, 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 | 493 | 145 | 29.4 |
| 25 to 34 years | 463 | 112 | 24.2 |
| 35 to 44 years | 490 | 73 | 14.9 |
| 45 to 54 years | 680 | 65 | 9.6 |
| 55 to 64 years | 838 | 43 | 5.1 |
| 65 years and over | 1,090 | 12 | 1.1 |
| Total, 15 years and over | [1] 4,054 | 450 | 11.1 |

[1] Including 518 deaths from accident, which are 12.8 per cent of the total deaths.

TABLE 143.—PROPORTIONATE MORTALITY FROM NONTUBERCULOUS RESPIRATORY DISEASES AMONG COAL MINERS (OCCUPIED ONLY) IN THE DURHAM AND NORTHUMBERLAND DISTRICT, 1900 TO 1902, BY AGE GROUPS.

| Age at death. | Deaths caused by nontuberculous respiratory diseases. | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Bronchitis. | | Pneumonia. | | Other. | | Total. | |
| | Number. | Per cent. | Number. | Per cent. | Number. | Per cent. | Number. | Per cent. |
| 15 to 24 years | 4 | 0.8 | 15 | 3.0 | 7 | 1.4 | 26 | 5.3 |
| 25 to 34 years | 5 | 1.1 | 25 | 5.4 | 4 | 0.9 | 34 | 7.3 |
| 35 to 44 years | 11 | 2.2 | 35 | 7.1 | 15 | 3.1 | 61 | 12.4 |
| 45 to 54 years | 23 | 3.4 | 67 | 9.9 | 19 | 2.8 | 109 | 16.0 |
| 55 to 64 years | 81 | 9.7 | 50 | 6.0 | 41 | 4.9 | 172 | 20.5 |
| 65 years and over | 132 | 12.1 | 36 | 3.3 | 37 | 3.4 | 205 | 18.8 |
| Total, 15 years and over | 256 | 6.3 | 228 | 5.6 | 123 | 3.0 | 607 | 15.0 |

The proportionate mortality from pulmonary tuberculosis in this important coal field is 11.1 per cent, in comparison with 9.8 for all occupied coal miners in England and Wales. The mortality from nontuberculous respiratory diseases, however, is 15 per cent, against a general average of 21.1 per cent for England and Wales. The proportion of accidents is slightly below the normal, but the most marked difference is in the distinctly smaller proportion of deaths from bronchitis and pneumonia.

### MORTALITY OF MINERS IN THE LANCASHIRE DISTRICT.

The corresponding data for coal miners in the Lancashire district are given in Tables 144 and 145.

TABLE 144.—PROPORTIONATE MORTALITY FROM PULMONARY TUBERCULOSIS AMONG COAL MINERS (OCCUPIED ONLY) IN THE LANCASHIRE DISTRICT, 1900 TO 1902, 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 | 351 | 52 | 14.8 |
| 25 to 34 years | 424 | 57 | 13.4 |
| 35 to 44 years | 454 | 63 | 13.9 |
| 45 to 54 years | 575 | 58 | 10.1 |
| 55 to 64 years | 570 | 33 | 5.8 |
| 65 years and over | 375 | 6 | 1.6 |
| Total, 15 years and over | [1] 2,749 | 269 | 9.8 |

[1] Including 395 deaths from accident, which are 14.4 per cent of the total deaths.

TABLE 145.—PROPORTIONATE MORTALITY FROM NONTUBERCULOUS RESPIRATORY DISEASES AMONG COAL MINERS (OCCUPIED ONLY) IN THE LANCASHIRE DISTRICT, 1900 TO 1902, BY AGE GROUPS.

| Age at death. | Deaths caused by nontuberculous respiratory diseases. | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Bronchitis. | | Pneumonia. | | Other. | | Total. | |
| | Number. | Per cent. | Number. | Per cent. | Number. | Per cent. | Number. | Per cent. |
| 15 to 24 years | 2 | 0.6 | 40 | 11.4 | 3 | 0.9 | 45 | 12.8 |
| 25 to 34 years | 11 | 2.6 | 71 | 16.7 | 6 | 1.4 | 88 | 20.8 |
| 35 to 44 years | 23 | 5.1 | 78 | 17.2 | 7 | 1.5 | 108 | 23.8 |
| 45 to 54 years | 64 | 11.1 | 93 | 16.2 | 22 | 3.8 | 179 | 31.1 |
| 55 to 64 years | 100 | 17.5 | 69 | 12.1 | 18 | 3.2 | 187 | 32.8 |
| 65 years and over | 96 | 25.6 | 19 | 5.1 | 8 | 2.1 | 123 | 32.8 |
| Total, 15 years and over | 296 | 10.8 | 370 | 13.5 | 64 | 2.3 | 730 | 26.6 |

The proportion of deaths from pulmonary tuberculosis is 9.8 per cent, the normal for all occupied coal miners in England and Wales, but the mortality from respiratory diseases is much higher and particularly so from bronchitis and pneumonia. In contrast to an average of only 15 per cent of deaths from this group of diseases in the mortality from all causes among the coal miners of Durham and Northumberland, the corresponding proportion in the mortality of the coal miners of Lancashire is 26.6 per cent. Even more interesting is the comparison in detail for bronchitis and pneumonia. The proportionate mortality from bronchitis is 6.3 per cent for Durham and Northumberland, against 10.8 per cent for Lancashire, while from pneumonia the corresponding proportions are 5.6 per cent and 13.5 per cent, respectively. How far these marked differences are attributable to variations in local mining conditions can not be stated at the present time. The proportions, however, are also affected by important differences in climatic conditions, atmospheric pollution, housing, habits, class of labor, etc.[1] Such conditions, however, can not explain the remarkably lower proportion of deaths from pulmonary tuberculosis at the younger ages in the Lancashire mining district. At ages 15 to 24 the proportion of pulmonary tuberculosis in Durham and Northumberland is 29.4 per cent of the mortality from all causes against 14.8 per cent in Lancashire, or just about one-half. At ages 25 to 34 the corresponding proportions are 24.2 per cent for Durham and Northumberland and 13.4 per cent for Lancashire. Extending the analysis to bronchitis, it is shown that the proportions are relatively low for every divisional period of life, except 15 to 24 years, for Durham and Northumberland in comparison with Lancashire, and at some ages, particularly 45 to 54, when the effect of occupation is most pronounced, the proportion of deaths from bronchitis in Durham and Northumberland is only 3.4 per cent of the deaths from all causes at this period of life against 11.1 per cent for Lancashire. An analysis of the mortality from pneumonia by divisional periods of life yields much the same result. The proportionate mortality from this disease is decidedly less at every age group in the Durham and Northumberland mining district than in the corresponding district of Lancashire. It may be said in this connection that the proportionate mortality from accidents is nearly the same.

[1] It would make a most interesting and valuable contribution to the scientific study of this question if the comparative climatological factors of the American and British coal fields were subjected to a critical analysis. All of the essential data should be available through the annual and monthly meteorological reports of the two countries, but especially as regards England, a fairly sufficient amount of consolidated climatological information is available through the report of the Royal Medical and Chirurgical Society of London, issued under the title, "The Climates and Baths of Great Britain," in two volumes, London, 1895 and 1902. This report includes some exceedingly valuable maps and charts, which it should not be difficult to correlate to the corresponding maps descriptive of the principal coal fields of the United Kingdom.

## MORTALITY OF MINERS IN THE WEST RIDING DISTRICT.

Similar data for coal miners in the West Riding district are given in Tables 146 and 147, as follows:

TABLE 146.—PROPORTIONATE MORTALITY FROM PULMONARY TUBERCULOSIS, AMONG COAL MINERS (OCCUPIED ONLY) IN THE WEST RIDING DISTRICT, 1900 TO 1902, 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 | 280 | 49 | 17.5 |
| 25 to 34 years | 319 | 60 | 18.8 |
| 35 to 44 years | 387 | 53 | 13.7 |
| 45 to 54 years | 430 | 62 | 14.4 |
| 55 to 64 years | 487 | 27 | 5.5 |
| 65 years and over | 488 | 4 | .8 |
| Total, 15 years and over | [1] 2,391 | 255 | 10.7 |

[1] Including 329 deaths from accident, which are 13.8 per cent of the total deaths.

TABLE 147.—PROPORTIONATE MORTALITY FROM NONTUBERCULOUS RESPIRATORY DISEASES AMONG COAL MINERS (OCCUPIED ONLY) IN THE WEST RIDING DISTRICT, 1900 TO 1902, BY AGE GROUPS.

| Age at death. | Deaths caused by nontuberculous respiratory diseases. | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Bronchitis. | | Pneumonia. | | Other. | | Total. | |
| | Number. | Per cent. | Number. | Per cent. | Number. | Per cent. | Number. | Per cent. |
| 15 to 24 years | ........ | ........ | 17 | 6.1 | ........ | ........ | 17 | 6.1 |
| 25 to 34 years | 3 | 0.9 | 39 | 12.2 | ........ | ........ | 42 | 13.2 |
| 35 to 44 years | 14 | 3.6 | 39 | 10.1 | 11 | 2.8 | 64 | 16.5 |
| 45 to 54 years | 32 | 7.4 | 42 | 9.8 | 16 | 3.7 | 90 | 20.9 |
| 55 to 64 years | 69 | 14.2 | 35 | 7.2 | 14 | 2.9 | 118 | 24.2 |
| 65 years and over | 103 | 21.1 | 23 | 4.7 | 23 | 4.7 | 149 | 30.5 |
| Total, 15 years and over | 221 | 9.2 | 195 | 8.2 | 64 | 2.7 | 480 | 20.1 |

In the West Riding district the proportionate mortality from pulmonary tuberculosis is 10.7 per cent, which compares with 9.8 per cent for all coal miners in England and Wales, 11.1 per cent for all in Durham and Northumberland, and 9.8 per cent for all in Lancashire. The proportions are relatively low at the younger ages compared with the corresponding mortality for the mining district of Durham and Northumberland, and relatively high compared with that for Lancashire. The exceptionally high mortality from pulmonary tuberculosis in Durham and Northumberland remains, therefore, in marked contrast with the lower mortality in other important mining districts, while by way of contrast the mortality from nontuberculous lung diseases is distinctly low in the district of Durham and

Northumberland, while relatively high in other sections. In West Riding, however, the combined mortality from nontuberculous respiratory diseases is 20.1 per cent, compared with 26.6 per cent for Lancashire and 15 per cent for Durham and Northumberland. This excess for Lancashire is chiefly attributable to a relatively high mortality from bronchitis and pneumonia. The mortality from accidents in the West Riding district is 13.8 per cent, compared with 14.9 per cent for all coal miners in England and Wales. This factor, therefore, can not be considered of importance in materially altering the relative proportions of deaths from specified diseases. Throughout it may be said that the bronchitis and pneumonia mortality of the West Riding district conforms to the normal for the United Kingdom. But it is suggestive that the mortality from bronchitis at ages 65 and over should be 21.1 per cent in West Riding against 12.1 per cent in Durham and Northumberland and 25.6 per cent in Lancashire. A correct interpretation of these differences is obviously impossible without a thorough knowledge of many important local contributory conditions.[1]

### MORTALITY OF MINERS IN THE DERBYSHIRE AND NOTTINGHAMSHIRE DISTRICT.

Corresponding data for coal miners in the Derbyshire and Nottinghamshire district are given in Tables 148 and 149, which follow:

TABLE 148.—PROPORTIONATE MORTALITY FROM PULMONARY TUBERCULOSIS AMONG COAL MINERS (OCCUPIED ONLY) IN THE DERBYSHIRE AND NOTTINGHAMSHIRE DISTRICT, 1900 TO 1902, 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 | 209 | 47 | 22.5 |
| 25 to 34 years | 176 | 34 | 19.3 |
| 35 to 44 years | 216 | 28 | 13.0 |
| 45 to 54 years | 265 | 28 | 10.6 |
| 55 to 64 years | 341 | 16 | 4.7 |
| 65 years and over | 465 | 7 | 1.5 |
| Total, 15 years and over | a 1,672 | 160 | 9.6 |

a Including 202 deaths from accident, which are 12.1 per cent of the total deaths.

[1] There are no available precise observations on variations in underground temperatures in coal mines. It is quite possible that such variations in the different coal areas may have an important bearing upon the relative frequency from nontuberculous respiratory diseases. An important contribution to this aspect of the problem is an address on "The Influence of Underground Temperatures upon the Labor Capacity of Miners," by Prof. John Cadman, of the University of Birmingham.

TABLE 149.—PROPORTIONATE MORTALITY FROM NONTUBERCULOUS RESPIRATORY DISEASES AMONG COAL MINERS (OCCUPIED ONLY) IN THE DERBYSHIRE AND NOTTINGHAMSHIRE DISTRICT, 1900 TO 1902, BY AGE GROUPS.

| Age at death. | Deaths from nontuberculous respiratory diseases. | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Bronchitis. | | Pneumonia. | | Other. | | Total. | |
| | Number. | Per cent. | Number. | Per cent. | Number. | Per cent. | Number. | Per cent. |
| 15 to 24 years | ........ | ........ | 16 | 7.7 | 1 | 0.5 | 17 | 8.1 |
| 25 to 34 years | 3 | 1.7 | 9 | 5.1 | 3 | 1.7 | 15 | 8.5 |
| 35 to 44 years | 6 | 2.8 | 26 | 12.0 | 2 | .9 | 34 | 15.7 |
| 45 to 54 years | 10 | 3.8 | 21 | 7.9 | 8 | 3.0 | 39 | 14.7 |
| 55 to 64 years | 43 | 12.6 | 23 | 6.7 | 15 | 4.4 | 81 | 23.8 |
| 65 years and over | 108 | 23.2 | 19 | 4.1 | 19 | 4.1 | 146 | 31.4 |
| Total, 15 years and over | 170 | 10.2 | 114 | 6.8 | 48 | 2.9 | 332 | 19.9 |

The proportionate mortality from pulmonary tuberculosis in the Derbyshire and Nottinghamshire district is 9.6 per cent, which compares with 9.8 per cent for all coal miners in England and Wales. The proportionate mortality from nontuberculous respiratory diseases considered in the aggregate is 19.9 per cent of deaths from all causes against 21.1 per cent for all coal miners in England and Wales; 15.0 per cent for Durham and Northumberland; 26.6 per cent for Lancashire; and 20.1 per cent for West Riding. The mortality from the different forms of tuberculous and respiratory diseases conforms, in the main, to the general experience and indicates no very important variations, excepting that the mortality from bronchitis and pneumonia is relatively low at the younger ages.

## MORTALITY OF MINERS IN THE STAFFORDSHIRE DISTRICT.

The data for coal miners in the Staffordshire district are given in Tables 150 and 151, as follows:

TABLE 150.—PROPORTIONATE MORTALITY FROM PULMONARY TUBERCULOSIS AMONG COAL MINERS (OCCUPIED ONLY) IN THE STAFFORDSHIRE DISTRICT, 1900 TO 1902, 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 | 166 | 21 | 12.7 |
| 25 to 34 years | 174 | 27 | 15.5 |
| 35 to 44 years | 195 | 28 | 14.4 |
| 45 to 54 years | 327 | 28 | 8.6 |
| 55 to 64 years | 374 | 10 | 2.7 |
| 65 years and over | 520 | 5 | 1.0 |
| Total, 15 years and over | [1] 1,756 | 119 | 6.8 |

[1] Including 233 deaths from accident, which are 13.3 per cent of the total deaths.

TABLE 151.—PROPORTIONATE MORTALITY FROM NONTUBERCULOUS RESPIRATORY DISEASES AMONG COAL MINERS (OCCUPIED ONLY) IN THE STAFFORDSHIRE DISTRICT, 1900 TO 1902, BY AGE GROUPS.

| Age at death. | Deaths caused by nontuberculous respiratory diseases. | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Bronchitis. | | Pneumonia. | | Other. | | Total. | |
| | Number. | Per cent. | Number. | Per cent. | Number. | Per cent. | Number. | Per cent. |
| 15 to 24 years | ........ | ........ | 12 | 7.2 | 1 | 0.6 | 13 | 7.8 |
| 25 to 34 years | 1 | 0.6 | 12 | 6.9 | 5 | 2.9 | 18 | 10.3 |
| 35 to 44 years | 4 | 2.1 | 14 | 7.2 | 5 | 2.6 | 23 | 11.8 |
| 45 to 54 years | 38 | 11.6 | 29 | 8.9 | 18 | 5.5 | 85 | 26.0 |
| 55 to 64 years | 75 | 20.1 | 34 | 9.1 | 16 | 4.3 | 125 | 33.4 |
| 65 years and over | 134 | 25.8 | 16 | 3.1 | 18 | 3.5 | 168 | 32.3 |
| Total, 15 years and over | 252 | 14.4 | 117 | 6.7 | 63 | 3.6 | 432 | 24.6 |

The proportionate mortality from pulmonary tuberculosis in the Staffordshire district is only 6.8 per cent, in marked contrast to an average proportion of 9.8 per cent for all coal fields of England and Wales, and a maximum proportion of 11.1 per cent for the Durham and Northumberland district. The combined mortality from nontuberculous respiratory diseases, however, is distinctly above the average, or 24.6 per cent, against 21.1 per cent for all coal fields, and a minimum of 15 per cent for the Durham and Northumberland district. The mortality from bronchitis is exceptionally low at the younger ages, but for all ages combined the proportion of deaths from this disease is relatively high, or 14.4 per cent, against 9.5 per cent for all coal fields, 6.3 per cent for Durham and Northumberland, 10.8 per cent for Lancashire, 9.2 per cent for West Riding, and 10.2 per cent for Derbyshire and Nottinghamshire. This excessive incidence of bronchitis is particularly suggestive at the older ages, and, for illustration, at ages 65 and over, the proportion of deaths from bronchitis in the mortality from all causes of coal miners in the Staffordshire district is 25.8 per cent against 20 per cent for all coal miners, 12.1 per cent for Durham and Northumberland, 25.6 per cent for Lancashire, 21.1 per cent for West Riding, and 23.2 per cent for Derbyshire and Nottinghamshire. The proportionate mortality from accidents in the Staffordshire coal fields is 13.3 per cent, or not much at variance with the normal of 14.9 per cent for all coal fields.

#### MORTALITY OF MINERS IN THE MONMOUTHSHIRE AND SOUTH WALES DISTRICT.

The data for coal miners in the Monmouthshire and South Wales district are given in Tables 152 and 153, as follows:

TABLE 152.—PROPORTIONATE MORTALITY FROM PULMONARY TUBERCULOSIS AMONG COAL MINERS (OCCUPIED ONLY) IN THE MONMOUTHSHIRE AND SOUTH WALES DISTRICT, 1900 TO 1902, 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 | 663 | 92 | 13.9 |
| 25 to 34 years | 731 | 120 | 16.4 |
| 35 to 44 years | 698 | 94 | 13.5 |
| 45 to 54 years | 735 | 66 | 9.0 |
| 55 to 64 years | 885 | 52 | 5.9 |
| 65 years and over | 731 | 10 | 1.4 |
| Total, 15 years and over | [1] 4,443 | 434 | 9.8 |

[1] Including 895 deaths from accident, which are 20.1 per cent of the total deaths.

TABLE 153.—PROPORTIONATE MORTALITY FROM NONTUBERCULOUS RESPIRATORY DISEASES AMONG COAL MINERS (OCCUPIED ONLY) IN THE MONMOUTHSHIRE AND SOUTH WALES DISTRICT, 1900 TO 1902, BY AGE GROUPS.

| Age at death. | Deaths caused from nontuberculous respiratory diseases. | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Bronchitis. | | Pneumonia. | | Other. | | Total. | |
| | Number. | Per cent. | Number. | Per cent. | Number. | Per cent. | Number. | Per cent. |
| 15 to 24 years | 1 | 0.2 | 56 | 8.4 | 6 | 0.9 | 63 | 9.5 |
| 25 to 34 years | 9 | 1.2 | 92 | 12.6 | 11 | 1.5 | 112 | 15.3 |
| 35 to 44 years | 16 | 2.3 | 94 | 13.5 | 20 | 2.9 | 130 | 18.6 |
| 45 to 54 years | 61 | 8.3 | 89 | 12.1 | 30 | 4.1 | 180 | 24.5 |
| 55 to 64 years | 181 | 20.5 | 83 | 9.4 | 49 | 5.5 | 313 | 35.4 |
| 65 years and over | 167 | 22.8 | 42 | 5.7 | 29 | 4.0 | 238 | 32.6 |
| Total, 15 years and over | 435 | 9.8 | 456 | 10.3 | 145 | 3.3 | 1,036 | 23.3 |

The proportionate mortality from pulmonary tuberculosis in Monmouthshire and South Wales coal fields is the same as for all coal fields combined, or 9.8 per cent. The aggregate mortality from all forms of nontuberculous respiratory diseases is 23.3 per cent for Monmouthshire and South Wales, against 21.1 per cent for all coal mines in England and Wales and a minimum of 15 per cent for the Durham and Northumberland district. The proportionate mortality from pulmonary tuberculosis by divisional periods of life indicates nothing abnormal; in fact, the indications are rather suggestive of a relatively low rate of incidence in comparison with other mining districts. For illustration, at ages 15 to 24 the proportion of deaths in Monmouthshire and South Wales is 13.9 per cent, against 29.4 per cent for Durham and Northumberland; at ages 25 to 34 the corresponding proportions are 16.4 per cent for Monmouthshire and South Wales, against 24.2 per cent for Durham and Northumberland; but at ages 35 and over the proportions tend toward conformity. It is, however, extremely suggestive that, comparing the two coal fields, the mortality from nontuberculous respiratory diseases should be so decidedly at variance. The proportion of deaths from bronchitis, for illustration, in Durham and Northumberland is 6.3 per cent, against 9.8 per cent for Monmouthshire and South Wales, and for pneumonia the corresponding proportions are 5.6 per cent and 10.3 per cent, respectively. To a limited extent these statistics are affected, of course, by the higher proportion of accidental deaths in the Monmouthshire and South Wales coal-mining district, as 20.1 per cent of deaths from all causes are from accidents, against 12.8 per cent for Durham and Northumberland. While the two mining districts have approximately the same mining population, however, and the same number of deaths from pulmonary tuberculosis, there are only 256 deaths from bronchitis in Durham and Northumberland, against 435 deaths in Monmouthshire and South Wales; and 228 deaths from pneumonia in Durham and Northumberland, against 456 deaths in Monmouthshire and South Wales. The relative mortality rates, therefore, per thousand exposed to risk would confirm the general conclusions based upon the proportional data, regardless of the important differences in the relative frequency of mine accidents.

### EFFECT OF VARIATIONS IN LOCAL CONDITIONS ON THE MORTALITY FROM RESPIRATORY DISEASES.

This rather extended analysis is far from sufficient for the purpose of emphasizing concisely and conclusively the local variations in the proportionate mortality from pulmonary tuberculosis and nontuberculous respiratory diseases in the different mining districts of England and Wales. It is a safe inference, however, that corresponding variations would be disclosed by a similar analysis of the mortality data for the different coal fields of the United States, which, however, unfortunately at the present time are not available. The differences are unquestionably in a measure attributable to local climatic variations, fogs, smoke, etc., which influence the death rates from nontuberculous respiratory diseases, aside from equally if not more important differences in habits, housing, and labor conditions. How far the medical terminology is entirely trustworthy is also an open question. It is quite possible that death certification is more accurate and complete in England and Wales than in the United States, and that the higher mortality from bronchitis and pneumonia is a true difference on account of accuracy in diagnosis, based upon a careful consideration of all the clinical symptoms of the diseases. The differential diagnosis of true pulmonary tuberculosis involves serious difficulties which, on the part of the superficial practitioner, may frequently lead to a death being assigned to pulmonary tuberculosis when as a matter of fact the disease was not true tuberculosis but a true pneumoconiosis or anthracosis, as the case may be. It is, therefore, of much importance that the subject should receive more extended critical and qualified scientific consideration, so that sound conclusions may be available in place of more or less misleading and superficial generalities.

## RELATIVE FREQUENCY OF ANTHRACOSIS.

The problem under consideration is much more complex than in the case of occupations where the accident factor is of relatively lesser importance. When, however, reasonable allowance is made for the effects of accidents upon the mortality of coal miners from pulmonary tuberculosis, it is safe to assume that in coal mining there is a lesser inherent liability to this disease than in metal mining in consequence of the special mechanical and chemical properties of coal dust, aside, of course, from certain well-recognized changes, such as materially improved methods of ventilation, better air conditions, lesser air pollution by high explosives, etc. Shufflebotham, in his Milroy Lectures on the "Hygienic aspect of the coal-mining industry in the United Kingdom," has stated that at the present time "in Great Britain fibrosis of the lungs among miners can be said to be practically nonexistent, and its disappearance can be wholly attributed to the enforced improvements in the ventilation in mines, to improvements in illumination, and to shorter working hours." He remarks that the evidence given before the departmental committee on industrial diseases was practically unanimous on this point. No corresponding investigations have been made in this country regarding the occurrence of true fibroid phthisis or nontuberculous lung disease among coal miners. Anthracosis, or infiltration of the lung with coal dust, is, of course, extremely common; in fact, universal. Investigations made in this country are quite conclusive that more or less health-injurious consequences must in course of time result from an extensive coal-dust infiltration. As regards pulmonary tuberculosis the experience in this country is confirmed by the investigations of Shufflebotham, who remarks, with special reference to Great Britain, that—

Tuberculosis of the lungs is not so commonly found among coal miners as among many other occupations, and the statistics of the registrar general with regard to mortality from this cause show that while the mortality figure for all occupied males in England and Wales is 175, that for the coal miner is only 85; metalliferous miners, however, are not so fortunate in this respect, the figure for the Cornish tin miner being 838 (the highest on the list of all occupations); the copper miner, 501; and the lead miner, 344. With regard to other diseases of the respiratory system, while the mortality figure for all occupied males is 78, that for the coal miner is 140. The copper miner heads the list with 665, the tin miner coming second, with a mortality figure of 187; the potter and the Sheffield grinder—frequent victims of this disease—are represented by mortality figures of 361 and 173, respectively.

Shufflebotham, in the lecture referred to, makes brief mention of American investigations by Wainwright and Nichols, whose experience was drawn from an extensive area of observations, and who conclude that "miners' asthma" is clinically chronic bronchitis and emphysema and that it is associated with epithelial irritation, thickening of the connective tissue and consequent loss of elasticity. "Miners' asthma" is a term in rather common use in the coal regions, but the general inference is that there are no serious complications with pulmonary tuberculosis, nor is the actual mortality from this disease as high as would naturally be expected. Collis, in his Milroy Lectures on "Industrial pneumoconiosis," observes, with reference to true dust asthma, that it is always associated with an excessive incidence of bronchitis; and he briefly presents the distinctive features of this form of asthma as follows: "(i) Occurrence of asthmatic attacks during exposure to dust and the cessation of attacks on leaving the dusty atmosphere, (ii) immobility of the diaphragm, and (iii) overaction of the superior intercostal and extraordinary muscles of respiration." With special reference to coal miners he remarks that—

Fifty years ago asthma was common among coal miners. "Then in every little mining village," writes the secretary of a miners' association, "there was a contingent of old miners past work on account of difficulty of breathing, a stage usually reached between 40 and 50 years of age"; and this statement is borne out by Greenhow, who tells of the ravages wrought in his day among coal miners in South Staffordshire by asthma. "Some miners retain their health till an advanced period of life, but the greater number suffer, more or less, from asthmatical symptoms before attaining the age of 50, and many break down and are disabled at 40 to 50 years of age, * * * a miner is usually an old man at 50, and few men * * * are found at work beyond that age." The same observer also mentions the disease as prevalent in the South Wales coal field, and while attributing it to bad ventilation in the mines, states that the miners blamed the fumes from explosives. He contrasts the condition with that seen among lead miners and tin miners, as one with emphysema more frequent, with less pneumonia, developing later in life, and, while associated with chronic bronchitis, not associated at an early period of life with slight dyspnœa.

Collis also refers to investigations by Wainwright and Nichols, published in the Journal of Medical Sciences for 1905 under the title "The relation between anthracosis and pulmonary tuberculosis," stating, in part, that at Scranton during 1894–1904 asthma accounted for 7 per cent of all deaths among coal miners as compared with 1.6 per cent among all occupied males; and these observers further state that the condition as seen among the miners is one of chronic bronchitis and emphysema. After carefully considering all the medical aspects of the disease, Collis concludes that the exact terminology of the disease remains somewhat doubtful, but that though formerly quite common, it is now extremely rare in its classical form, at least in the coal mines of the United Kingdom.[1] Shufflebotham concludes his observations on coal dust with the following interesting and important statement, also including observations by Wainwright and Nichols, based upon American experience:

It has been asserted by many authorities that coal dust has germicidal properties, and in favor of this view we have the experience of colliery surgeons who record that extensive wounds full of coal dust heal rapidly, and even lacerated wounds sustained through injuries in coal mines can be stitched up without hesitation; veterinary surgeons have similar experience in the treatment of pit ponies. As a result of their experiments Wainwright and Nichols dismissed the theory that coal dust possesses any germicidal property; they believe that coal dust in the lungs does exert a real protective influence against the tubercle bacilli, but that the reduced mortality from tuberculosis is not due to any antiseptic property of the coal dust but to its stimulating effect on the lung tissue and increased growth of connective tissue. Among other experiments they kept guinea pigs for two months in an atmosphere of coal dust, and afterwards a pure culture of tubercle bacilli was injected. Animals were treated similarly who had not been subjected to the coal dust. They found that in the latter cases tubercle was found in the lung on post-mortem examination, but that in the former case no tubercles could be detected. Nichols advances the theory that the protective influence of the coal dust is due to the action of the soluble calcium salts which form a large proportion of the ash of the coal dust.

### COMPARATIVE MORTALITY IN COAL MINING AND AGRICULTURE.

As explained in the general introduction, the proportionate mortality is more useful and conclusive in connection with inquiries into the medical aspects of industrial hygiene than the use of mortality rates per thousand of those exposed to risk. Whenever available, however, such rates can be utilized to good advantage, and in Table 154 the general mortality of the coal miners of England and Wales, by divisional periods of life, is compared with the mortality of occupied males in agricultural districts. The comparison also includes the data in detail for the six mining districts of the United Kingdom.

[1] For a more recent discussion of the relation of coal dust to phthisis, see The Hospital, London, June 17, 1916, p. 252.

TABLE 154.—COMPARATIVE MORTALITY (RATES PER 1,000) FROM ALL CAUSES AMONG COAL MINERS (OCCUPIED ONLY) AND OCCUPIED MALES IN AGRICULTURAL DISTRICTS, ENGLAND AND WALES, 1900 TO 1902.

| Age at death. | Occupied males (agricultural districts). | Coal miners (all districts). | Durham and Northumberland. | Lancashire. | West Riding. | Derbyshire and Nottinghamshire. | Staffordshire. | Monmouthshire and South Wales. |
|---|---|---|---|---|---|---|---|---|
| 15 to 19 years | 1.95 | 3.20 | 3.14 | 3.65 | 2.85 | 2.56 | 2.49 | 4.03 |
| 20 to 24 years | 4.21 | 4.47 | 4.88 | 4.86 | 3.40 | 3.79 | 4.00 | 5.01 |
| 25 to 34 years | 5.16 | 4.93 | 4.54 | 6.01 | 4.27 | 3.33 | 4.16 | 5.78 |
| 35 to 44 years | 7.17 | 7.65 | 6.76 | 9.03 | 7.48 | 5.97 | 6.65 | 8.94 |
| 45 to 54 years | 11.73 | 14.67 | 13.79 | 17.44 | 13.01 | 11.25 | 16.07 | 15.94 |
| 55 to 64 years | 22.53 | 35.98 | 31.63 | 42.41 | 33.97 | 31.25 | 38.00 | 39.84 |
| 65 years and over | 85.08 | 139.82 | 155.40 | 136.61 | 142.19 | 149.04 | 163.21 | 105.30 |

The table clearly reflects the relatively favorable mortality of coal miners, but some important exceptions to this conclusion are brought out by the comparison, particularly for certain mining districts and the more advanced age periods. The rates are highest at ages 25 to 64 in the Lancashire district, and at ages 65 and over in the mining district of Staffordshire. At the younger ages, that is, under 25, the rates are highest in the mining district of Monmouthshire and South Wales.

A similar comparison of the mortality from pulmonary tuberculosis (phthisis) is shown in Table 155.

TABLE 155.—COMPARATIVE MORTALITY (RATES PER 1,000) FROM PHTHISIS OF COAL MINERS (OCCUPIED ONLY) AND OCCUPIED MALES IN AGRICULTURAL DISTRICTS, ENGLAND AND WALES, 1900 TO 1902.

| Age at death. | Occupied males (agricultural districts). | Coal miners (all districts). | Durham and Northumberland. | Lancashire. | West Riding. | Derbyshire and Nottinghamshire. | Staffordshire. | Monmouthshire and South Wales. |
|---|---|---|---|---|---|---|---|---|
| 15 to 19 years | 0.36 | 0.41 | 0.73 | 0.36 | 0.39 | 0.32 | 0.15 | 0.34 |
| 20 to 24 years | 1.09 | 1.01 | 1.65 | .89 | .70 | 1.13 | .68 | .90 |
| 25 to 34 years | 1.10 | .91 | 1.10 | .81 | .80 | .64 | .65 | .95 |
| 35 to 44 years | 1.02 | 1.05 | 1.01 | 1.25 | 1.02 | .77 | .95 | 1.20 |
| 45 to 54 years | 1.16 | 1.47 | 1.32 | 1.76 | 1.88 | 1.19 | 1.38 | 1.43 |
| 55 to 64 years | .88 | 1.84 | 1.62 | 2.45 | 1.88 | 1.47 | 1.02 | 2.34 |
| 65 years and over | .81 | 1.63 | 1.71 | 2.17 | 1.16 | 2.24 | 1.57 | 1.44 |

The table emphasizes the wide variations in the specific death rates of pulmonary tuberculosis in the different mining districts and the relatively low rates prevailing in all districts when comparison is made with the corresponding mortality of occupied males in agricultural districts. It must be considered in this connection, however, that the social and economic status of agricultural labor in England and Wales is distinctly below the average for the United States.

On account of the exceptional importance of the nontuberculous respiratory diseases in the case of coal miners, Table 156 shows the rates of mortality from bronchitis and pneumonia, in a manner uniform with the preceding tables for all causes and for pulmonary tuberculosis.

TABLE 156.—COMPARATIVE MORTALITY (RATES PER 1,000) FROM BRONCHITIS AND PNEUMONIA OF COAL MINERS (OCCUPIED ONLY) AND OCCUPIED MALES IN AGRICULTURAL DISTRICTS, ENGLAND AND WALES, 1900 TO 1902.

| Age at death. | Occupied males (agricultural districts). | Coal miners (all districts). | Durham and Northumberland. | Lancashire. | West Riding. | Derbyshire and Nottinghamshire. | Staffordshire. | Monmouthshire and South Wales. |
|---|---|---|---|---|---|---|---|---|
| BRONCHITIS. | | | | | | | | |
| 15 to 19 years | 0.0083 | 0.0032 | 0.0154 | ........ | ........ | ........ | ........ | ........ |
| 20 to 24 years | ........ | .0199 | .0505 | 0.0469 | ........ | ........ | ........ | 0.0138 |
| 25 to 34 years | .0261 | .0646 | .0490 | .0156 | 0.0402 | 0.0567 | 0.0239 | .0711 |
| 35 to 44 years | .0713 | .2284 | .1517 | .4572 | .2706 | .1660 | .1363 | .2045 |
| 45 to 54 years | .2179 | 1.0951 | .4663 | 1.9410 | .9671 | .4244 | 1.8680 | 1.3230 |
| 55 to 64 years | .9593 | 5.5466 | 3.0570 | 7.4400 | 4.8120 | 3.9410 | 7.6200 | 8.1470 |
| 65 years and over | .8431 | 27.9639 | 18.8600 | 34.9700 | 30.0100 | 34.6000 | 42.1000 | 24.0606 |
| PNEUMONIA. | | | | | | | | |
| 15 to 19 years | .0794 | .2339 | .0929 | .4309 | .1317 | .2913 | .1132 | .3325 |
| 20 to 24 years | .0201 | .3250 | .1516 | .5404 | .2492 | .1881 | .3598 | .4429 |
| 25 to 34 years | .2349 | .5285 | .2452 | 1.0058 | .5225 | .1701 | .2870 | .7270 |
| 35 to 44 years | .5510 | .8932 | .4828 | 1.5500 | .7540 | .7191 | .4771 | 1.2040 |
| 45 to 54 years | .8084 | 1.6382 | 1.3580 | 2.8210 | 1.2704 | .8912 | 1.4250 | 1.9300 |
| 55 to 64 years | 1.1620 | 2.9966 | 1.8770 | 5.1300 | 2.4410 | 2.1080 | 3.4500 | 3.7360 |
| 65 years and over | 2.7620 | 5.8328 | 5.1300 | 6.9200 | 6.7000 | 6.0900 | 5.0200 | 6.0500 |

These tables will be found exceptionally useful in the furtherance of an effort to ascertain in a more conclusive manner the true incidence of pulmonary tuberculosis and nontuberculous respiratory diseases among coal miners, with a due regard to the geographical distribution of the mining industry. It sustains the earlier conclusion that the relative infrequency of pulmonary diseases among coal miners is more apparent than real, when consideration is given to the excess in the mortality from nontuberculous respiratory diseases among coal miners, in comparison with other industries or labor employed in agriculture. The entire question of anthracosis, or coal miners' phthisis, has been recently reviewed by Sir Thomas Oliver, in Kober and Hanson's Diseases of Occupation and Vocational Hygiene. Sir Thomas Oliver explains that "from an historical point of view the opening out of the South Wales coal fields is a modern development compared with those of Northumberland, but owing to the smokeless character of the coal and its suitability for steamship purposes, the industry received an impetus half a century ago which has not yet begun to decline." He recalls that, "When Sir John Simon wrote upon the subject nearly 50 years ago he was of the opinion that there was a larger amount of bronchial and respiratory diseases among the Welsh miners than among the Northumberland, a circumstance which he attributed to the better ventilation of the mines in the North of England." These earlier observations are only to a limited extent confirmed by more recent experience, which does not indicate an excess of pneumonia or bronchitis in the coal fields of Monmouthshire and South Wales, as clearly brought out by the preceding series of tables.

### ANTHRACOSIS AND PHTHISIS.

Unfortunately most of the prevailing views regarding anthracosis, or the so-called coal miners' phthisis, are not based upon a thorough and critical analysis of morbidity and mortality data. This conclusion applies to the very interesting observations of Wainwright and Nichols, first published in the American Journal of the Medical Sciences (1905) under the title, "The relation between anthracosis and pulmonary tuberculosis." The conclusions advanced rest in part upon a superficial analysis of the mortality statistics of the United States census for 1900 and a special analysis of the death certificates of the city of Scranton, Pa. The authors observe that miners' phthisis is an unfortunate term used in England, and undoubtedly a misnomer as far as the phthisical aspect of miners' lung diseases is concerned. Tuberculous lesions in miners are, of course, due to the tubercle bacillus, without which, in other words, true tuberculosis can not exist. The nontuberculous lung diseases among coal miners in particular are, therefore, of special importance; but there are reasons for believing that a clinical diagnosis is frequently quite superficial and fails to distinguish fairly between a case of true phthisis, or pulmonary tuberculosis, and a case of apparent phthisis, or anthracosis, which is, in its inception at least, a nontuberculous lung disease, manifesting itself in a chronic bronchitis, asthma, or pneumonia. By means of special methods of research Wainwright and Nichols ascertained that the foreign matter in the lungs of old miners, on the basis of autopsy findings, was about 33 per cent of the dried lung, whereas in normal subjects not especially exposed to dust the proportion is only from 1 to 3 per cent. In view of the thorough impregnation of the lung with coal dust, it is, therefore, difficult to accept the conclusion that such impregnation to the quantitative extent of one-third of the lung substances should not be injurious.

It is true, as pointed out by Wainwright and Nichols, that there are special advantages in mine work, and that in Pennsylvania in particular the mine employee frequently "has to walk several miles to the shaft through the fine air of high altitudes," and there is the additional advantage of a fairly satisfactory economic status. All of this, no doubt, must have some influence on the health of miners in general, and the relative frequency of pulmonary tuberculosis in particular. The authors, however, go too far when they maintain that it is not a fact that miners who have contracted tuberculosis frequently seek lighter work, and frequently on death they are registered in the second occupation, to which they do not belong, and that, therefore, the true death rate among miners is artificially reduced. To anyone thoroughly familiar with the conditions in the mining districts of the United States there can be no question of doubt that labor changes are quite common and that in a measure they are directly attributable to a desire to replace an apparently unhealthful employment underground, by an occupation with a lesser liability to diseases resulting from continuous and considerable coal-dust exposure. (On this point, see p. 381.)

The same authors hold that there is also no justification for the view that there is a process of natural selection in the case of miners, in accordance with which the physically superior type would seek employment, rather than the general average of boys and men not particularly concerned as regards the physical aptitude for the more or less arduous work underground. They hold that weaklings, even when admitted to the mining occupations, are not weeded out later, and that mine labor "is certainly not more laborious than that of the farm laborer, with whom they are nearly equal in point of tuberculosis mortality." This conclusion can not be accepted, for mine labor underground is continuous during 8, 9, or 10 hours, as the case may be, whereas farm labor is intermittent, and excessive physical strain is rather exceptional. In modern coal mining, practically on account of the extensive use of heavy mining machinery, the physical requirements are, in all probability, even greater than under the earlier conditions of mining by pick and hand. (See p. 319.)

The analysis of the Scranton vital statistics was not made with reference to age, so that the proportionate mortality figure of 3.37 per cent of deaths from pulmonary tuberculosis can hardly be considered conclusive when compared with the corresponding percentage for other occupied males of 9.97. The authors do not draw sufficient attention to the fact that the proportion of deaths from asthma in their own figures was 7.07 per cent for anthracite coal miners against 1.58 per cent for all other occupied males, and throughout their discussion they fail to emphasize the possible nonapplication of their conclusion to bituminous coal miners, with whom the conditions may vary fundamentally as regards the chemical and mechanical properties of the coal dust from the corresponding conditions in anthracite mining. After combining the proportionate mortality from all lung diseases, whether tuberculous or nontuberculous, the results show that of the deaths of anthracite mine workers 23.45 per cent were caused by this group of respiratory diseases against 27.86 per cent for all other occupied males. It is quite probable that the latter group includes a considerable proportion of men who formerly worked in mines, which in part would account for the higher proportionate mortality figure from pneumonia, or 13.85 per cent for all other occupied males at Scranton against 10.96 per cent for anthracite mine workers.

The vital statistics of the State of Pennsylvania, unfortunately, are not available by occupations, with a due regard to divisional periods of life. The city of Scranton consists so largely of men employed in coal mining, or formerly employed in that occupation, that it is of some significance that the proportionate mortality from tuberculous and respiratory diseases should be 23.6 per cent of the mortality from all causes against 22.2 per cent for the State of Pennsylvania.[1] Similar data for the city of Wilkes-Barre show a divergence from the Scranton data and indicate a lower proportion of deaths from pulmonary tuberculosis and pneumonia but a somewhat higher proportion of deaths from accidents. Excluding the deaths from accidents, it appears that in Scranton 26.4 per cent of all the deaths are caused by tuberculous or nontuberculous respiratory diseases against 23.1 per cent for the city of Wilkes-Barre and 23.9 per cent for the State of Pennsylvania. When, therefore, proper allowance is made for the factor of occupational elimination, the available data indicate that the alleged immunity of coal miners from pulmonary tuberculosis, while unquestionably true in a measure, is not as important as generally assumed on account of the relatively excessive mortality from nontuberculous respiratory diseases, of which no doubt a considerable proportion are deaths from anthracosis not complicated by a superinduced pulmonary tuberculosis or true phthisis. There is the utmost urgency in this matter that old and more or less general and frequently misleading

[1] A more recent analysis of the mortality of the city of Scranton, with comparative data for Wilkes-Barre and the remainder of the State, for the period 1911 to 1915, is as follows:

*Comparative mortality of Pennsylvania, 1911 to 1915.*

[Rate per 100,000 population.]

| Cause of death. | Scranton. | Wilkes-Barre. | Remainder of State. |
|---|---|---|---|
| Pulmonary tuberculosis | 79.9 | 74.9 | 110.5 |
| Other tuberculosis | 16.6 | 19.4 | 16.4 |
| Respiratory diseases | 261.2 | 212.5 | 184.2 |
| Violence | 153.5 | 179.7 | 98.9 |

According to this table, which, of course, is for the general population and not exclusively for the mining population, the mortality from tuberculosis attributable to the two principal urban centers of the anthracite mining industry was considerably below the average for the remainder of the State; in contrast, the mortality from nontuberculous respiratory diseases was quite considerably in excess for both Scranton and Wilkes-Barre, aside from a much higher mortality than these two localities for violence. The proportion of population, ages 15 to 64 years, is practically the same, or about 65 per cent, in Scranton, Wilkes-Barre, and the remainder of the State; the proportion of population, ages 65 years and over, however, according to the census of 1910, was 2.8 per cent for Scranton, 2.9 per cent for Wilkes-Barre, against 4.3 per cent for the State as a whole.

data and observations should be disregarded and that the entire question should be subjected to a strictly scientific and critical analysis. Conclusions based upon fragmentary observations derived from the experience of physicians in coal-mining centers throughout the world can not be safely applied to modern coal-mining conditions in the United States. The relatively high mortality from asthma, bronchitis, and pneumonia among coal miners is certainly suggestive of more or less health-injurious conditions underground, probably directly related to dust exposure, which can not be explained on any other principle of correlation in disease.

### MORTALITY OF AMERICAN COAL MINERS.

Table 157 shows the proportionate mortality of coal miners in the experience of the Prudential Insurance Co. of America for the period 1907 to 1914, including 3,658 deaths from all causes and 354 deaths from pulmonary tuberculosis, or 9.7 per cent. This is almost the exact proportion (9.8 per cent) ascertained by the analysis of the English mortality statistics for occupied miners only for an earlier period.

TABLE 157.—PROPORTIONATE MORTALITY OF COAL MINERS FROM PULMONARY TUBERCULOSIS, INDUSTRIAL EXPERIENCE OF PRUDENTIAL CO., 1907 TO 1914, 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 | 364 | 27 | 7.4 |
| 25 to 34 years | 395 | 52 | 13.2 |
| 35 to 44 years | 468 | 58 | 12.4 |
| 45 to 54 years | 840 | 103 | 12.3 |
| 55 to 64 years | 917 | 78 | 8.5 |
| 65 years and over | 674 | 36 | 5.3 |
| Total, 15 years and over | 3,658 | 354 | 9.7 |

TABLE 158.—PROPORTIONATE MORTALITY OF COAL MINERS FROM NONTUBERCULOUS RESPIRATORY DISEASES, INDUSTRIAL EXPERIENCE OF PRUDENTIAL CO., 1907 TO 1914, BY CAUSE OF DEATH.

| Cause of death. | Deaths from nontuberculous respiratory diseases. | |
|---|---|---|
| | Number. | Per cent of deaths from all causes. |
| Asthma | 137 | 3.7 |
| Bronchitis | 81 | 2.2 |
| Pneumonia | 397 | 10.9 |
| Other nontuberculous respiratory diseases | 124 | 3.4 |
| Total | 739 | 20.2 |
| Accidents | 885 | 24.2 |

The comparison of the Prudential and English experiences is exceptionally instructive. The combined mortality from nontuberculous respiratory diseases in the English experience was 21.1 per cent, against 20.2 per cent in the experience of the Prudential Co., but the details of the experience vary widely, especially as regards the proportionate mortality from pulmonary tuberculosis during the earlier years of life, which in a measure no doubt is directly attributable to the more effective safeguarding of young men employees and restrictive legislation against the employment of children underground. At the older ages the proportionate mortality from pulmonary tuberculosis in this country is apparently higher than in England, due possibly to a tendency in superficial clinical diagnoses to report deaths as phthisis which should more properly be returned as chronic bronchitis and asthma; or possibly the tendency may be the other way in England, to return deaths as bronchitis properly assignable to pulmonary tuberculosis. There are, however, reasons for believing that nontuberculous lung diseases are more common among the coal miners in this country than among those of England and Wales. The comparative statistics are further affected by climatic conditions and also by the fact that coal-mining accidents in this country are more common than in England. The Prudential statistics are strictly limited to coal miners and do not include other mine employees in so far as the fact is indicated on the death certificates. For the purpose of facilitating convenient comparison with corresponding proportionate mortality statistics for England and Wales Table 159 is included showing the details by divisional periods of life for nontuberculous respiratory diseases.

TABLE 159.—COMPARATIVE MORTALITY OF COAL MINERS FROM NONTUBERCULOUS RESPIRATORY DISEASES, INDUSTRIAL EXPERIENCE OF PRUDENTIAL CO., 1907 TO 1914, BY AGE GROUPS.

| Age at death. | Deaths from all causes. | Deaths from nontuberculous respiratory diseases. | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Asthma. | | Bronchitis. | | Pneumonia. | | Other. | | Total. | |
| | | Number. | Per cent. | Number. | Per cent. | Number. | Per cent. | Number. | Per cent. | Number. | Per cent. |
| 15 to 24 years | 364 | ...... | ...... | 1 | 0.3 | 22 | 6.0 | 2 | 0.5 | 25 | 6.9 |
| 25 to 34 years | 395 | ...... | ...... | 3 | .8 | 26 | 6.6 | 3 | .8 | 32 | 8.1 |
| 35 to 44 years | 468 | 7 | 1.5 | 5 | 1.1 | 44 | 9.4 | 14 | 3.0 | 70 | 15.0 |
| 45 to 54 years | 840 | 33 | 3.9 | 14 | 1.7 | 135 | 16.1 | 25 | 3.0 | 207 | 24.6 |
| 55 to 64 years | 917 | 61 | 6.7 | 26 | 2.8 | 103 | 11.2 | 48 | 5.2 | 238 | 26.0 |
| 65 years and over | 674 | 36 | 5.3 | 32 | 4.7 | 67 | 9.9 | 32 | 4.7 | 167 | 24.8 |
| Total, 15 years and over | 3,658 | 137 | 3.7 | 81 | 2.2 | 397 | 10.9 | 124 | 3.4 | 739 | 20.2 |

The table is particularly suggestive as indicating a relatively higher proportion of deaths from asthma than from bronchitis, and even for both diseases combined the averages fall below the corresponding averages for the coal miners of England and Wales. Unfortunately, the English statistics do not differentiate asthma. The mortality from pneumonia is apparently somewhat higher in this country, or 10.9 per cent in the Prudential experience, against 8.6 per cent in England and Wales.[1]

The Prudential experience is for coal miners in general, since a differentiation of even anthracite and bituminous miners has not been feasible. There are convincing reasons for believing that similar variations in the rate of frequency of the different forms of respiratory diseases, whether tuberculous or nontuberculous, would be met with in the principal coal-mining districts, but thus far no extended analysis has been made of the official statistics even for States in which local registration is approximately accurate and complete.[2] Occasional discussions in mining journals as regards the alleged long life of the mine worker, or the comparative freedom of

[1] Since the comparative statistics of the mortality from tuberculosis and nontuberculous respiratory diseases for the United States and England and Wales are not generally accessible, the following table is included:

*Comparative mortality from tuberculosis and nontuberculous respiratory diseases of the United States registration area and England and Wales, 1911 to 1915.*

[Rate per 100,000 of population.]

| Cause of death. | United States registration area. | | England and Wales. | |
|---|---|---|---|---|
| | Males. | Females. | Males. | Females. |
| Tuberculosis of lungs | 139.8 | 109.5 | 115.8 | 80.0 |
| Acute miliary tuberculosis | 5.2 | 4.7 | 11.2 | 9.3 |
| Tuberculous meningitis | 8.8 | 8.1 | 15.3 | 12.7 |
| Tuberculosis of other organs | 9.9 | 9.7 | 16.0 | 13.1 |
| Disseminated tuberculosis | 1.3 | 1.2 | 6.9 | 5.3 |
| Tuberculosis, all forms | 165.0 | 133.2 | 165.1 | 120.4 |
| Bronchitis | 17.1 | 19.5 | 144.7 | 109.4 |
| Broncho-pneumonia | 48.2 | 47.6 | 57.5 | 46.5 |
| Pneumonia, lobar and unqualified | 93.1 | 73.6 | 75.5 | 44.9 |
| Pleurisy | 4.0 | 3.0 | 4.9 | 3.0 |
| Asthma and emphysema | 3.0 | 2.7 | 7.6 | 4.7 |
| Other respiratory diseases | 7.9 | 6.9 | 18.0 | 15.7 |
| All respiratory diseases | 173.3 | 153.3 | 278.2 | 224.2 |

[2] An extended report on a "Sickness survey of principal cities in Pennsylvania and West Virginia" was published by the Metropolitan Life Insurance Co. of New York in 1917. This report includes comparative data for other communities previously investigated. According to this investigation, "among anthracite coal miners 15 years of age and over, the rate for sickness involving disability for work was 23.4 per 1,000. This rate was lower than that for disabling sickness for other male members of anthracite coal miners' families (25.9 per 1,000), about the same as the rate for disabling sickness among bituminous coal miners (23.9 per 1,000), a little more than the rate for other members of bituminous coal miners' families (22.2 per 1,000), and about five points per 1,000 more than the rate for disabling sickness among iron and steel mill employees aged 15 years and over. Anthracite coal miners between 25 and 34 years show a sickness rate of 13.1 per 1,000, which is about three points per 1,000 higher than the rates for disabling sickness in the group of other males of the same ages in anthracite families, about three points lower than the disabling sickness rate among bituminous coal miners of the same ages, and practically the same as the disabling sickness rate among iron and steel mill employees."

the coal miner from pulmonary tuberculosis, are practically valueless in that they are not with reference to ascertained facts, but based upon general assumptions and conditions superficially observed in foreign countries. An occasional obituary notice of an aged miner is erroneously construed into an argument in favor of the noninjuriousness of coal dust, or underground work, and in disregard of the fact that in the United States, for illustration, the proportion of coal miners at ages 45 and over is only 17.3 per cent of the total number employed, according to the census of 1910, against 29.3 per cent for all persons employed in agriculture. As observed in an editorial in the Coal Age for March 16, 1912, "the miner has always declared the mines unhealthy," but in curious contrast, the official and other evidence has been construed to the effect that mine labor, especially in coal mines, is not incompatible with the attainment of a normal average duration of life.

The mortality of coal miners has also been reported upon by the Metropolitan Life Insurance Co. in Bulletin 207 of the United States Bureau of Labor Statistics, on "Causes of Death by Occupation." This investigation includes 1,557 deaths of coal miners presented in detail by specified important causes in the table below:

TABLE 160.—NUMBER AND PER CENT OF DEATHS FROM SPECIFIED CAUSES AMONG COAL MINERS, 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 | 1,557 | ...... | 151 | 135 | 182 | 319 | 407 | 363 |
| Influenza | 23 | 1.5 | 0.7 | ...... | 1.6 | 0.6 | 2.2 | 2.2 |
| Tuberculosis of the lungs | 91 | 5.8 | 4.0 | 11.9 | 12.1 | 6.6 | 3.4 | 3.3 |
| Cancer (all forms) | 71 | 4.6 | .7 | 1.5 | 2.7 | 3.4 | 6.9 | 6.6 |
| Cerebral hemorrhage, apoplexy, and paralysis | 94 | 6.0 | .7 | .7 | 1.6 | 4.1 | 7.6 | 12.4 |
| Organic diseases of the heart | 149 | 9.6 | 2.6 | 4.4 | 6.6 | 8.8 | 10.8 | 15.2 |
| Acute and chronic bronchitis | 49 | 3.1 | ...... | ...... | 1.1 | 1.6 | 4.2 | 6.9 |
| Pneumonia (lobar and undefined) | 161 | 10.3 | 4.6 | 7.4 | 10.4 | 14.7 | 11.3 | 8.8 |
| Cirrhosis of the liver | 37 | 2.4 | ...... | .7 | 1.1 | 4.1 | 2.9 | 2.5 |
| Bright's disease | 116 | 7.5 | ...... | 1.5 | 6.6 | 7.8 | 11.5 | 8.3 |
| Suicide (all forms) | 18 | 1.2 | .7 | 2.2 | 2.2 | 2.2 | .7 | ...... |
| Accidental violence | 317 | 20.4 | 62.9 | 43.7 | 30.7 | 15.7 | 10.3 | 4.1 |
| All other causes | 431 | 27.7 | 23.2 | 25.9 | 22.9 | 30.4 | 28.0 | 29.9 |
| Total | 1,557 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |

According to this experience the mortality from pulmonary tuberculosis was practically negligible at ages 15 to 24, having been only 4 per cent as compared with 33.8 per cent in all occupations. The relative index, therefore, was only 11.8. At ages 25 to 34, however, the proportionate mortality from pulmonary tuberculosis was 11.9 per cent against 40.9 per cent for all occupations, and at ages 35 to

44 it was only 12.1 per cent against a general average of 32.9 per cent. The mortality at the older ages was practically negligible. The experience, therefore, sustains the corresponding data of the Prudential, subject, however, to the conclusion that the two experiences in all probability are not strictly comparable. The experience of the Prudential is much more extensive and possibly more representative and less affected by methods of medical inspection and examination. The two companies in this respect do not follow precisely the same practice. The experience of both institutions, however, indicates conclusively a decidedly low proportionate mortality from pulmonary tuberculosis among coal miners in this country. The discussion by Dr. Dublin is, in part, as follows:

The low proportionate mortality from tuberculosis of the lungs among coal miners is a matter of general record. The data of the registrar general of England and Wales, and of Hoffman in his occupational mortality statistics of the Prudential, give very low indices for pulmonary tuberculosis; for all ages combined the data of the former show 64.5 and of the latter 50.7. The Metropolitan index of 28.3 is the least recorded. Coal miners seem to be relatively free from pulmonary tuberculosis at every age period from 15 years to 65. The death rates from tuberculosis of the lungs also point to this conclusion. Thus the registrar general of England and Wales reports that the death rate from phthisis among coal miners at the age period 15 to 24 is 70.6 per 100,000 living. This rate is 68.1 per cent of that prevailing for all occupied males.

The low tuberculosis rate among coal miners is, moreover, coupled with a high rate from accidental violence. This is characteristic of all age periods, but especially up to age 45. For all ages the relative indices are all over 300. The age period 45 to 54 has a relative index of 184.7; in the age period 55 to 64 the index is 158.5. In the last age period, 65 and over, it is only 93.2. The Prudential experience is very nearly the same as that of the Metropolitan; for all ages the relative index is 246.2. The index for the material of the registrar general's office is 256.9. The above figures show clearly the effect of the dangers of the occupation upon the mortality of coal miners.

The low proportionate mortality from tuberculosis of the lungs and the high proportionate mortality from accidental violence are closely related phenomena. It is evident that deaths from accidental violence, especially at the earlier ages, tend to decrease the number of deaths that would ordinarily have been reported from tuberculosis. The proportion of miners who die from accidents but who are also affected with tuberculosis can be determined only by a special investigation. It may at first thought appear that the low tuberculosis rate is a direct consequence of the high rate from accidents, and that we are really not concerned with a true immunity against tuberculosis in this occupation. The weight of much indirect evidence is, however, strongly in favor of the theory of such a relative immunity. Thus we find a high proportionate mortality from pneumonia among coal miners at all ages; the index is 143.1. After age 25 the index is uniformly higher than for all occupations. The same may be said with reference to the proportionate mortality from acute and chronic bronchitis after age 34. Coal miners, therefore, show a high representation of the respiratory diseases. This is clear even in the presence of the high accident rate.

The Prudential experience is, in a large measure, confirmed by the above statistics of the Metropolitan Life Insurance Co. for the period of 1911–1913, including 1,557 deaths of coal miners from all causes, of which 91, or 5.8 per cent, were from pulmonary tuberculosis. This is a much lower percentage than the corresponding mortality figure of 9.7 per cent for the Prudential experience, suggesting that in all probability the difference is to be accounted for by variations in the mining territory covered by the respective operations of the two companies. The proportion of deaths from pneumonia in the Metropolitan experience was 10.3 per cent, against 10.9 per cent for the Prudential, but the deaths from accidents were 20.4 per cent for the Metropolitan, against 24.2 per cent for the Prudential. The smaller proportion of deaths from pulmonary tuberculosis is maintained throughout every divisional period of life.

### GENERAL CONCLUSIONS.

The preceding conclusions are based in part upon the alleged antagonistic properties of coal dust to the development of phthisis, and it is quite possible that a protective power is exercised by pure carbon dust in this particular, though rather limited, direction. But it is of no practical importance from a mortality point of view whether the injury done to the lungs results in a true tuberculosis, or in a form of nontuberculous, so-called miners' phthisis, which, according to all available statistical data, is of more than general frequency among the coal-mining population. The statement made by Sir Thomas Oliver, therefore, that in consequence of the better ventilation of coal mines at the present time, "the health of coal miners is satisfactory," and that this is particularly so as regards tuberculosis, must be accepted with reserve. The same author has directed attention to the statement made in the discussion on anthracosis, by Wainwright and Nichols, that the calcium salts in coal dust furnish a certain amount of protection to the lungs on account of their germicidal properties, in support of which it is said that it is astonishing, for example, how rapidly wounds in coal miners heal, and that tetanus is said to be exceedingly rare in the case of underground miners, which in part no doubt is attributable to the possible germicidal action of coal dust. Too much, however, must not be made of this fact, which can have but an indirect bearing upon the coal miners' increased liability to respiratory diseases, more or less seriously complicated by continuous and considerable coal-dust exposure. In the opinion of Sir Thomas Oliver, so far as coal miners' phthisis is concerned, "it may be stated that a collier who develops anthracosis may live for years and be little inconvenienced by his malady," but he also points out that in consequence of dust exposure serious damage is done to the ciliated epithelium of the trachea and bronchii, which act as a defensive barrier to the lungs, in that the dust caught in the mucus secreted by the tubes is, by the waving action of the ciliated epithelium, wafted outward; and that, therefore, the recurrent colds lead to a shedding of the ciliated epithelium and with this desquamation an important defense is lost to the lungs. "This circumstance," he concludes, "is not without importance since recurrent catarrh of the upper respiratory passages is a frequent prelude to pneumoconiosis." On this account alone there is evidence that there is a direct relation between dust and the excessive mortality from nontuberculous diseases, or from all respiratory diseases combined, whether tuberculous or otherwise, in view of the fact that the clinical diagnosis is frequently superficial and not sustained by postmortem. Sir Thomas Oliver is unquestionably correct in his statement that "in the case of the coal miner it is not the carbon particles of the coal but the stony particles to which the carbon particles are affixed which injure the lungs;" but in this case also the conclusion must not be carried too far, since at the present time no data are available regarding the true nature of a sufficient number of coal-dust samples with reference to mineral and even metallic impurities. The statistical evidence, however, is sufficient for the purpose, that coal mining, on account of dust exposure, requires to be included among the duty trades injurious to health, with a decided consequential predisposition to respiratory diseases, whether tuberculous or nontuberculous, as the case may be.

The only additional statistical information available regarding the mortality of coal miners in the United States is the combined collective experience of American life insurance companies, issued by the medico-actuarial committee. The experience, fortunately, is divided into anthracite and bituminous, but not with reference to the causes of death. The data are set forth in detail in Table 161, which indicates the ratio of the actual to the expected mortality, showing for the anthracite coal miners a ratio of 191 deaths actually experienced against 132 for the bituminous miners. How far the factor of occupational selection is of importance has not been determined. In all probability the average duration of insurance in bituminous coal fields is less than in the older anthracite fields. The experience for both classes is entirely too limited for a safe conclusion in that there are only 66 deaths of anthracite coal miners and 45 deaths of bituminous coal miners. The small number exposed to risk at the older ages is suggestive of extreme care in medical selection. The table, particularly for the younger ages, indicates that the general mortality of coal miners in the United States is distinctly above the average.

TABLE 161.—MORTALITY FROM ALL CAUSES AMONG COAL MINERS OF UNITED STATES (MEDICO-ACTUARIAL EXPERIENCE), BY AGE GROUPS.

| Age at death. | Number exposed to risk. | Actual deaths. | Expected deaths. | Ratio of actual to expected deaths. |
|---|---|---|---|---|
| ANTHRACITE COAL MINERS. | | | | |
| 15 to 29 years | 1,412 | 11 | 6.71 | 164 |
| 30 to 39 years | 1,460 | 15 | 8.89 | 169 |
| 40 to 49 years | 949 | 22 | 9.76 | 225 |
| 50 to 59 years | 405 | 17 | 8.89 | 191 |
| 60 years and over | 9 | 1 | .30 | 333 |
| Total | 4,235 | 66 | 34.55 | 191 |
| BITUMINOUS COAL MINERS. | | | | |
| 15 to 29 years | 2,883 | 22 | 12.60 | 175 |
| 30 to 39 years | 2,684 | 18 | 13.75 | 131 |
| 40 to 49 years | 738 | 4 | 6.00 | 67 |
| 50 to 59 years | 106 | 1 | 1.79 | 56 |
| 60 years and over | 3 | ........ | .08 | ........ |
| Total | 6,414 | 45 | 34.22 | 132 |

In concluding these observations mention should be made of the observations by Hayhurst, which have reference to the bituminous coal mines of Ohio. No field investigation of the coal-mining industry was made by the division of occupational diseases, but it is said that the principal occupational afflictions to which miners in the types of mines which are worked in Ohio are most liable are: "Respiratory diseases (pneumonia, anthracosis, pulmonary cirrhosis, emphysema, phthisis, pleurisy, and middle-ear disease), hookworm disease, typhoid fever, trachoma or granulated eyelids, nystagmus or dancing pupils, 'beat hand,' 'miners' elbow,' while the effects of sulphur fumes upon the lungs, skin, and eyes should be inquired into."

Reference is made to the Ohio vital statistics for the three years 1910–1912, according to which out of 1,484 deaths of miners from all causes, 114, or 7.68 per cent, were deaths from pulmonary tuberculosis. The corresponding proportion for farm labor was 7.13 per cent. The average age at death of 464 coal miners in Ohio in the year 1911 was 49.3 years. These observations are in general conformity to the results of other investigations, but they obviously fall far short of the required scientific conclusiveness. The coal-mining industry is of such vast importance to the Nation, and to the large number of men employed in the industry, that there is the utmost urgency for a strictly scientific inquiry into the facts of disease pre-industry is of such vast importance to the Nation and to the large economic loss on account of an excess in the death rate from all causes, and from respiratory diseases, whether tuberculous or otherwise, in particular. Aside therefrom there is unquestionably also a very considerable amount of needless premature invalidity, as is clearly shown by the experience of German miners' associations, and to a lesser extent by the investigations made by life insurance companies in the United States.[1] It is, therefore, to be hoped that future investigations, medical or statistical, will be made with a due regard to more exacting requirements, so that the existing amount of superficial information, more or less misleading, may be replaced by trustworthy data and conclusions which bear the stamp of scientific accuracy and impartiality.[2]

## QUARRYING.

The quarrying industry, according to the report of the Bureau of Mines for 1915, gave employment to 100,740 persons, among whom there occurred 148 fatal accidents, or 1.80 per 1,000 300-day workers, compared with 3.89 for metal mines and 4.44 for coal mines.[3] The relative importance of the accident factor in its relation to the mortality from disease is, therefore, obviously of lesser importance in this branch of the mining industry. The vital statistics of quarrymen are as a rule combined with the mortality data of stone workers, so that only the most general conclusions can be drawn from the available data.

Parry, in his treatise on the "Risks and dangers of occupations," observes that—

> Quarrymen engaged in taking out stone, slate, etc., have a high death rate, 582 compared with 402 for all males from lung diseases, the danger of the occupation varying with the physical and chemical properties of the dust created. In the various operations for obtaining alabaster, graphite, and china clay the particles produced are not sharp or angular, and the effects of inhalation consequently not so very serious. It may here be noticed that the minute fragments of graphite are also breathed in during the manufacture of lead pencils.

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[1] For the essential facts of what is perhaps the most successful and important of modern social institutions established for the progressive betterment of the conditions of mine labor and life, and the mitigation of the economic hardships resulting from the more or less inevitable casualties in the mining of coal, see "German Miners' Insurance and Annuity Funds," by F. L. Hoffman, published in The Engineering and Mining Journal, Vol. 90, Nos. 18, 19, 20, and 21 (New York, Oct. 29, Nov. 5, 12, and 19, 1910).

[2] On account of the increasing attention which is being given to the use of powdered coal as fuel, it is a foregone conclusion that the subject of coal dust in its relation to health will require more extended consideration in the future. The technical aspects of the manufacture of powdered coal for fuel are set forth in a discussion by Harry Holmes in the Scientific American for April 18, 1914, and with reference to briquetting methods a Belgian process is described by the late Lindon Bates, jr., in the Scientific American Supplement for December 10, 1910. The handling of coal dust at a coal washery, in conformity to modern methods, is described by J. Drummond Paton in the Coal Age for October 18, 1913. The hygienic aspects of dust control in anthracite breakers are set forth by J. J. Jones in the Engineering and Mining Journal of April 2, 1910.

[3] United States Bureau of Mines, Technical Paper 168, p. 51.

In chalk and limestone quarries the work is carried out so much in the open air that the dust is largely got rid of before it is inhaled, and the occupation does not appear to be a very risky one. Slate quarrying is the most formidable of all, as here the atoms are so sharp and pointed, and it is among those who are occupied in the sawing and dressing of the stone, where the dust is specially freely produced, that lung disease is most rampant. The only special remark as to prevention is this: During operations in which most dust is created, respirators should be worn.

These observations can not be considered conclusive, and the recommendation regarding the general use of respirators is inapplicable to most of the important processes in the quarrying industry.[1] Lloyd, in his treatise on "Diseases of occupations," largely with reference to American conditions, points out that—

Stonecutters and quarrymen suffer in various degrees from the inhalation of dust. The extent of the evil in their cases depends upon, first, the character of the dust, and, second, the circumstances amid which the work is pursued. Quarrymen are liable to accidents and to the effects of very hard labor. If they work underground or in deep quarries they may suffer with the effects of dampness. The quality of the stone has much to do with the extent of pulmonary disease among stonecutters. Some stone is much more dusty than others. A sedimentary stone, for instance, that was formed originally simply by the deposit of earthy and silicious particles under water is much more liable to give off a large quantity of dust than is a stone that was fused in early geological ages—the igneous stones, for instance, like granite. Although the particles from these stones are exceedingly hard, there is not much true dust, only the particles actually displaced by the contact with the tool being thrown off. These probably do not carry far in the air, and are mostly too large to gain access to the alveoli as dust. This was the explanation given by Hamilton, of Aberdeen (quoted by Arlidge), for the fact that the masons and polishers at the Aberdeen quarries do not suffer much if any with industrial phthisis.

Lloyd combines stonecutters and quarrymen in a broad generalization, which is obviously unscientific in view of the widely varying conditions under which quarrying methods proper are carried on as separate and distinct from the millwork, which consists chiefly in the sawing, cutting, and polishing of the stone. His observation, however, that the quality of the stone has much to do with the extent of pulmonary disease among stonecutters is equally applicable to

[1] See in this connection the "Elements of Mining and Quarrying," by Sir C. Le Neve Foster, London, 1903; also an exceptionally interesting though brief discussion on "Quarrying hazards," in the Travelers' Standard, April and May, 1917; an earlier but still very useful account of quarrying methods by F. W. Sperr is included in the report on Building Stones and the Quarrying Industry of the Tenth Census. Except to the extent that new methods have been introduced into the industry during the intervening period of time this account is still one of the most useful for practical purposes. Reference, however, requires also to be made to Census Bulletin 45, Washington, 1891, in which the methods of quarrying are described with reasonable thoroughness. A descriptive account of present-day methods is by Frank C. Perkins, Scientific American Supplement No. 2118, August 5, 1916.

quarrymen, although the latter unquestionably suffer decidedly less from the risk of dust inhalation, chiefly on account of the fact that most of the work is carried on in the open air.

A fairly comprehensive discussion of the health of quarrymen with special reference to the conditions of employment, by Brown and Kelynack, is included in Oliver's Dangerous Trades. A quarry is defined as "an excavation, pit, or place from which stone or rock material is separated by digging, cutting, blasting, or similar processes." This definition includes most, but not all, forms or methods of rock excavation in which hand and power drills are extensively and frequently exclusively employed. Quarrying includes a larger variety of stone products than the stone industry separately considered, when the term "quarrying" is made to include the common methods of rock crushing, which are unquestionably among the most unhealthy branches of the industry. This conclusion applies especially to trap rock, which is quarried and crushed on a large scale for road-building purposes. The term, however, is not applicable to tunneling, which is more properly a branch of the mining industry. According to Brown and Kelynack, "the quarryman, from the nature of his work and the circumstances under which it is carried on, is necessarily exposed to influences which may (1) excite or (2) predispose to morbid conditions, and in not a few cases it is difficult, if not impossible, to sharply distinguish between them." Aside from the obvious liability to serious and fatal accidents, the subject of disease frequency is referred to with special reference, of course, to prevailing conditions in the United Kingdom, in part as follows:

After having made extensive inquiries with a view to ascertain the extent of actual disease which may be fairly considered as incidental to quarrying, we are drawn to the conclusion that such work, generally speaking, is not necessarily detrimental to health. The medical officers and managers of most of the large quarries from whom we have sought information are decisive in considering quarrying, as usually carried out in this country, a fairly healthy occupation. Of course quarry workers are liable to many ailments to which all laborers are more or less prone, and their habits and social customs are not always such as to maintain a high degree of physical vigor. Unfortunately, in many parts the quarrymen are thriftless and drunken. Their homes also are often ill built and ill kept. A neglect of habits of cleanliness is, in many instances, only too apparent. In some parts of the country the quarrymen are of poor physique, which arises, according to local opinion, from too early marriage, intermarriage, excessive tea drinking, and poor diet.

In continuation, it is said that quarrying is by no means an employment dangerous to health, as is made evident by the fact that in many quarry districts old men abound, many of whom work until over 80 years of age. This observation is likely to be misleading, on account of the comprehensive nature of the quarry industry. Unquestionably much of the work, especially when carried on without the use of power drills, is not distinctly injurious to health, and old men may safely be employed in processes not involving serious physical strain. Since most of the work in connection with quarries is carried on in the open air, there are frequently decided physical advantages, but notwithstanding these, the general statistical evidence for the United Kingdom and, as far as available, for the United States is quite conclusive that the mortality from pulmonary tuberculosis among quarrymen, considered as a group, is distinctly above the normal. Brown and Kelynack, in continuation of their observations on the diseases of quarrymen, with special reference to the respiratory organs, observe that—

Lesions in connection with the lungs and air passages have long and rightly been considered the more particular accompaniment of work associated with the production of dust. But in most forms of quarrying the amount of dust and its means of access to the respiratory tract must be considered so limited that serious pulmonary disease is quite the exception.

Where, however, in connection with quarry works there is also extensive dressing of soft material like sandstone or the preparation of material giving rise to such irritating particles as granite, changes in the bronchi and lungs are liable to occur. The bronchi then become the seat of an excessive formation of mucus, and it may be that a catarrhal process is established which may progress to a chronic bronchitis, to which will sooner or later be added the usually associated conditions.

The lungs may absorb more or less of the dust particles which, becoming deposited in the interalveolar and subpleural lymphatics, or arrested in the bronchial glands, give a greater or less degree of pigmentation to the lung (pneumoconiosis). Should, however, as is very likely, the particles of stone dust produce marked irritation, the reaction of the tissues will lead to the formation of fibrous tissue which may not only lessen the function of the lungs as blood-aerating organs but predispose them to the invasion of the tubercle bacillus.

It is difficult to understand how, in view of the foregoing and the readily ascertainable facts of the conditions under which the industry is carried on, the authors of the preceding observations should conclude that, "Quarry workers would appear to be but little predisposed to tuberculosis, and doubtless the outdoor character of the work greatly militates against the liability to infection."

According to the available occupation mortality statistics for England and Wales (1900–1902), quarrymen, chiefly with reference to stone and slate, considered as a group and numbering, according to the last census, 71,450, experienced a general death rate slightly above the standard for occupied males at ages 15 to 25 and 55 to 65 years. In the main working time of life their comparative mortality figure was 6 per cent less than the standard. The mortality from respiratory diseases and from phthisis was "no less than 70 per cent above the standard." Comparing the data for 1900–1902 with previous years, it appears that the death rate from all the principal causes had declined, but regardless of the diminution, including a reduction in the mortality from phthisis, the most recent statistics reemphasize the earlier conclusion of a substantial excess in the death rate of quarrymen from pulmonary tuberculosis.

### AMERICAN MORTALITY EXPERIENCE.

For the United States there are no recent statistics generally applicable to the problem under consideration other than the experience of the Prudential Insurance Co. of America, limited, however, to only 149 specified deaths of quarry employees from all causes; and of this number only 22, or 14.8 per cent, were from pulmonary tuberculosis. The experience is set forth in the usual form in Table 162.

TABLE 162.—PROPORTIONATE MORTALITY FROM PULMONARY TUBERCULOSIS AMONG QUARRY WORKERS, INDUSTRIAL EXPERIENCE OF PRUDENTIAL CO., 1907 TO 1914, COMPARED WITH THAT OF ALL MALES IN THE UNITED STATES REGISTRATION AREA, 1900 TO 1913, BY AGE GROUPS.

| Age at death. | Deaths of quarry workers, 1907 to 1914, from— | | Per cent of deaths from pulmonary tuberculosis among— | |
|---|---|---|---|---|
| | All causes. | Pulmonary tuberculosis. | Quarry workers. | Males in registration area, 1900 to 1913. |
| 15 to 24 years | 12 | 2 | 16.7 | 27.0 |
| 25 to 34 years | 12 | 1 | 8.3 | 30.5 |
| 35 to 44 years | 26 | 6 | 23.1 | 23.4 |
| 45 to 54 years | 27 | 4 | 14.8 | 14.7 |
| 55 to 64 years | 39 | 8 | 20.5 | 7.9 |
| 65 years and over | 33 | 1 | 3.0 | 2.6 |
| Total, 15 years and over | 149 | 22 | 14.8 | 13.9 |

This table can not be considered entirely conclusive, but it is quite suggestive that the apparent mortality from pulmonary tuberculosis in this group should have been in such close conformity to the normal mortality of males in the registration area. When, however, separately considered, particularly at the ages over 55, there is apparently a tendency toward an excess in the proportionate mortality from pulmonary tuberculosis which it is reasonably safe to assume would upon the basis of a more extensive inquiry be found even more pronounced than is the case in the rather limited experience available.

## DUST HAZARDS OF THE QUARRYING INDUSTRY.

The inclusion of certain branches of the stone industry under quarrying has seemed preferable to the consideration of the hygienic aspects of such employments under specified trades with exposure to mineral dust. The technology of quarrying is extremely involved, and the preceding conclusions must be accepted with reserve, and, as regards the different branches of the quarrying industry, they are subject to the more extended consideration of the dust hazards in the several branches of the stone industry. Stone, in all of its forms, contains varying proportions of impurities, both metallic and mineral, which, under given conditions, may seriously complicate the statistical consideration of the question as to how far any particular stone material is directly injurious to health and a predisposing cause of pulmonary tuberculosis. The hygiene of quarrying has not been made a subject of extended and qualified inquiry, but a most useful contribution to the technology of marble quarrying, with carefully considered observations on quarrying methods, including the removal of the over-burden, the drilling of the holes, and the subsequent millwork and finishing of the stone product, has been made public by the United States Bureau of Mines. Additional information of value is contained in a number of special reports of the United States Geological Survey, chiefly on the granites of New England and the Southeastern Atlantic States. The mortality of stonecutters as a class has also been considered by the Massachusetts State Board of Health, according to which, for the year 1907, of the mortality among stonecutters in the Quincy district 41 per cent of the deaths were from pulmonary tuberculosis, and approximately the mortality from this disease among stone and marble cutters and carvers was five times greater than among farmers or lumbermen.[1] The Ohio State Board of Health in the January, 1914, Bulletin (p. 99) takes occasion to point out in this connection that—

A man doing ordinary work breathes 21 cubic feet of air per hour. If this air is saturated with dust, gases, or poisons he also breathes

[1] The occurrence of lung diseases among quarrymen is the subject of an interesting editorial in the British Medical Journal of March 23, 1912. With reference to conditions in Shropshire, it is said that—

The stone contains 95.4 per cent of silica. On microscopical examination the particles of stone are found to vary from 1/100 to 1/600 of an inch in diameter. Some of the particles are rounded and transparent, others are sharp and angular.

As to the menace of dust inhalation Dr. Wheatley is quoted in the statement that—

In guttering the stone considerable quantities of dust are inhaled, as the men have to lean forward and bend closely down upon their work. As the quarrymen have good homes, live in a healthy district, receive wages above the average working population, and are on the whole a temperate class, the high mortality rate from phthisis among them must be largely the result of their occupation. Some of the men retire from the quarries and stone work after a few years. Most of the men in the district who are alive after 60 have not worked exclusively in stone. Taking the average annual death rate from phthisis per 1,000 for 31 years, quarrymen give 7.94 and masons 16.71, whereas the death rate of males over 20 years of age from phthisis in the same district is only 1.47, a figure which compares most favorably with the phthisical death rate of males over 20 years of age for 1901 in England and Wales, which was 2.37. The high death rate from phthisis of stoneworkers, which is seven times greater than that of the other people of the county, can only be explained by the dusty nature of the occupation.

them. In our modern methods of drilling rock, slate mining, quarrying, and stonecutting, men breathe no end of pernicious dust. The English found that rock drillers, who have no protection, average 8 to 10 years at the trade, and their average age at death is 35 years. The harder the rock the more the danger. Those who work piecework succumb the soonest. Death is principally due to pneumonia and consumption. One-fourth of the weight of the lungs of a rock driller at death has been found to be due to silica—that is, inhaled rock dust.

Employers should cooperate in lessening the incidence of these diseases among this class of workers by (1) employing men of sound constitution, and particularly should attention be given to this point in case of youths; (2) inform the men of the dangerous character of this work; (3) arrange for periodic medical examinations; (4) all machine planing, as well as sawing, should be done in the wet (perhaps using mineral oil); (5) stonemasons' sheds should be cleaned out and made free from dust each day; (6) openings to the shed should be at the floor or not higher than 3 feet from the floor, so that the dust, which is rather heavy, will not rise to the breathing level when it is blown out; and (7) where mechanical power is used fans should be installed and air delivered above the head of the men so that the dust is blown downward, while locally applied exhaust systems can be used in several processes of the work. The employee should breathe only through his nose, and, when inhalation of dust is unavoidable, should wear a wet sponge or other form of respirator. All the schools in a stone area should give special lessons on the danger of dust, upon proper methods of breathing, while medical school supervision would find the cases of obstructed nasal breathing during youth.

Additional evidence seems hardly necessary to emphasize the seriousness of the dust hazard in the quarrying industry, irrespective of the material extracted or the methods employed, except in so far as the degree of injuriousness is invariably increased by the more or less extensive use of pneumatic tools.[1]

### VITAL STATISTICS OF CENTERS OF GRANITE INDUSTRY.

Quarrying is, of course, the preliminary extraction process in the stone industry. The more important aspects of the stone dust exposure have been elsewhere discussed in some detail, but it has seemed advisable to bring together for the present purpose some rather interesting statistics of the mortality from pulmonary tuberculosis and from other respiratory diseases in the centers of the American stone industry, with special reference to the nature of the stone product quarried. Table 163 exhibits the mortality of the centers of granite production, by counties, in the States of Maine, New Hampshire, and Vermont. In each case the county referred

[1] See in this connection the report elsewhere referred to "On the Prevalence of Phthisis among Quarry Workers and Miners," by Sidney Barweis, M. D., county medical officer, Derbyshire, 1913; also an address on "Quarrying," by S. Le Neve Foster, Journal of the Sanitary Institute, London, 1894.

to as a granite center is such as is specifically made note of in the annual reports of the United States Geological Survey on the stone industry.[1] Of course, in some counties the industry is of much greater predominating importance than in others.

TABLE 163.—MORTALITY FROM PULMONARY TUBERCULOSIS AND FROM OTHER RESPIRATORY DISEASES IN THE CENTERS OF THE GRANITE INDUSTRY, 1909 TO 1913.

| Locality. | Pulmonary tuberculosis. | | Other respiratory diseases. | |
|---|---|---|---|---|
| | Per cent of deaths from all causes. | Death rate per 100,000. | Per cent of deaths from all causes. | Death rate per 100,000. |
| Hancock County, Me. | 6.8 | 104.6 | 11.7 | 180.4 |
| Kennebeck County, Me. | 7.4 | 133.6 | 12.5 | 226.5 |
| Augusta | 7.9 | 194.1 | 12.8 | 316.5 |
| Waterville | 8.9 | 136.8 | 14.7 | 225.7 |
| Rural | 6.7 | 111.4 | 11.7 | 195.2 |
| Knox County, Me. | 8.4 | 145.7 | 8.7 | 152.4 |
| Lincoln County, Me. | 6.4 | 102.0 | 9.1 | 144.1 |
| Waldo County, Me. | 7.0 | 121.1 | 10.1 | 174.4 |
| Washington County, Me. | 9.6 | 137.0 | 11.5 | 165.2 |
| Maine granite counties | 7.7 | 126.9 | 11.1 | 183.8 |
| State of Maine | 7.0 | 110.8 | 12.1 | 192.9 |
| Carroll County, N. H. | 4.9 | 82.5 | 12.3 | 206.8 |
| Hillsboro County, N. H. | 6.6 | 115.3 | 12.6 | 218.3 |
| Manchester | 6.5 | 113.9 | 13.9 | 242.5 |
| Nashua | 5.8 | 95.2 | 11.7 | 191.1 |
| Rural | 7.5 | 136.3 | 10.1 | 184.0 |
| Merrimack County, N. H. | 6.8 | 128.0 | 9.8 | 186.0 |
| Concord | 6.0 | 128.0 | 8.9 | 189.6 |
| Rural | 7.4 | 128.0 | 10.6 | 183.5 |
| New Hampshire granite counties | 6.5 | 116.0 | 11.7 | 203.6 |
| State of New Hampshire | 6.2 | 105.0 | 11.6 | 196.7 |
| Caledonia County, Vt. | 5.9 | 94.5 | 11.5 | 182.2 |
| Windsor County, Vt. | 4.3 | 79.6 | 11.6 | 213.2 |
| Vermont granite counties | 5.0 | 86.6 | 11.5 | 198.6 |
| State of Vermont | 5.8 | 91.8 | 11.7 | 183.1 |
| *Summary.* | | | | |
| All granite counties | 6.9 | 117.4 | 11.4 | 196.2 |
| States of Maine, New Hampshire, and Vermont | 6.5 | 104.7 | 11.9 | 191.7 |

Combining all the counties in which the granite industry in the three States is of sufficient local importance, it appears that the mortality rate from pulmonary tuberculosis as well as from other respiratory diseases is not very materially above the average for the States, considered as a group; and the same conclusion applies to the proportionate mortality for respiratory diseases other than pulmonary tuberculosis, which, in fact, is slightly lower. Some very important differences, however, are shown in the larger centers of the granite industry in Maine, as, for illustration, at Augusta, where the death rate from pulmonary tuberculosis is 194.1 per 100,000, against 110.8 for the State as a whole. The mortality of Augusta from other respiratory diseases is also extremely high, or 316.5 per 100,000,

[1] For a strictly scientific discussion of "The Commercial Granites of Massachusetts, New Hampshire, and Rhode Island, with Maps and Illustrations," see Bulletin No. 354, of the U. S. Geological Survey, Washington, 1908. See also a separate discussion of "The Granites of Vermont," by the same author, in Bulletin No. 404 of the U. S. Geological Survey, Washington, 1909. For a discussion of Safety in Stone Quarrying, with observations on ventilation, etc., by Oliver Bowles, see Technical Paper 111, Bureau of Mines, Washington, 1915.

against 192.9 for the State as a whole.[1] Somewhat similar are the conclusions for certain granite-producing counties considered in detail for the States of New Hampshire and Vermont. This method of analysis is at present the only available means of arriving at approximately accurate conclusions, since thus far no investigation of the subject has been made by Federal or State authority or by a detailed analysis of life insurance experience.

### VITAL STATISTICS OF CENTERS OF MARBLE INDUSTRY.

The geographical distribution of the marble industry for the States for which official vital statistics are available is very limited, and the data for the State of Vermont are of most value. Table 164 shows that in the Barre district, which is the center of the Vermont marble industry, both the proportionate and the relative mortality from pulmonary tuberculosis are decidedly above the average for the State as a whole; in fact, it is extremely suggestive that even for all the marble counties combined the excess in the mortality from pulmonary tuberculosis should be as pronounced as is actually the case.

TABLE 164.—MORTALITY FROM PULMONARY TUBERCULOSIS AND FROM OTHER RESPIRATORY DISEASES IN THE CENTERS OF THE MARBLE INDUSTRY, 1909 TO 1913.

| Locality. | Pulmonary tuberculosis. | | Other respiratory diseases. | |
|---|---|---|---|---|
| | Per cent of deaths from all causes. | Death rate per 100,000. | Per cent of deaths from all causes. | Death rate per 100,000. |
| Bennington County, Vt | 4.7 | 70.4 | 11.2 | 166.3 |
| Franklin County, Vt | 6.4 | 94.5 | 11.1 | 164.3 |
| Grand Isle County, Vt | 8.9 | 108.8 | 12.0 | 146.9 |
| Washington County, Vt | 9.1 | 136.6 | 12.1 | 181.4 |
| Barre | 18.5 | 239.7 | 11.8 | 152.5 |
| Rural | 6.4 | 100.3 | 12.2 | 191.6 |
| Vermont marble counties [1] | 7.3 | 108.8 | 11.6 | 171.6 |
| State of Vermont | 5.8 | 91.8 | 11.7 | 183.1 |

[1] Exclusive of Rutland County, which will be found under slate counties. This county shows an excessive rate over the rate for the State as a whole.

In the Barre district the proportionate mortality from pulmonary tuberculosis is 18.5 per cent against only 5.8 per cent for the State as a whole; while the relative mortality per 100,000 of population is 239.7 for Barre against 91.8 for the State. In contrast, however, the proportionate mortality from other respiratory diseases is about normal, while the death rate from this group of diseases for Barre is below the average for the State. Here again the averages are merely approximate, and they must be made use of with extreme caution.

[1] How far these rates are affected by local hospitals or institutions can not be stated, but the possibility of such an effect should not be lost sight of.

### VITAL STATISTICS OF CENTERS OF SANDSTONE INDUSTRY.

The centers of the sandstone industry are chiefly in the States of New York, Ohio, and Pennsylvania. Combining the returns for all the sandstone counties, both the proportionate and the relative mortality from pulmonary tuberculosis are below the averages for the States considered as a group; but there are, however, some exceedingly interesting and suggestive exceptions to this conclusion, particularly in the case of the Rome district in Oneida County, N. Y., where the relative rate from pulmonary tuberculosis is 264.9 per 100,000 against 152.3 per 100,000 for the State of New York. But the corresponding mortality from other respiratory diseases is somewhat below the average. The mortality from respiratory diseases in some sections is relatively high, but throughout the data brought together are not distinctly suggestive of a pronounced excess in the mortality of the counties which are representative of the sandstone industry, as being above the average for the remainder of the territory under consideration. The details for the sandstone centers are given in Table 165.

TABLE 165.—MORTALITY FROM PULMONARY TUBERCULOSIS AND FROM OTHER RESPIRATORY DISEASES IN THE CENTERS OF THE SANDSTONE INDUSTRY, 1909 TO 1913.

| Locality. | Pulmonary tuberculosis. | | Other respiratory diseases. | |
|---|---|---|---|---|
| | Per cent of deaths from all causes. | Death rate per 100,000. | Per cent of deaths from all causes. | Death rate per 100,000. |
| Orleans County, N. Y. | 7.2 | 105.5 | 9.2 | 133.5 |
| Oneida County, N. Y. | 7.8 | 138.5 | 12.7 | 225.7 |
| Rome | 12.6 | 264.9 | 9.1 | 192.0 |
| Utica | 7.3 | 136.4 | 13.7 | 257.0 |
| Rural | 6.3 | 95.9 | 12.9 | 197.1 |
| New York sandstone counties | 7.7 | 132.9 | 12.2 | 210.0 |
| State of New York | 9.9 | 152.3 | 14.0 | 215.7 |
| Cuyahoga County, Ohio | 8.5 | 115.6 | 11.7 | 159.0 |
| Cleveland | 8.7 | 119.2 | 11.9 | 163.6 |
| Lakewood | 7.6 | 81.3 | 9.3 | 100.1 |
| Rural | 7.5 | 91.0 | 10.9 | 131.6 |
| Lorain County, Ohio | 6.7 | 83.4 | 10.7 | 132.5 |
| Lorain | 6.1 | 76.2 | 11.3 | 141.8 |
| Elyria | 6.0 | 74.5 | 10.1 | 125.9 |
| Rural | 7.7 | 94.5 | 10.4 | 127.0 |
| Ohio sandstone counties | 8.4 | 112.1 | 11.6 | 155.2 |
| State of Ohio | 9.2 | 122.6 | 10.4 | 138.4 |
| Clearfield County, Pa | 4.2 | 47.8 | 14.5 | 166.3 |
| Fayette County, Pa | 5.0 | 71.2 | 14.9 | 210.4 |
| Connellsville | 6.9 | 94.0 | 11.7 | 158.5 |
| Uniontown | 5.1 | 79.1 | 10.7 | 165.7 |
| Rural | 4.9 | 68.9 | 15.5 | 218.0 |
| Mercer County, Pa | 5.7 | 73.1 | 11.1 | 142.0 |
| Sharon | 7.5 | 102.1 | 12.5 | 170.2 |
| Rural | 5.2 | 64.9 | 10.6 | 134.1 |
| Westmoreland County, Pa | 4.9 | 62.5 | 13.0 | 167.1 |
| Greensburg | 4.6 | 77.1 | 11.0 | 185.5 |
| Monessen | 5.5 | 60.2 | 18.5 | 203.5 |
| Rural | 4.9 | 61.9 | 12.9 | 164.3 |
| Pennsylvania sandstone counties | 4.9 | 64.4 | 13.6 | 177.1 |
| State of Pennsylvania | 7.7 | 112.5 | 13.3 | 194.5 |
| *Summary.* | | | | |
| All sandstone counties | 7.0 | 96.6 | 12.4 | 170.9 |
| States of New York, Ohio, and Pennsylvania | 9.0 | 131.6 | 13.0 | 191.2 |

### VITAL STATISTICS OF CENTERS OF LIMESTONE INDUSTRY.

In curious contrast, more definite indication of health-injurious conditions is brought out by an analysis of the statistics for the limestone counties of Kentucky, Missouri, and Indiana as shown in Table 166.

TABLE 166.—MORTALITY FROM PULMONARY TUBERCULOSIS AND FROM OTHER RESPIRATORY DISEASES IN THE CENTERS OF THE LIMESTONE INDUSTRY, INDIANA (1909 TO 1913), KENTUCKY AND MISSOURI (1911 TO 1913).

| Locality. | Pulmonary tuberculosis. | | Other respiratory diseases. | |
|---|---|---|---|---|
| | Per cent of deaths from all causes. | Death rate per 100,000. | Per cent of deaths from all causes. | Death rate per 100,000. |
| Warren County, Ky | 14.9 | 225.7 | 9.0 | 136.7 |
| Kentucky | 14.3 | 186.6 | 10.0 | 130.6 |
| Jasper County, Mo | 13.2 | 161.2 | 12.1 | 147.4 |
| Missouri | 10.3 | 131.3 | 11.6 | 146.8 |
| Lawrence County, Ind | 12.5 | 165.3 | 9.9 | 131.3 |
| Monroe County, Ind | 12.6 | 161.8 | 10.2 | 131.4 |
| Indiana | 10.1 | 132.8 | 9.7 | 127.6 |
| *Summary.* | | | | |
| Limestone counties | 13.2 | 174.4 | 10.4 | 136.7 |
| States of Kentucky, Missouri, and Indiana | 11.1 | 144.6 | 10.4 | 134.6 |
| Per cent of mortality excess in limestone counties | 18.9 | 20.6 | ............ | 1.6 |

In all of the counties combined both the proportionate and the relative mortality from pulmonary tuberculosis are above the average, while the mortality from other respiratory diseases is about the same. There is an extraordinary excess in the mortality from pulmonary tuberculosis in Warren County, Ky., as well as in Jasper County, Mo., where, however, the situation is complicated by the zinc and lead-mining industries. (See p. 360.)

### VITAL STATISTICS OF CENTERS OF BLUESTONE INDUSTRY.

In the case of all the counties under consideration the mortality from respiratory diseases other than pulmonary tuberculosis is relatively normal. The counties in which the bluestone industry is of importance in the States of New York and Pennsylvania show rather a lesser mortality, with, however, a rather important exception at Kingston, in Ulster County, N. Y., where the industry is thoroughly well represented, the mortality rate from pulmonary tuberculosis being 205.6 per 100,000, against 152.3 for the State. The mortality from other respiratory diseases, however, is both proportionately and relatively below the average. In Pike County, Pa., the relative mortality from pulmonary tuberculosis is 125.9 per 100,000, which compares with 112.5 per 100,000 for the State as a whole. All the bluestone counties combined, however, show a lower proportionate and relative mortality from pulmonary tuberculosis than the States considered as a group. The same conclusion applies to other respiratory diseases. The details for the bluestone industry are given in Table 167.

TABLE 167.—MORTALITY FROM PULMONARY TUBERCULOSIS AND FROM OTHER RESPIRATORY DISEASES IN THE CENTERS OF THE BLUESTONE INDUSTRY, 1909 TO 1913.

| Locality. | Pulmonary tuberculosis. | | Other respiratory diseases. | |
|---|---|---|---|---|
| | Per cent of deaths from all causes. | Death rate per 100,000. | Per cent of deaths from all causes. | Death rate per 100,000. |
| Delaware County, N. Y | 4.9 | 70.8 | 11.4 | 166.7 |
| Ulster County, N. Y | 9.0 | 140.7 | 12.2 | 189.2 |
| Kingston | 10.9 | 205.6 | 9.5 | 180.3 |
| Rural | 8.1 | 115.1 | 13.5 | 192.8 |
| New York bluestone counties [1] | 7.7 | 117.6 | 11.9 | 181.8 |
| State of New York | 9.9 | 152.3 | 14.0 | 215.7 |
| Pike County, Pa | 8.5 | 125.9 | 13.7 | 201.4 |
| Susquehanna County, Pa | 5.3 | 81.7 | 12.4 | 192.2 |
| Wayne County, Pa | 7.4 | 101.0 | 10.9 | 148.3 |
| Wyoming County, Pa | 4.2 | 57.5 | 11.9 | 160.7 |
| Pennsylvania bluestone counties | 6.1 | 87.7 | 12.0 | 173.4 |
| State of Pennsylvania | 7.7 | 112.5 | 13.3 | 194.5 |
| *Summary.* | | | | |
| Bluestone counties | 7.1 | 105.8 | 11.9 | 178.5 |
| States of New York and Pennsylvania | 8.9 | 134.2 | 13.7 | 206.0 |

[1] Sullivan County, N. Y., is a large producer but was left out because of the tuberculosis sanatoria at Liberty.

**VITAL STATISTICS OF CENTERS OF SLATE INDUSTRY.**

Finally, as regards slate-producing counties, the data are also far from conclusive. The details for the centers of the slate industry in Pennsylvania, New York, and Vermont are shown in Table 168.

TABLE 168.—MORTALITY FROM PULMONARY TUBERCULOSIS AND FROM OTHER RESPIRATORY DISEASES IN THE CENTERS OF THE SLATE INDUSTRY, 1909 TO 1913.

| Locality. | Pulmonary tuberculosis. | | Other respiratory diseases. | |
|---|---|---|---|---|
| | Per cent of deaths from all causes. | Death rate per 100,000. | Per cent of deaths from all causes. | Death rate per 100,000. |
| Washington County, N. Y. [1] | 5.6 | 88.3 | 12.3 | 194.1 |
| State of New York | 9.9 | 152.3 | 14.0 | 215.7 |
| Lehigh County, Pa | 7.4 | 116.6 | 11.3 | 179.2 |
| Allentown | 7.7 | 118.9 | 9.6 | 149.4 |
| Rural | 7.1 | 114.6 | 12.7 | 204.8 |
| Northampton County, Pa | 6.6 | 96.1 | 12.2 | 177.2 |
| Easton | 6.4 | 105.2 | 10.9 | 180.7 |
| South Bethlehem | 6.8 | 105.8 | 14.6 | 226.0 |
| Rural | 6.6 | 89.9 | 12.0 | 162.3 |
| Pennsylvania slate counties | 7.0 | 106.1 | 11.7 | 178.2 |
| State of Pennsylvania | 7.7 | 112.5 | 13.3 | 194.5 |
| Rutland County, Vt. [1] | 6.4 | 98.7 | 12.0 | 184.3 |
| Rutland | 5.9 | 100.0 | 10.4 | 176.9 |
| Rural | 6.6 | 98.2 | 12.7 | 187.2 |
| State of Vermont | 5.8 | 91.8 | 11.7 | 183.1 |
| *Summary.* | | | | |
| Slate counties | 6.7 | 102.5 | 11.8 | 181.3 |
| States of New York, Pennsylvania, and Vermont | 8.8 | 133.3 | 13.6 | 205.6 |

[1] These counties are adjoining and the same slate veins are mined.

There is apparently no very clearly defined relation in the general mortality from pulmonary tuberculosis and respiratory diseases in the slate-producing counties when comparison is made with the States under consideration or the States considered as a group. There are, however, some important exceptions. The general mortality of a given section, unless very pronounced, is not likely to be materially affected by the specific, even though quite excessive, mortality of some occupational group subject to more or less injurious exposure to irritating dust. The number of persons employed in distinctly health-injurious processes in most communities is usually relatively so small that the health-injurious consequences of special conditions become obscured by the numerically much more important general circumstances affecting the health and life of the community at large.

## METALLURGICAL INDUSTRIES.

The mortality and the disease liability of men employed in the metallurgical industries and in the occupations supplementary thereto, essential to ore milling or other concentration processes, have not been made the subject of a sufficiently extensive investigation in this or other countries to furnish data of sufficient intrinsic, scientific conclusiveness applicable to American problems of health and industry.[1] According to the last annual report of the United States Bureau of Mines on metal mine accidents the number of persons employed in ore milling and related concentration processes during the year 1915 was 18,564, and in addition thereto the number employed at smelters was 31,327. The industry considered in the aggregate is one of extreme complexity and of widely varying labor and sanitary conditions. All mineral products are as a rule subject to preliminary breaking or crushing processes, in connection with which a large amount of finely comminuted dust is produced, which, according to its chemical or mechanical properties, must necessarily prove more or less injurious to health. The dust hazard is probably of least importance in connection with hand picking or sorting, much of which is frequently done underground, but in the large majority of cases the picking or sorting is carried on in the rock house and in the mills.[2] In modern plants the picking is done chiefly at movable or continuous belts at which the dust hazard is probably of lesser importance than in connection with subsequent crushing and concentration processes. For rock-grinding purposes a large variety of special mills of widely varying construction have been evolved in the progress of ore dressing, from the primitive arrastra to the most modern so-called

[1] For practical details of American ore dressing, see "A Text-Book of Ore Dressing," by Robert H. Richards, S. B., LL. D.; New York, 1909.

[2] For a brief but useful account of "Mill and Smelter Methods of Sampling," by H. J. Stander, see Bulletin No. 26, Metallurgical Series No. 1, University of Arizona, Tucson, 1915-16.

Chili-Huntington mills. Probably the most serious dust hazard is in connection with so-called sampling processes, in which the material to be subjected to subsequent analysis by assaying or otherwise is reduced to the finest possible comminuted condition. In such sampling processes the nature of the gangue or rock material is of much greater importance than the metallic content, and perhaps the most typical illustration of such sampling methods is in connection with modern copper mining, smelting, and refining. The copper ores require a preliminary process of preparation for the subsequent process of roasting, during which the materials are reduced to a condition of extreme dryness in connection with which a considerable amount of dust is produced with more or less health-injurious consequences to the employees. In all of the subsequent processes of roasting, whether in lump or in pulverized form, or in the calcining and the smelting itself, irrespective of the type of the furnace, a considerable amount of dust exposure is inevitable, but since most of the operations are carried on in the open air the health hazards are materially reduced. The introduction of mechanical methods of charging the furnaces and the inclosure of many of the most serious dust-producing operations have during recent years improved working conditions to a measurable degree. There are also reasons for believing that the accident hazards have been reduced, for according to the report of the Bureau of Mines for the year 1915, the fatality rate at ore mills was 1.62, and at smelters 1.21 per thousand employees, which, considering the inherent dangers of the industry, can not be considered excessive.

A descriptive account of the machinery generally in use for rock crushing and ore milling would unduly enlarge the present discussion and be more or less unintelligible without the use of illustrations. Thus far a systematic and well-considered effort has not been made to provide such machinery as far as may be practicable with dust-arresting devices, or to provide otherwise for the more effective protection of the workmen against the risk of dust inhalation which in connection with certain processes attains to most serious proportions. Fortunately from a sanitary point of view much of the labor employed is casual or intermittent, so that distinctly health-injurious effects are less frequently observed than would be the case if continuous employment with considerable dust exposure were prolonged over a period of years. The best scientific account of the diseases of men employed in ore reduction, smelting, and refining is by O. Saeger, of the Friedrichshütte, Upper Silesia (Jena, 1895), following a more extended discussion of accident liability, the effects of severe labor, the health-injurious consequence of heat exposure, contaminated air, intense light, etc. The dust problem is briefly reviewed with reference to its mechanical and chemical characteristics. The latter are of special importance in metallic dust, where lead, arsenic, etc., may prove more immediately injurious than the consequence of dust inhalation in general.

The injurious effect of the finely comminuted dust is conceded without special reference to the metallic content, which, according to its nature, may or may not be of special importance. Modern smelting processes have a decided tendency toward a reduction in the metallic content of the fumes and gases which, in a measure at least, serve the purposes of dust dissemination. Saeger is of the opinion that the mechanical properties of the dust are of greater importance than the dust considered in its chemical aspects, and he refers to the statistics of the miners' union of Upper Silesia for the period 1889–1892, according to which the average percentage of sickness was 47.4 per annum, and the proportion attributable to diseases of the respiratory organs was 7.4. The distribution of this morbidity was as follows: Acute diseases of the lungs and larynx, 7 per cent; chronic diseases of the lungs and larynx, 1.1 per cent; pneumonia, 1.2 per cent; tuberculosis, 0.36 per cent; and other diseases of the respiratory organs, 0.34 per cent. These statistics do not indicate exceptionally serious conditions, but it should be considered that they have reference to persons employed in connection with ore reduction, smelting, and refining in the aggregate and not specifically with any of the more injurious subdivisions, such as work in the rock samplers or at the crushers, grinders, etc. In the absence of trustworthy statistical information the conclusions must therefore be rather general and in conformity to the closely related health-injurious processes in the general mining and stone industries; in other words, the dust hazard in connection with certain preliminary processes in ore dressing, sampling, smelting, and refining is without question of serious sanitary importance, demanding decidedly more qualified consideration than it has heretofore received.

No statistics are available to prove that pulmonary tuberculosis is excessively common among men employed in smelting and refining. The practical problem concerns the control of metallurgical smoke, which consists of three distinct substances—gases, the flue dust, and the fume. Of these three it is only the flue dust that is of serious importance, consisting of small particles of the different ores, fluxes, or fuel. According to an extended account by Charles H. Fulton, in Bulletin 84 of the Bureau of Mines, "the gases, on account of their high velocity entrain these fine particles and when the velocity is reduced in the dust chambers the particles settle. The amount of flue dust made in different smelting operations varies greatly, depending upon such factors as design of furnace, fineness or coarseness of the ore charge, blast pressure or draft employed, and working condition of the furnace. Estimated on the basis of the tonnage of charge that is smelted, it may range from a fraction of 1 per cent up to 10 per cent of the weight of the furnace charge. Thus, in copper blast-furnace smelting at the Copper Queen mine in Arizona, 1 ton of flue dust was produced for every 17 tons of charge, or 5.6 per cent." According to the same authority, "flue dust varies in size from 0.25-inch to 0.125-inch particles of the lighter materials down to an extremely fine dust resembling impalpable powder." The recovery of this dust in modern metallurgical practice, on account of its metallic content, has attained to considerable economic importance; but it is technically difficult to give separate consideration to flue dust as distinct from fume. The latter, according to Fulton, "consists of the volatile constituents of the ore charge which pass off in the form of vapor with the gases from the furnaces and then sublime into minute solid particles in the cooler part of the flues." He explains further that "in examining the dust chambers and the flue system of a smelting plant, it will be noted that a fine gray-white impalpable powder is deposited on the walls, roof, and the floor of the flues near the stack end of the flue system, the amount being greatest at the stack and diminishing as the furnace is approached. In certain sections of the flues and chambers this fume is mixed with the fine flue dust." Since the harmful constituents of smelter smoke generally are (1) sulphur dioxide gas, (2) sulphuric acid formed from sulphur trioxide generated in the furnaces, (3) fume or fine solid particles containing lead and arsenic compounds and acid sulphates, it is self-evident that the hygiene of smelting and refining is of extreme complexity, practically precluding general conclusions in the absence of an extended scientific inquiry at the present time. Sufficient evidence, however, is available to sustain the conclusion that employment in the so-called bag houses is distinctly injurious to health, particularly in connection with the work necessary in the shaking of the bags. According to H. H. Alexander, in an address before the American Institute of Mining Engineers, on the silver-lead smelting practice at the Globe Smelting & Refining Co., Denver, Colo., "in dislodging the adhering fume from the bags handshaking, when done properly, gives the best results, but it is a slow and disagreeable task, and is being replaced by various mechanical shakers. This mechanical shaking is accomplished by striking the inflated bag lengthwise, quickly jerking the deflated bag up and down, swinging back and forth, or a combination of the motions. Another method is to reverse the flow of the gas through the bags by means of an individual fan or by a second connection between each compartment and the suction side of the main fan." Such methods of bag filtration have been found quite satisfactory in extended experience and a considerable amount of dust hazard has been eliminated. The number of men employed in these operations is very small, so that a trustworthy average exposure is hardly obtainable.

The most hazardous work is in connection with employment in the arsenic recovery house, but there is no evidence to prove that the work predisposes to pulmonary tuberculosis.

Since most of the larger smelting plants have been thoroughly reconstructed during recent years, many improvements have been introduced with substantial benefits to the employees. The public aspects of the smelter-fume question have also directed attention to the urgency of fume-dust controlling devices, but, as stated in the report of the Selby Smelter Commission,[1] the normal diffusion of sulphur dioxide is not distinctly injurious to health or productive of disturbing physiological effects upon the lining of the mucous membrane of the throat and lungs of human beings and domestic animals. Under more primitive methods of smelting practice, such as in former years prevailed at Butte, Mont., deaths were frequently caused by the dissemination of sulphur and arsenic fumes into the general atmosphere, but modern methods of fume prevention and control have practically eliminated this risk. Conversely, the changes have been of benefit to employees in the general smelting industry, and mention also should be made of the fact that smoke helmets are employed to an increasing extent for protective purposes, and quite generally in extremely specialized occupations with exposure to the liability of arsenical, lead, and other forms of metallic poisoning. Such investigations as have been made, chiefly by Dr. Alice Hamilton,[2] indicate that the labor force at smelting and refining plants is of an exceptionally shifting nature and at best less than 30 per cent of the force remain in their employment as long as one year. This condition, on the one hand, tends to increase the liability to lead and other forms of metallic poisoning on account of ignorance or indifference to the risk incurred, while on the other hand there is a diminished liability to chronic forms of lung disease, chiefly pulmonary tuberculosis, because of insufficient length of exposure to the injurious effects of mineral and metallic dust. The safety precautions employed are chiefly with regard to the liability to lead poisoning, but they have a direct bearing also upon the reduction in the general liability to more or less serious dust exposure.

The relative importance of dust exposure at different smelting plants naturally varies according to the nature of the product. At a representative smelting plant on the Pacific coast, out of 231 men employed in smelting, 55 were employed in sampling, 17 in ore crushing, and 3 at bag-house labor. Referring to conditions of employment at a typical mill operated under earlier and more primi-

[1] Report of Selby Smelter Commission, by J. A. Holmes, Edward C. Franklin, and Ralph A Gould, with accompanying papers. Bulletin 98, Bureau of Mines, Washington, 1915.

[2] In this connection see, "Lead Poisoning in the Smelting and Refining of Lead," by Alice Hamilton, M. A., M. D.; U. S. Bureau of Labor Statistics Bulletin, No. 141, Washington, Feb. 17, 1914.

tive conditions, William Winthrop Betts, M. D., of Salt Lake City, Utah, in a communication to the Journal of the American Medical Association (Jan. 13, 1900), directs attention to the fact that in consequence of the increased use of the cyanide process, ore-reduction methods have resulted in a more finely comminuted dust, with a material increase in the mortality rate of the employees. According to Dr. Betts, "Whether we call the cases fibroid phthisis, chronic interstitial pneumonia, stonecutters' phthisis, miners' consumption, or chalicosis, depending on the character and amount of foreign matter, or classify them under the generic name of pneumoconiosis, makes but little difference. All convey to our minds a pathologic process with a clinical history the exact nature of which depends largely on the stage in which the case is found by the pathologist." It is explained by Dr. Betts that at the Delamar mill the ores, which are a gold-bearing quartzite, are crushed, dried, and ground into a fine powder in what is known as the Griffin mill, conveyed to bins, and thence through chutes to cars which are wheeled to the tanks. In and about the mill the air is filled with an impalpable dust and in portions of the mill it is so dense that one can not be recognized a few feet away.

In continuation it is said that—

The mill has been in operation since September, 1894, employing about 40 men, the capacity being increased from time to time until about 60 men are now being employed. It is stated that most of the men who worked in the mill from seven to nine months previous to January, 1898, are dead and the others are sick. A review of the cases as compared by the employees to March 1, 1899, gives 166 deaths. Since then to my personal knowledge three have died in St. George. A later statement by a gentleman who has the disease himself, and is the editor of a Nevada paper, puts it at 200. Dr. Mayo, who was the company's physician from January, 1895, till a few months ago, and to whom I am indebted for much valuable information, states that only 38 have come to his knowledge. This I am sure is too low, and, while 200 is an exaggeration, I believe an average of these figures nearer correct, as almost every town in Nevada and southern Utah has had its victim, for it is a fact that neither the company nor the men realized their danger until the deaths began to occur. My attention was directed to these facts while at St. George, as quite a number of the young men were employed in the Delamar mill, 11 of whom have died within the past year. A number of others are suffering from the disease. After interviewing the attending physicians and the unfortunate families, I have been able to gather much of interest concerning the cases.

The investigations of Dr. Betts are among the most important ever made in this country, and therefore are deserving of much more extended consideration than has heretofore been accorded them, regardless of the material improvements in methods of management during the intervening period of time. He is of the opinion that many of the men suffer serious injury to their lungs, but return to their distant homes, where "many have died and others must, as the disease involves lesions which do not admit of recovery, and sooner or later prove fatal." He presents the details, of what may be considered a typical case, of a foreman of carpenters who for 27 months had been exposed to the risk of dust inhalation, but who worked 18 months before suffering any inconvenience, although the pathologic process had undoubtedly been established for some time. According to Dr. Betts, he—

First noticed shortness of breath, loss of appetite, fatigue on slight exertion, and emaciation. The cough and expectoration were slight for months. He has now been in the city for about a year. The pathologic process continues and his symptoms do not improve, though from present indications he will live some months. His clinical history and physical examination reveal a condition typical in fibroid phthisis, and in marked contrast to the poor fellows who after three months' exposure died within a year. Thus we have all grades, as will be shown later, depending on the general constitution and natural resisting power of the men, also largely on the amount of foreign matter inhaled. The mucous and alveolar cells are the normal scavengers of the lungs and are capable of protecting the organ in a measure, but when the dust is excessive the scavengers are overworked and break down, so to speak, leaving the lungs exposed to just what occurs in these cases.

This case may be considered fairly typical of the health-injurious consequences in ore dressing and sampling plants, where sanitary and safety precautions are neglected. According to Dr. Betts—

Every man who works in the mills from two to three weeks is subject to attacks of acute bronchitis, which is due not only to the irritating effects of the dust, but to his apparent inability to resist slight exposure. The mucous membranes of the nose, throat, and conjunctiva are all subject to acute inflammations. The bronchitis is followed by a soreness along the course of the trachea and bronchial tubes, usually more marked on the right. After coughing has continued for a time there will be soreness in the region of the stomach and loss of appetite. There is loss of weight and shortness of breath, the respirations running as high as 38 to 42 per minute on the slightest exertion. As the weeks pass the loss of weight continues. The respiration does not improve, the patient suffers a general malaise and soon finds it impossible to get about, and by the time he is confined to his room has lost from 30 to 60 pounds in weight. The features are drawn and eyes sunken. The pulse ranges from 90 to 120, and is weak and intermittent. Patients are restless, anxious, and apprehensive of results; they do not sleep well and are subject to hideous dreams. As the disease becomes more marked and in its later stages, the temperature may rise to 102 or 104, though a high temperature is not always present. There is a characteristic odor of the breath at all times, probably due to the peculiar odor of the silicious dust modified by the cyanide odors about the mill, which permeate the clothing and surroundings of the patient. There is no arsenic, as has been stated.

Investigations of this kind involve much labor and serious thought, but they constitute most valuable contributions to the science of industrial hygiene. Dr. Betts sent out special history blanks to all the men whom he could reach, who had worked in the Delamar mill 30 days and over, from the date of commencement until September, 1899. The average number of men employed was only 50, but the change in the personnel working 30 days or over was about 50 each, and in some instances many times more. On account of the unusual labor turnover the actual number of men exposed to the risk of lung injury in consequence of dust exposure during the five-year period was about 1,000. A large number of these were found "to have chronic interstitial pneumonia," and about 100 deaths were ascertained to have occurred, indicating an exceedingly high mortality rate. Thirty cases were tabulated in detail by Dr. Betts as follows, including, most fortunately, observations regarding special processes and a tabulated statement of details of permanent value in the study of the subject:

TABLE 169.—HISTORY OF 30 CASES OF DEATH OF EMPLOYEES OF SMELTING MILLS.

| Name and address. | Age. | Height. | Weight. | Commenced work. | Stopped work. | Time worked. | Time to death. | Whole time. |
|---|---|---|---|---|---|---|---|---|
| | | *Ft. In.* | *Lbs.* | | | *Mos.* | *Mos.* | *Mos.* |
| D. A. A., St. George, Utah, married. | 38 | 5– 7 | 175 | Mar., 1897 | Feb., 1898 | 12 | 10 | 22 |
| G. A. L., St. George, Utah, married. | 33 | 5–10 | 165 | May, 1897 | Dec., 1897 | 8 | 3 | 11 |
| O. L., St. George, Utah, married. | 22 | 6– 0 | 175 | Aug., 1896 | Feb., 1898 | 16 | 11 | 27 |
| F. C., St. George, Utah, married.. | 35 | 6– 1 | 180 | May, 1896 | June, 1899 | (1) | 1 | 37 |
| L. C., St. George, Utah, single.... | 20 | 5–10 | 170 | Oct., 1895 | Sept., 1897 | [2] 23 | 6 | 29 |
| G. W. M., St. George, Utah, married. | 38 | 5– 9 | 150 | Mar., 1896 | Feb., 1898 | 19 | 2 | 21 |
| H. M., St. George, Utah, married. | 28 | 5– 7 | 140 | Dec., 1895 to Mar., 1897. | Sept., 1897 | [3] 9 | 19 | 28 |
| J. F., St. George, Utah, married.. | 28 | 5– 8 | 160 | Apr., 1896 | June, 1896 | 3 | 7 | 10 |
| M. C., St. George, Utah, single... | 24 | 5–10 | 170 | Sept., 1896 | Dec., 1896 | 3 | 12 | 15 |
| L. B., St. George, Utah, single... | 27 | 5–10 | 165 | Jan., 1896 | Dec., 1898 | 23 | 2 | 25 |
| R. L., Beaver, Utah, single...... | 24 | 5– 7 | 160 | Oct., 1897 | June, 1898 | 9 | 4 | 13 |
| T. L., Pangistch, Utah, married.. | 28 | 5–11 | 155 | June, 1896 | Apr., 1897 | 15 | 3 | 18 |
| J. H. L., Pangistch, Utah, married. | 40 | 5– 6 | 165 | 1898....... | 1898....... | 5 | 7 | 12 |
| J. H., Delamar, Nev., single...... | 40 | 5– 9 | 140 | Oct., 1895 | Oct., 1897 | 24 | 1 | 25 |
| Wm. C., Delamar, Nev., single... | 39 | 5– 5 | 135 | Nov., 1896 | Dec., 1897 | 12 | 1 | 13 |
| P. T., Baltimore, Md............ | 23 | 5– 4 | 165 | Nov., 1897 | Oct., 1898 | 11 | 3 | 14 |
| A. W., Columbus, Ohio, single... | 24 | 5– 8 | 140 | July, 1896 | Aug., 1898 | [3] 25 | 3 | 28 |
| J. H., Hillsboro, Ohio, single..... | 27 | 6– 0 | 210 | May, 1895 | Aug., 1898 | [3] 10 | 12 | 39 |
| A. S., Fillmore, Utah, single..... | 22 | 5– 9 | 155 | Apr., 1897 | Mar., 1898 | 12 | 1 | 13 |
| J. C., Oregon, single.............. | 35 | 5– 6 | 150 | Aug., 1896 | Sept., 1897 | 12 | 14 | 26 |
| M. F., unknown, single.......... | 35 | 5– 7 | 150 | Jan., 1896 | Apr., 1897 | 14 | 18 | 34 |
| J. McC., unknown, single........ | 27 | 5– 7 | 157 | Jan., 1896 | July, 1896 | 7 | 5 | 12 |
| Chs. F., Gunnison, Utah, married. | 36 | 5– 7 | 165 | Mar., 1896 | Sept., 1898 | 18 | 12 | 30 |
| R. H., Masonvally, Nev., married. | 38 | 5– 7 | 155 | 1896....... | 1898....... | 22 | 11 | 33 |
| O. N. W., St. George, Utah, married. | 43 | 6– 1 | 175 | Sept., 1894 | June, 1897 | [3] 30 | 12 | 55 |
| E. S., Richfield, Utah, married.. | 33 | 6– 2 | 226 | Aug., 1895 | Nov., 1898 | [3] 19 | 10 | 48 |
| A. W. H., Annabelle, Utah, single. | 31 | 5– 8 | 155 | Mar., 1896 | July, 1896 | 4 | 13 | 17 |
| J. A. B., Paragonah, Utah, married. | 27 | 6– 0 | 165 | Aug., 1895 | June, 1898 | [3] 12 | 15 | 48 |
| R. P., Colorado, married......... | 35 | 5– 9 | 145 | Aug., 1897 | Jan., 1898 | 6 | 10 | 16 |
| F. C., Arizona, married.......... | 38 | 5– 6 | 150 | June, 1897 | Feb., 1898 | 8 | 6 | 14 |
| General average............ | 30 | 5–8½ | 170 | | | 14 | 10 | 29 |

[1] Thirteen months in mill; 9 months night foreman, remainder in mill.
[2] Intermittent; 18 months actual time.
[3] Intermittent.

It will be seen by this report [as shown in Table 169] that all were comparatively young men, from 20 to 40 years old, with the exception of O. N. W., who was 43. All were fine specimens of physical vigor, with no unfavorable family histories, and none had acquired tuberculosis nor any other lung trouble. It will also be noted that the time of employment extended over a period of 3 months in the case of J. F., who survived 7 months after leaving the mill, to 25 months in the case of A. W., who survived but 3 months. The average time of employment, however, was 14 months, and the average time survived, 10 months. The average time from entering the mill to the termination of the pathologic process was 29 months.

The employment was not continuous in all cases. In some instances there would be a lay off of several months, though I was unable to secure exact time. I have designated such as intermittent and given actual time worked. O. N. W. was not, properly speaking, a mill employee, but a carpenter, who originally worked on the construction of the mill, and does not figure in these statistics. He had been employed from time to time in and about the mill on repairs and improvements, thus coming in contact with the same influences as the regular operatives. He survived 4 years and 9 months. In three cases the weights were taken a few days before death. D. A. A. dropped from 175 to 120 pounds, C. F. from 165 to 110, and H. M. from 140 to 80.

The capacity of the Delamar mill is the reduction of 300 tons of ore every 24 hours. The men employed in this process are divided into shifts of eight hours each. Among the 30 cases reported are the members of what I choose to call the Frome shift, as C. F., of Gunnison, who died September 22, 1899, was the last survivor of one of the groups of 18 who worked together long enough at one time between March, 1896, and September, 1898, to claim the personnel of a shift. I mention this as an interesting fact and to further impress the necessity of reforming the hygienic conditions in this line of work.

In amplification several autopsy records are included, of which the two following may be considered typical:

*F. C. of St. George.*—After the usual preliminaries the sternum was disarticulated from the clavicle, and it, with the cartilaginous ends of the ribs, removed. The inferior surface was adherent to what was at first supposed to be the pleura. After a careful dissection a congested serous membrane was revealed, extending from the sternoclavicular articulation to the diaphragm and well under the ends of the ribs to the right. After further dissection the right lobe of the lung came into view. On the left the adhesions seemed firmer and extended well down some 4 inches. During this dissection a slight puncture was made in the surface, followed by the escape of gas accompanied by bubbles of fluid. This relieved the pressure, and it became apparent that we had an enlarged pericardium to deal with—or pneumopericardium. The adhesions could nowhere be separated with the hand—in fact, they were so strong that it was only after a careful dissection from the diaphragm and spinal column and laterally and posteriorly from lung tissue that the sac could be removed. An effort was made to remove it intact, but most of the fluid escaped, and was of a serous nature, slightly tinged with blood; its size can be imagined from the measurements, 9 inches long and 17 in circumference.

On splitting up and inverting the pericardium the cardial surface was found to be greatly roughened, having much the appearance of tripe. While the membrane was thickened, the heart itself had much the same appearance, the surface being rougher at the base than at the apex. The whole organ was enlarged, flabby, and dilated; the valves were in a fairly normal condition so far as their anatomic relations were concerned.

The anatomic relations of the arch of the aorta and large vessels to the mediastinum, as well as the trachea and bronchi, were entirely obliterated and so matted together that dissection was not attempted. The vessels and bronchi were severed and the lungs removed with little further difficulty, though there were local areas of adhesions which could mostly be separated with the hands. The general appearance was that of congestion, the surface to the eye was fairly smooth, though to the touch nodular and hard, surface generally pigmented, which with the congestion gave a dark color, and the impression that the patient might have died from pneumonia. The edge of the superior, middle, and inferior lobes of the right lung were very hard, though the whole lung seemed firm to the touch. In cutting into the lung there was considerable resistance, made more apparent as local areas of cirrhotic tissue were encountered. The cut surface was reddish brown and extensively pigmented. Between the densely cirrhotic areas the lung was infiltrated with a mucopurulent secretion, which, on the slightest pressure, bathed the surface in a reddish-gray fluid. The appearance after a fresh incision was that of mottled hepatization of pneumonia, i. e., a mixture of the gray and red. The left lung was of the same general character except the lower half of the superior lobes, which was the only portion of the lung apparently being used at the time of death, and that was far from normal. A number of tracheal and bronchial glands from the size of a hazelnut to that of a large olive were removed; these, on section, were slate-gray in color.

*O. N. W. of St. George.*—There was emaciation; ribs prominent. The sternum, with the cartilage ends of the ribs, was removed. The sternoclavicular articulation was ossified. Adhesions were firm to the pleura and pericardium, the latter adherent to diaphragm; also posteriorly, and slightly so to the left. Bands of adhesion also bound down the aorta and large vessels. The anterior mediastinum was obliterated. The pericardium was slightly thickened through its cardial surface, but smooth and normal in appearance. The heart generally was hypertrophied, otherwise normal. On passing the hand over the lung, slight resistance was met by bands of adhesions, laterally and posteriorly, which, however, were not general and could be easily separated. To the touch the left lung was firm and hard, more that of well-developed muscle covered with dense fascia. In grasping the lobe between the thumb and fingers and using all the force possible approximation was very slight, much the same resistance that would be met in grasping the muscles of the thigh in a similar manner. An incision through the inferior lobe met with considerable resistance and revealed dense fibrous tissue, to the touch a shot-like granular surface and deeply pigmented. The serous coat was dense and one-quarter of an inch thick, gradually becoming thinner toward the apex of the superior lobe. The lung, while cirrhotic throughout, was less dense at the apex, though it was evident it had not been used for some time. As we lifted the right one from the pleural cavity its appearance was that of a single lobe. The adhesions between the inferior and middle lobe were complete, the surface perfectly smooth, only the suggestion of a line remaining. Between the middle and superior lobe there was a slight separation at the very tip, otherwise adherence. A careful examination was made and the fibrous process was found well developed and extensive, the lower border of the inferior and middle lobes being the most cirrhotic. The cut surface was reddish-brown, deeply pigmented and bathed in a mucopurulent secretion, and the same mottled hepatization as in the previous case. The upper half of the inferior lobe and one or two areas near the apex had apparently been sustaining the patient previous to the acute inflammation, which had been present for about a week. All portions of the right lung capable of action were undergoing active pneumonia, with the accompanying characteristics. As in the previous case the tracheal and bronchial glands were enlarged. In both cases a careful search was made for cavities, but none were found. The mucous membrane of the large bronchi and trachea were in a state of chronic inflammation. Owing to the great prejudice and that there had been no symptoms pointing to disease of other organs, the case was not examined further.

In conclusion, the following observations are of much practical importance, especially as regards the actual silicate dust content of the lungs, ascertained in one case to be equivalent to 1.43 ounces, or about 3.38 cubic inches:

In the acute stages of the disease the diagnosis becomes important as the condition has been mistaken for typhoid fever, typhoid pneumonia, acute miliary tuberculosis, and bilious remittent fever and tuberculosis. While pneumoconiosis is the generic name given to the various affections of the lungs produced by the inhalation of dust-like particles, chalicosis pulmonum is given to the pulmonary changes induced by the inhalation of stone dust. Niemeyer, Flint, Osler, and others agree that the irritation from dust lights up a bronchitis and is conveyed through the lymph spaces and lymph vessels into the interlobular and perilobular connective tissue; and some of the particles reach the bronchial glands. The chemical examination of the lung shows the presence of silica, 2.8 per cent, in the lung tissue and 3.8 per cent in the glands. There is a great disposition to the formation of nodules and diffused masses of fibrous tissue. The cases are, therefore, more properly regarded as chronic interstitial pneumonia, which consists in the gradual substitution, to a greater or less extent, of connective tissue for normal lung, by the gradual process of organization of the fibrous plugs in the air-cells, while the alveolar wall becomes greatly thickened by the new growth, and the whole lung may undergo a fibrous transformation.

In addition to the foregoing, Dr. Betts makes the following recommendations concerning possible methods of prevention:

Among the cases coming under our observation there are none where "an ounce of prevention is worth a pound of cure" more emphatically applies than in the diseases induced by the inhalation of irritating dust. No one can study the industrial hygiene and carefully note the relations of occupation to life and health without fully recognizing that from the gentleman of leisure to the mechanical operative, the soldier, and millhand, all have their dangers incident to the various occupations; but it should not follow that no effort should be made to minimize them. I believe it is our duty as scientific physicians not only to point out the danger from contagion, and to render innocuous the germs lurking in our food and water supply, but also to call attention to the causes of disease induced by the industrial occupations, suggest proper sanitary and hygienic measures, and force, by our teachings, a wholesome regard for the comfort, health, and life of the employees, thus reducing the dangers to a minimum. I do not believe any organization, however influential, should presume to dictate to the medical profession or embarrass the physician in his work; much less endanger the health and life of men who are lured by the wages offered—$2 to $5 a day—into what may prove a death trap, and feel they have discharged their obligations to the men, their families, and the public by producing revenues for a "soulless" corporation, regardless of the sacrifice of human life. Notwithstanding the obstruction and criticism I have encountered in the preparation of this paper, no man nor association of men is on trial. This is one of the cases in which truth is stranger than fiction, and I have simply stated facts. If I have succeeded in attracting the attention of the profession and through it the public to the necessity of reform in the field of so-called preventive medicine, I will feel repaid for my time and labor.

## SOME GENERAL OBSERVATIONS AND CONCLUSIONS.

The problem under consideration is one of immense magnitude and unusual complexity. Dusty operations are so general and practically unavoidable in all the principal industries, and even in minor occupational activities, that a precise line of demarcation between injurious and noninjurious processes on account of the dust hazard can not be drawn, even on the basis of a thoroughly scientific investigation. The practical importance of the subject, however, is clearly brought out by every qualified inquiry in this country and abroad. Even in coal mining, where the hazard of coal-dust inhalation is apparently of minor significance as regards the predisposition of mine workers to tuberculous and nontuberculous respiratory diseases, modern practices of reducing the calamity hazard, or the liability to disastrous explosions by means of so-called rock dusting, result in occupational dangers which, under given conditions, may reach the proportions of serious menaces to health and life.

According to a discussion of the prevention of coal-dust explosions by watering, or the use of rock dust, in the Coal Age of August 11, 1917, "In the United States rock dusting on a large scale was first tried in a Colorado mine, where sprinkling had caused roof falls. The application of dry adobe dust began in March, 1911, and has been continued to date." Limestone dust is extensively used in the Pittsburgh district, although the method has not gone beyond the experimental stage. It is said further in the article referred to that "objection has been made to using rock dust on account of alleged danger to miners' lungs. Pulverized shale dust has been shown to be noninjurious by British commissions which have particularly investigated this point. Dust containing free silica or sharp particles of any sort is likely to be injurious. Microscopic examination is a quick method of detecting the presence of sharp points or edges and the likelihood of danger from this source." Much more, however, is required than a superficial microscopical examination. As conclusively shown by the South African experience, the silica dust hazard is in almost exact proportion to the minuteness of the dust particles. Careful supervision of rock dusting in mines is, therefore, absolutely necessary and of the greatest importance.

Practically conclusive descriptive accounts of industrial processes are essential to a full understanding of the conditions which give rise to dust hazards in industry. As typical of modern methods of investigation in this direction, though not primarily for the purpose of ascertaining conditions injurious to health and life, is Technical Paper No. 155, of the United States Bureau of Mines, on "Gypsum Products, Their Preparation and Uses," by R. W. Stone, of the United States Geological Survey. This account includes a full description of mining, crushing, drying, grinding, calcining, regrinding, mixing, storage, etc. Such descriptive accounts are, fortunately, being made to an increasing extent for the more important branches of the mining and metallurgical industries. The solution of the dust problem, in so far as it permits of a solution at all, must necessarily depend very largely upon a thorough understanding of the technical industrial processes which give rise to health-injurious conditions reflected in the statistical evidence of an excessive incidence of tuberculous and nontuberculous respiratory diseases.

From a medical point of view further progress is essential in the direction of greater accuracy and scientific conclusiveness as regards the classification of pulmonary tuberculosis as well as of nontuberculous lung diseases. An important recent contribution to this aspect of the problem, by Walter L. Rathbun, of the Municipal Sanatorium, Otisville, N. Y., has been made available through The American Review of Tuberculosis (March, 1917). Reference may also be made to a strictly scientific discussion of the important question of "Respiratory Exchange, with a Description of a Respiration Apparatus for Clinical Use," by Benedict and Tompkins, contributed to the Boston Medical and Surgical Journal of June 15, 22, and 29, 1916. There could be no more erroneous view than that all that needs be known concerning the physiology and pathology of the respiratory function is fully understood at the present time. Mention need only be made of such an important discussion as that on "The Effect of Changes in Atmospheric Conditions upon the Upper Respiratory Tract," by Drs. James Alexander Miller and Gerhard Hutchison Cocks, contributed to the "Transactions of the American Climatological and Clinical Association," in 1915.

This discussion clearly emphasizes the importance of changes of temperature and abnormal temperature conditions, which frequently coincide with abnormal dust exposure in the mineral and metallurgical industries. Mr. Edwin M. Chance, the chief chemist of the Philadelphia & Reading Coal & Iron Co., contributed an important practical discussion on "The Examination and Physiological Action of Pathogenic Mine Atmospheres, with Considerations Governing the Use of Breathing Apparatus," to the Journal of the Franklin Institute, for November, 1911, which has an indirect bearing upon the larger question of health-injurious results of underground employment in consequence of continuous exposure to abnormal atmospheric conditions. It is regrettable that an exceptionally promising investigation on "Pulmonary Anthracosis," by Oskar Klotz, of the pathological laboratories of the University of Pittsburgh, made in connection with the smoke investigations of the Mellon Institute of Industrial Research, should not have been continued and amplified by the required additional data based upon a larger number of autopsy records. This admirable study, however, includes some very suggestive anatomical considerations, the ascertainment of the distribution of pigment beneath the visceral pleura, the occurrence of interstitial pulmonary anthracosis, and the modification of anthracotic deposits by other factors. There have been few more useful American contributions than this to the strictly scientific study of lung diseases in their relation to the continuous inhalation of health-injurious dusts and inorganic atmospheric pollution. The discussion concludes with some observations on the quantitative estimation of carbon in the lungs, limited, unfortunately, to nine cases. Among the conclusions advanced is the statement that pulmonary anthracosis, as clearly differentiated from coal miners' anthracosis, is distinctly an urban disease and is proportionate to the smoke content of the air, and that carbon deposits, by inducing fibrosis, tend to encapsulate chronic tuberculous foci, and therefore afford a relative measure of protection against the further development of incipient tuberculosis, which probably accounts for the lower proportionate mortality from the disease among coal miners as well as among the population of coal mining communities or localities subject to a large amount of atmospheric (carbon) pollution.

These observations are referred to on this occasion merely as promising indications of research efforts of a high order of practical importance to employers and employees in trades and occupations subject to an exceptional degree of health-injurious exposure to industrial dusts. It requires no argument to reemphasize the point of view that as a general rule no single factor in industry is directly responsible for even the larger portion of the excess in the mortality from tuberculous or nontuberculous respiratory diseases, although the removal or control of the dust hazard will often bring about a material reduction in the death rate. The dust hazard is but one of many factors and conditions in modern industry more or less detrimental to health and life, and genuine and lasting progress in this direction must therefore rest upon rational considerations of industrial hygiene, as clearly set forth in an address on the "Standardization of Working Essentials," by Miss Lillian Erskine, investigator of occupational diseases of the New Jersey Department of Labor, contributed to the proceedings of the American Academy of Political and Social Science in 1917. This address includes an extended and most useful reference to the problem of dust removal, it being stated in part that—

When it is remembered that at each breath some 60 cubic inches of dust-laden air may be inhaled by a worker, the ultimate injury possible to the 20 square feet of surface of the 500,000,000 air cells of his lungs becomes apparent. In the case of buffers, grinders, and polishers (before the days of mechanical exhaust protection), the tuberculosis mortality of the group exceeded 60 per cent, in contrast to the normal 14 per cent for the general registration area. Printers, subjected to lead dust and fume, show a consumption mortality in the neighborhood of 70 per cent. Almost as high are the records of potters exposed to flint dust, and of mill workers subjected to clouds of irritating wood dusts.

Aside, however, from questions of health, a dusty workroom inevitably lowers standards of shop discipline and output; induces chronic intemperance (due to thirst engendered by congestion of the mucous membrane of the throat), and a general sense of physical malaise and depression; and commonly increases friction in personal relations with the foremen, among those whose normal recuperation from physical and nervous fatigue is made impossible by the unsanitary conditions of their working environment. While the direct financial loss involved in the waste of a majority of dusts and fumes in the workrooms is not of serious moment to the management, the indirect losses above noted justify the most rigid precautions for their control. The secret of successful mechanical exhaust removal of dust and fume from working processes lies in its control at the point of origin. While this was once regarded as impractical in many industries, modern engineering experience has solved practically every working problem, whatever be the specific gravity of the dust or fume in question.

Miss Erskine properly directs attention to the harmful results of indefinite and unscientific sanitary requirements, and the misuse of the terms "adequate" and "sufficient" resulting frequently in only a very limited amount of protection, secured at very considerable expense. She points out that—

The usual and inexpert practice in building a dust-exhaust system, such as is required for buffing, polishing, or grinding wheels, is to proportion the main suction pipe so that at all cross-sectional points it only equals the combined areas of the branch pipes entering the same; while the inlet of the exhauster used on such a system has an area that but equals the combined areas of all the branch pipes used on the system. For example, for twenty-five 4-inch branch pipes the largest diameter of main pipe and exhauster would be 20 inches. A 50-inch exhauster would have an inlet 20 inches in diameter; if it were necessary to get a suction head at each branch pipe sufficiently strong to displace 2 inches of water in a pressure gauge (commonly called a U-shaped tube) it would require an actual velocity of 4,000 linear feet per minute in the branches, and it would be necessary for the exhauster to handle 8,720 cubic feet of air. It would require approximately 16 horsepower to obtain these results.

These observations fully justify Miss Erskine's conclusions that inadequate and unscientific systems of ventilation should no longer be permitted, since standards based upon actual working tests and experience prove conclusively "that efficiency requires for 4-inch pipes a main pipe with, at all its cross-sectional points, an area 20 per cent larger than the combined areas of branch pipes entering the same. The inlet of the exhauster attached to the system must have an area 20 per cent larger than the combined areas of all branch connections on the system. For example, a system having twenty-five 4-inch branch pipes would require an exhauster that has an inlet 22 inches in diameter; and the main pipe connected with this exhauster would taper, in accordance with the location of the branches, from the exhauster to the tail of the system. This kind of system would require a 55-inch exhauster having a main pipe 22 inches in diameter; and to obtain a suction sufficient to displace 2 inches of water in a U-shaped tube, the air in each branch pipe would be obliged to have a velocity of 4,000 linear feet per minute. The exhauster would handle 8,720 cubic feet of air a minute; and the exhauster would take about 12 horsepower to operate it."

Through the adoption of scientific methods of dust removal it is possible to secure a saving of 25 per cent in horsepower, aside from the resulting reduction in, or elimination of, conditions of air pollution detrimental to the health and life of the employees.

In its final analysis the problem of dust control in industry demands obviously both practical and strictly theoretical considerations. There has heretofore been too much reliance upon general practical aspects of dust removal, since, as a matter of everyday experience, the mere mechanical material reduction of the dust hazard in industry almost invariably results in a consequent improvement in the health and longevity of the employees directly concerned. In connection with many highly involved industrial processes the effective control of the dust menace is, however, often subject to exceedingly complex theoretical considerations suggestive of further research in a field which has received inadequate attention on the part of those qualified to render most useful services to the workers engaged in industrial processes indispensable to the needs of mankind.

The most encouraging evidences of an aroused national interest in this important and promising field of industrial research are the occupational disease investigations of the United States Bureau of Labor Statistics and the United States Bureau of Mines. On account of its practical importance emphasis may, therefore, in conclusion, be given to a recent circular of the Bureau of Mines, prepared by Dr. A. J. Lanza, of the United States Public Health Service, and Joseph H. White, of the Bureau of Mines, on "How a miner can avoid some dangerous diseases," and which, with reference to rock dust, emphasizes conclusions generally applicable to the dust problem, as follows:

Dust is not a disease, but it is the cause of disease. Any hard, sharp rock dust when breathed into the lungs irritates and cuts them, making many small scars. These scars make the lungs less able to perform their proper duty. Besides, because of the constant irritation, the lungs become inflamed, and consumption is liable to develop. Men who breathe hard-rock dust constantly often get consumption. The constant irritation of the lungs weakens them and at the same time gives the seeds of consumption a good chance to grow. The dust breather is also more liable to fall a victim to the careless spitter than the man whose lungs are sound. If he gets pneumonia his chance of recovery is not so good. The dust breather has to fight not only the effects of any lung disease he may get, but also the harmful effects of the hard-rock dust, which is constantly adding to the ravages of the disease.

Working in dust, like exposure, is at times unavoidable, but a great deal, if not most of the dust breathing, is due to carelessness on the part of the miner himself, who does not realize the danger of so doing, or, if he does, is indifferent to it. It is another example of failing to keep up the bars around an open place. In dust breathing, however, cause and effect are not so plain—at least they do not seem so to the miner. But the relation is there just the same. The number of deaths from lung diseases among metal miners is much greater than among coal miners and is probably ten times greater than it ought to be.

What can the miner do to avoid breathing dust? Water drills are being used more and more. In dry drilling with machines it is possible to lay the dust by water lines or by using a squirt gun and water from a bucket, but often men drill with the hole dry rather than turn on the water, because it spatters on them, or makes the place sloppy. If you are drilling overhead, and the water has to come back on you, wear a rubber hat and boots and, if necessary, a rubber coat. This is a bother, but it is also a bother to observe all the rules of "safety first"—which save lives. A man working where there is much dust should wear a respirator if possible, and see that the respirator is in good condition. Respirators are clumsy and more or less of a nuisance, but it is better to wear one than to have consumption. Do not breathe hard-rock dust day after day, because, if you do, it will disable you in time. Men who can "eat rock dust"—like the men who can "breathe gas"—die young.

These recommendations apply to a large section of the mining population and to men employed in metallurgical industries. In a broader sense, however, all inorganic dust in industrial occupations demands the most effective safeguarding of the employees against unnecessary hazards to health and life. What has thus far been done in this direction has unquestionably resulted in far-reaching benefits to the wage earners.[1] Much more, however, is required if the obviously excessive mortality from tuberculous and nontuberculous lung diseases in the dusty trades is to be materially reduced as a prerequisite for the attainment of a higher standard of labor and life than prevails in this and other countries at the present time.

[1] See in this connection Bulletin 132, of the United States Bureau of Mines, on Siliceous Dust in Relation to Pulmonary Diseases among Miners in the Joplin District, Missouri. Washington, 1917. Note also the appointment of a special committee on the Scientific Study of Dusty Trades in their Relation to Pulmonary Tuberculosis by the National Association for the Study and Prevention of Tuberculosis.

# INDEX.

## A.



## B.



## C.

## D.

E.



F.



G.

## H.

## T.

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