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OCCUPATIONAL DISEASES

The Problems of Their Practicable Prevention in Industry

By F. ROBERTSON JONES

ASSOCIATION OF CASUALTY AND SURETY EXECUTIVES, NEW YORK, N. Y.

INDUSTRY has so many and such a wide variety of major problems these days that to many the problems presented by occupational diseases among workers may seem comparatively insignificant. This is, however, far from being the case. Either from the standpoint of cost or of social betterment the situation confronting many employers as a result of their growing liability to provide compensation for or pay damages to the victims of occupational diseases is equally as serious as the ever-increasing tax rates and the prospect of soon being compelled to contribute to unemployment insurance funds. Speaking as a representative of the largest stock casualty insurance companies of the country, I can assure you that these companies are well aware of the almost overwhelming burden of cost which seems about to be heaped upon industry by the general extension of the compensation system to cover occupational diseases of all kinds. Our companies, of course, have only what might be called an indirect interest in the problems you are discussing, but they will be adversely affected if necessary insurance costs grow so great that they will be "more than the traffic will bear." They are naturally tremendously interested in these problems and anxious to cooperate in their solution. It is my opinion, which I believe firmly to be well founded, that the primary essential in meeting the problems of occupational diseases is prevention. If these diseases, through engineering and the medical sciences, can be reduced to the level of exceptional misfortunes, the remaining economic and legal problems can be readily solved. It therefore seems to me that most intensive consideration should be given to this phase of the situation immediately by the outstanding experts of the country, so that suffering by workmen from preventable maladies may be reduced to a minimum and so that industry may not avoidably be drained of its resources. The character of this meeting and the program to be presented indicates clearly that The American Society of Mechanical Engineers is alive to the situation and has the cooperation of the medical fraternity in its most laudable objective of prevention.

The specific subject for discussion at this meeting is the "Engineering Aspects of the Prevention of Occupational Disease." It is not my purpose so much to enter into this subject as rather to lead up to it by calling to your attention some aspects of the problem not special to engineering but which industrial engineers should study and bear in mind.

From the start, it needs to be borne in mind that all forms of ill health—"occupational" or of ordinary life—to which industry in any wise contributes, as, for examples, through defective lighting or ventilation, or excessive exertions, or exposures to the inclemencies of the weather, are matters for prevention. That, however, is a cyclopedic subject. You have advisedly restricted your discussion at this session to the topic of *occupational* diseases—which I construe to mean—in popular phraseology—those diseases, not of ordinary life, chargeable to health-hazards which industry itself creates. Even that is too broad a subject for me to deal with in a brief introduction. Therefore I will restrict my remarks generally to prevention of occupational dust diseases of the lungs, with particular reference to silicosis—since those diseases, of which silicosis ranks first, have now given rise to a problem of such magnitude and pressing importance to industry as, temporarily at least, to relegate other occupational diseases to a position of relative immateriality.

From what I can learn the disease now known as silicosis is as old as history. But whether because of a recent increase through the use of modern machinery, or because of a growing public recognition of its seriousness, or because of these two factors in conjunction, and possibly others also, silicosis has now become a mortal menace to industry. Whether under a system of employers' liability for damages or under a system of compensation—"regardless of fault"—for occupational diseases, the cost of silicosis is becoming so heavy as to entail the rapid or gradual ruin of many industries, unless the incidence of the disease can be radically reduced. The cure of silicosis, once it has progressed beyond a very early stage, is, according to the preponderance of medical opinion, practically out of question. Consequently, for silicosis, *prevention* is most emphatically the primary and principal problem.

That problem has engineering, medical, economic, legal, educational, and political aspects—all of which need to be realized by all concerned in the task of prevention.

In its engineering aspects, the principal problem in prevention of silicosis is the removal or prevention of inhalation of dust. As a layman I cannot imagine how, practically, all dust can be removed or kept from inhalation. Therefore, primarily at least, efforts should probably be directed principally to the elimination of harmful dusts. Here you are confronted with several difficulties. The preponderance of medical opinion is that, of the inorganic dusts constantly generated in industry, only dust of free silica (silicon dioxide), and perhaps asbestos dust—and these dusts only when in minute particles—are harmful, that is, harmful in the sense and to the extent of causing specific disabling diseases of the lungs. But that is merely a majority opinion, from which there are dissents; and it is open to doubt. Only a few months ago a high authority[1] on this subject in Great Britain declared: "We need a scientific 'recessional' in which to reexamine with an open mind many of the generalizations now accepted as current coin in relation to silicosis and 'miners' phthisis.' " Moreover, silicosis is, in colloquial language, "all mixed up with" tuberculosis. Apparently, tuberculosis induces silicosis, and silicosis lessens resistance to tuberculosis, or something like that. But tuberculosis may be caused by organic dust or, for all that I can learn to the contrary, may be indirectly activated by other dusts. Consequently, how far all dusts, or, if not all, then what dusts imperatively need to be eliminated is, as yet, a problem to be determined largely by experi-

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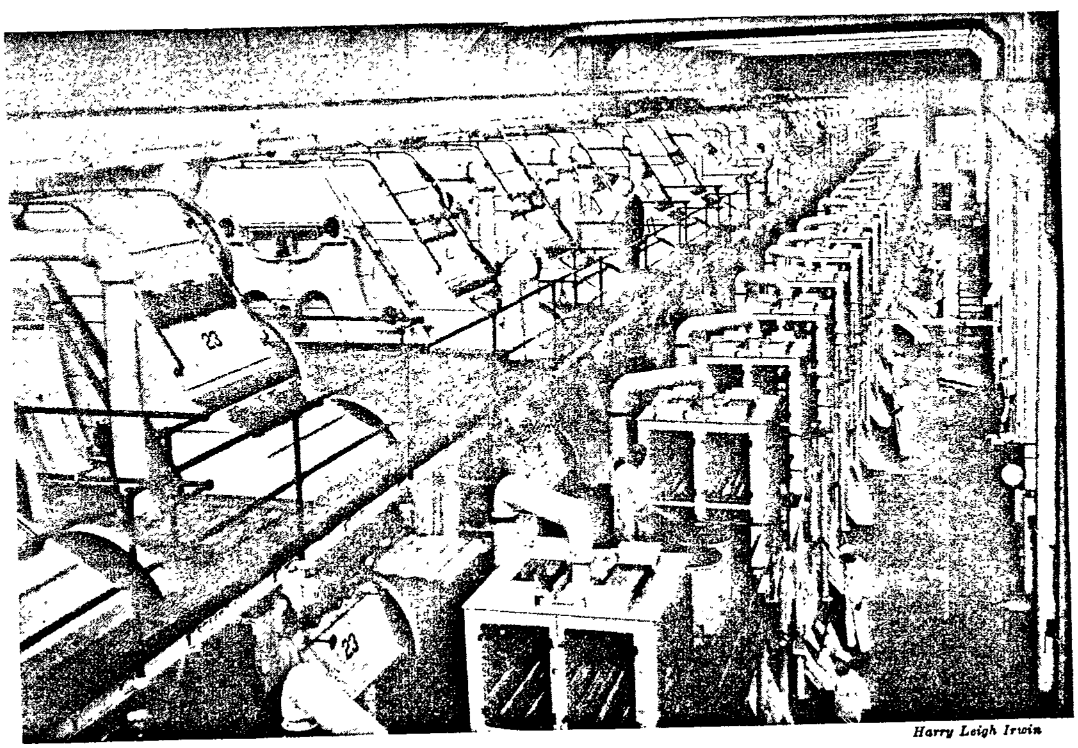
[1] Prof. S. L. Cummins, Adviser to the British Tuberculosis Research Committee, quoted in *Industrial Medicine*, April, 1934.

mentation, not based a priori on present medical opinion, but on the results of experience—on the results in the way of reducing morbidity from the use of specific means for prevention, engineering means among others.

A problem of vital importance in the study of engineering means of prevention is the determination of what is practicable—economically and humanly. Economically, the best means for prevention may often be impracticable. Industry cannot afford to be continually replacing its machinery to experiment with the latest gadgets. It would be a jump out of the frying pan into the fire to load an industry to death to prevent exposure to an occupational disease; and some means of prevention may be such that the workmen simply cannot be induced to use them properly and consistently. This problem will be particularly acute in the smaller undertakings. What is practicable in large and well-organized establishments is often impracticable in minor operations. Thus in the prevention of lead poisoning, the well-established paint factories have been almost completely successful, whereas among the job painters the incidence of that disease has been very little reduced. Results will probably be similar as to silicosis. In South Africa, where silicosis seems to be concentrated principally in mines, generally large establishments, measures of prevention are succeeding in reducing the incidence of the disease, encouragingly; but in Cumberland County, New South Wales, where a scheme of compensation for silicosis applicable to such small-job trades as quarrying, rock drilling, sewer excavation, etc., is in force, it seems that little progress in prevention is being made, though strenuous medical means are resorted to. It may turn out to be a job for engineers to discover means for prevention of silicosis practicable for the "little fellow." At least that point will require study.

This question of what is practicable, as distinguished from the ideal, leads up to another aspect of the matter. In my opinion, besides studying the best practicable ways and means for prevention, engineers should also give consideration to the formulation of *minimum* standards, and to ways and means for procuring their observance. Authoritative formulation of such standards is needed for many purposes—to impress backward industrialists, to guide and support insurers in granting or refusing coverage, and to furnish a scientific basis for regulations to be enforced by public authorities. A code of such standards needs to be elaborate, so as to fit different conditions, and to be open to continual revision, to keep abreast with the developments of research and experience. A present obstacle to prevention, not often realized but of no mean importance, is that many states have laws which impose upon employers *indefinite* obligations for the protection of the health of employees, such as to provide "adequate" ventilation, and to do this where "practicable" and to do that where "reasonable," subject to liability for damages for non-compliance, leaving it to juries in litigated cases to determine what is "adequate," "practicable," or "reasonable" under the circumstances. How can any of you expect an employer to go to much expense to follow your advice when an ignorant and misled jury may mulct him in damages for not doing differently? In my opinion, it is practically essential to prevention by engineering means to procure the replacement of such laws as these by public regulations prescribing *definite* standards, for the development of which your cooperation is requisite, and to get rid of the disturbing influences of juries in determining engineering questions by means of the adoption of "compensation" as the exclusive remedy for occupational diseases, for which your assistance would be of great weight.

All this that I have had to say has been discursive as a whole and speculative in parts. I hope, however, that it will be of some use to indicate to you the ramifications of your subject and how the particular topics to be discussed today fit into the broad problem of prevention, in the solution of which technicians in many lines must all cooperate.



Harry Leigh Irwin

A BATTERY OF MACHINES THAT CONVERT SOLUTIONS OF CELLULOSE NITRATE OR CELLULOSE ACETATE INTO TRANSPARENT, FLEXIBLE FILM BASE. KODAK PARK, ROCHESTER, N. Y.

The Administration of OCCUPATIONAL DISEASE CONTROL

By ALBERT S. GRAY

CONNECTICUT STATE DEPARTMENT OF HEALTH

INDUSTRY, in order to stay in business and maintain its position in the economic world of today, must avail itself of all the materials and processes which have been shown to increase the efficiency and speed the output of its production.

New substances and processes and new uses for older ones are constantly being utilized by industry. New chemicals, plating solutions, dopes, solvents, degreasers, condensation products, varnishes, paints, lacquers, dyes, abrasives, and fabrics—substances used to increase and broaden production—are often employed without a knowledge of their possible effects upon health. A fire hazard is eliminated by replacing an inflammable solvent with one that is not inflammable, without the realization that there has been substituted for the fire hazard a hazard to health in the new solvent. And it is in the use of these new substances and processes (and some of the old) that the health of the workers is affected and occupational disease results.

This has been recognized by a number of states, and though compensation for occupational disease was originally limited to a few specific occupational diseases, schedules have been gradually enlarged with a tendency, perhaps, toward the blanket coverage which has already been adopted in a number of states. I am not, however, confining my discussion of occupational diseases to the limited compensation interpretation of them, but shall consider them in the broader aspect of the effect of industrial environment on health. Hayhurst defines occupational disease as "Injuries and disturbances of health contracted in industrial pursuits or other vocations in lives as a result of exposure to toxic agencies, infectious organisms, or other conditions inimical to health."

Unhealthful industrial environment not only causes specific occupational diseases but increases the incidence of disease among the general population.

The life expectancy of the industrial worker is several years less than that of those otherwise employed. Tuberculosis rates are much higher and pneumonia rates twice as high in the industrial group. Mortality rates for degenerative diseases are two to three times as high in the industrial group.

According to the 1930 Census there were more than 15,000,000 persons gainfully employed in manufacturing and mechanical industries and the extraction of minerals in the United States. And in these industries there are more than 900 occupations potentially hazardous to health.

The control of occupational diseases, therefore, may be seen to present a public-health problem of the first magnitude.

Mechanical engineers have a tremendous responsibility in the control of these diseases, for in the majority of instances this control is but the application of mechanical principles, whether it be enclosure, ventilation, or both.

The progress of accident prevention during the past ten or fifteen years has resulted in the saving of thousands of lives and millions of dollars. A much greater saving may be accomplished by properly administered occupational-disease control. There has not been the incentive to prevent the occurrence of occupational disease that has been accorded accident prevention, for an accident is self-evident; a man slips on the floor, falls, or is burned or caught in a press—there is no question that he is injured and how. Unfortunately, the conditions predisposing to occupational disease are more subtle. They are not so attention-compelling as an accident; they may appear only as increased labor turnover or decreased production. The effect upon the individual is not so self-evident, and so the cause of the condition is not so readily recognized.

There is nothing particularly arresting in the gradual loss of power in the hands of those absorbing lead; nothing to stimulate the interest, no startling appeal in the slowed gait and mental peculiarities of those exposed to certain solvents; the development of anemia and tiny hemorrhages in those exposed to other poisonous materials; or the gradual development of fibrosis of the lungs from exposure to certain dusts. The onset is gradual, the change imperceptible from day to day, until the individual either leaves to be replaced by another worker who passes through the same cycle, or remains at work under progressively lessened efficiency until he can no longer work or becomes a compensable case. If he leaves for employment elsewhere, he continues at work at lowered efficiency for a greater or less time, dependent upon how much of the material he has absorbed. The body is capable of wide adjustment to environment and much harm may be done before evidence of the condition is noted.

Occupational disease is not a new problem but it is only within comparatively recent times that we have attempted to measure, definitely and accurately, its relationship to industrial environment. We now know that there is a very definite relationship between the health of the individual and the environment in which he works. We have been able to establish the smallest amount of many of the materials used in industry that will affect health (which we have called the "threshold dose"), and when this information is not available, the amount which good industrial practice dictates; and we can now measure the exposure of the individuals to these materials to determine whether this amount is exceeded. We know the amounts of toxic materials and the processes that will affect health. We know that if these various materials and processes are not controlled they will seriously affect the health of the individuals exposed to them, and may even affect the health of the people in the community.

THE CONNECTICUT BUREAU OF OCCUPATIONAL DISEASES

Connecticut, in 1928, recognizing the tremendous importance of the effects of industrial environment on the health of the workers in the state, set up as part of the State Department of Health, a Bureau of Occupational Diseases under statute which provides that all cases of occupational disease be re-

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ported to the State Department of Health and which authorizes the investigation of conditions causing or suspected of causing occupational disease, and which further provides that reports of occupational disease or the results of investigations cannot be used as evidence in compensation claims.

This bureau receives and investigates reports of occupational diseases made to it in accordance with the statute; makes surveys and field studies of workroom environment, including special determinations of dusts, fumes, gases, or other toxic materials, measurements of ventilation, illumination, etc., or any condition or process thought to be affecting the health of industrial employees, to determine whether the environment is safe or where and to what extent a health hazard may be present.

It provides a central source of information for physicians, industry, or any agency interested in the cause, treatment, or prevention of occupational diseases. It maintains in this connection a reference library containing the most recent information relative to the effects of various industrial materials and processes upon health, and in addition, as part of the set-up, a well-equipped laboratory.

The personnel of this bureau comprises technically trained men, who in the aggregate possess a broad knowledge of industrial hygiene, of industrial materials and processes and their effects on health, and the capacity to interpret the result of a survey or study as a basis for recommendations for control.

BUREAU'S FINDINGS REPORTED TO INDUSTRY

Each industry in which a study or survey is made receives a complete report of the bureau's findings, presenting the results of actual physical and chemical determinations of the working environment and the exposures of the individuals engaged in it, with recommendations for the elimination or control of any hazard that may be shown to exist. Actual determinations are made of the number of dust particles per cubic foot of air and of the concentrations of toxic materials present in the air to which the individual is exposed. These procedures necessitate the application by specially trained technical personnel of precise physical and chemical determinations. But it is in the proper interpretation of these results that the existence or non-existence of a hazard is established.

It is impossible for a lay inspector to tell by mere inspection whether the dust or other toxic material in the air of a workroom is present in sufficient quantities and is of such a nature as to constitute a hazard, whether the protection afforded is adequate, or the ventilation sufficient. It is only by measuring the exposure to these materials and processes that we can know that the individuals exposed to them are subject to injury from them.

The reports of these investigations are not just mailed to the industry but are presented by a technically trained man and discussed with the officials and engineers of the organization. This information not only establishes the nature and extent of an existing hazard but provides constructive data which engineers can utilize for the control of the hazard.

Already the work of the bureau, with the assistance of the engineering profession, has resulted in definite improvement in working conditions, changes in processes, substitution of materials, and, in a number of instances, in the purchase of entirely new equipment, not as the result of any mandatory orders, but due entirely to the fact that these industries were given definite concrete information on the effects of the environment on health. The actual requests for this service from industry have been so numerous it has been necessary to schedule work months in advance.

I say "with the aid of the engineering profession" advisedly, for the work of the bureau in the control of occupational disease is to render the laboratory and field service necessary to make the determinations of workroom environment, whether they be dusts, fumes, gases, illumination, ventilation, or any material or process that may affect health—that is, to measure the exposure and determine whether the environment is safe and if a hazard exists, where and to what extent, and due to what causes, and to present recommendations for its control. If the control involves specific engineering problems, as it frequently does, that is the job of the engineer; the bureau makes no attempt to provide this type of service, so that in the final analysis engineers have a definite responsibility in the control of occupational disease.

THE RÔLE OF INDUSTRY IN THE CONTROL OF OCCUPATIONAL DISEASE

In any program for the control of occupational disease the cooperation of industry is essential. Possibly one of the principal reasons why industry has been less willing in the past to correct an environment hazardous to health is that little attempt has been made to provide it with definite data. Such changes as have been effected were largely accomplished as the result of arbitrary orders from a law-enforcing agency and no serious attempt had been made to establish the exact nature and extent of the condition.

Industry is penalized through compensation payments if its environment causes occupational diseases, and, if it can be definitely shown that a health hazard exists, realizes that it is a matter of good business to control the condition causing it. But no industry will cooperate to the extent of changing its processes, installing new equipment, substituting new materials, etc., on the mere opinion of a lay inspector that a hazard exists. Under such circumstances it will do only what it is compelled to do, particularly when information secured as the result of such inspection can be used against it either in the form of mandatory orders, claims for compensation or both.

With a set-up such as exists in Connecticut, where the law provides that the results of investigations cannot be used in compensation claims, with a specially trained technical personnel to make determinations and interpret the conditions found in industrial environment, industry is provided with just the information it has a right to demand before it is required to change its processes, substitute materials, or take other necessary control measures.

Actual determinations of exposures are made in the working environment, and industry is presented with definite concrete facts that not only establish a hazard where it exists but provide constructive data for eliminating it.

It is our experience that when industry is approached by a health agency in behalf of a health program and is presented with definite data regarding its working environment, in a spirit of service rather than law enforcement, with the assurance that the results of the investigations will not be used in furtherance of claims against it, it not only accepts the service as a matter of good business but actually requests the assistance of such an organization in the improvement of its general working conditions.

THE ENGINEER'S PAST

The engineer's part in a properly administered program is of vital importance to successful control of occupational disease conditions. As an integral part of the personnel of the Bureau of Occupational Diseases, the engineer can offer an important contribution in interpretation of some phases of data obtained and in the development of recommendations for control of occupational disease hazards.

The field of occupational disease control is by no means confined, however, to that group which may give full time to this problem. With the awakening of industry to the necessity of providing healthful environment, the entire engineering profession has a large opportunity for constructive work. With the data at your disposal developed by the type of plant investigation I have outlined, you have new tools and more precise yardsticks.

In order to perform your part in the control of occupational disease you must be prepared to predicate your work not on the amount of air or material you remove but on the amount that is left behind and be prepared to meet a standard that will keep the working environment safe. To you we must look for the practical application of our findings and recommendations. It is you who design the machines and equipment for the use of these materials in industry.

There is, of course, a great deal of equipment used by industry that can be safeguarded in so far as the creation of occupational disease is concerned by additional protective equipment, but it seems to me that you should keep in mind as a future development the importance of taking care of the problem in the original design so that hazardous conditions may not develop. Why design a rock-crushing machine without proper dust-collecting devices, a degreasing machine which permits toxic quantities of vapors to escape, or an asbestos carding machine that subjects operators to 35 million particles of dust per cubic foot of air, when, after installation, these equipments will require additional devices to protect the worker, more expensive and less satisfactory than if the equipment had been originally designed properly to protect the operator?

Industry is very much alive to the necessity of providing safe working environment for its employees and you have a splendid opportunity through the exercise of your profession to profit and do your part in the prevention of occupational disease. An appreciation of the effects of these materials and the importance of such data as I have outlined is not only essential to the proper performance of your task, but will go far in convincing industry that the design and installation of protective devices is not a tinsmith's job but one for a competent engineer.

H. W. Fortey

WARNER & SWASEY NO. 5 UNIVERSAL TURRET LATHE AT WORK IN THE SHOP TURNING OUT A DOUBLE-END WORM OF A-1 STEEL FOR USE IN THE APRON OF WARNER & SWASEY TURRET LATHES

Mech. Eng. 57: 95-98 (1935)

TOXIC DUSTS

Their Origin and Sources in Various Industries

By REUEL C. STRATTON

THE TRAVELERS INSURANCE COMPANY

THE SUBJECT assigned to me presupposes that many industrial diseases are produced through contact with or inhalation of industrial dusts of a toxic nature. Personally, I do not believe that the consideration of occupational disease prevention should confine itself to dusts alone; it should include all materials produced in such manner that they may be inhaled by a worker. The question of whether a material exists as a gas, a vapor, or a dust is but one of particle size and chemical make-up; but with materials whose source is in industry, it does not seem fitting to stop with substances commonly known as dusts and thus fail to consider those which usually exist as vapors.

It is a common fault to focus attention upon one object to such an extent that others of equal importance are thereby relegated to obscurity. For the present, pneumonoconiosis, or more particularly silicosis, occupies the center of the stage and possibly for the purpose of this meeting such importance is justified. However, the engineer interested in the control of occupational disease by plant equipment and operation must not forget that there are many occupational diseases produced through exposure to industrial dusts other than silica-bearing ones and to vapors, and that the control of these industrial diseases may be brought about through the application of the fundamental principles which will be propounded by other speakers today. At present and until new avenues of control are discovered, explored, proved, and utilized, the problem in many instances seems almostl acking a complete solution, but it is unquestionably true that certain occupational or industrial diseases need not occur. The engineering aspects of their control are so well known that in the hands of capable plant officials there can be little excuse for their occurrence. In the control of such diseases, industry today faces a problem, the solution of which rests in the hands of the scientist, the physician, and the engineer.

While the generation of dust in various types of industries has a more or less common mode of origin, namely, the production of finely divided material, yet it does not seem fitting to group industries together even though the operations producing dust are somewhat similar. Therefore, in this paper, operations will be discussed as individual to a general industry rather than as individual unto themselves and assigned to many industries. While this may produce some repetition of material, yet for the sake of those engineers who are especially interested in an individual industry, I feel the paper will have added value.

QUARRY OPERATIONS

Although the exposure in a quarry due to dust varies in severity based upon the chemical composition of the material being quarried, most operations are similar. Drilling operations, both well and small-bore, produce voluminous quantities of small particles of the material in which the operations occur. Air-flushed drills distribute these particles over a wider area than do water-flushed drills, but the offal from water-flushed drills dries and then becomes distributed in the air. When crushers are operated, either gyratory or jaw, dust is produced in an amount depending mainly upon the size of the unit involved and upon the fineness of the material which is being processed.

Sizing and screening operations also distribute dust, although they may not in themselves be producers.

SHAFT SINKING, TUNNELING, EXCAVATION, AND DEMOLITION

Drilling operations in all such activities afford opportunity for dust generation. Again, the exposure depends upon the type of rock encountered. Transportation of materials to and from the face or working area also allows dust to be distributed. Steam-shovel work in excavations exposes workers to dust clouds. In demolition work, the pulling of walls, the dropping of floors, the loading and unloading of debris causes the generation of much dust. Blasting operations when required not only generate dust through the action of the explosive itself, but may precipitate other settled dusts by the shock transmitted to the surrounding structures or areas.

STONE DRESSING AND FINISHING

When this activity is in conjunction with quarry operations, the same quarry items previously listed pertain. Stone dressing and finishing is probably one of the most prolific sources of dust known. At least the exposure is one of the most serious due to the intimate personal contact of employees to the area in which the dust is generated. Stone dressing promotes much hand-tool labor.

Surfacing work, both hand and machine, produces quantities of fine dust. Sawing, cutting, and channeling, as well as drilling, are also prolific sources of contamination. Hand chiseling produces a certain amount of fine dust but in this work the larger particle sizes usually predominate. Hand polishing produces some dust but only a very small quantity as compared to a mechanical polishing mill or jack. Even when wet polishing is done, the quantity of dust is only slightly reduced. Sandblasting operations, if not isolated, are dust producers. Such dust generation is cumulative, as the abrasive material is broken and forms a dust in conjunction with the material which is being blasted and eroded.

In addition to the operations indicated, workers themselves create a dust hazard by the blowing, by means of a compressed-air nozzle, of dust which has accumulated around the tools or operations.

BUILDING CLEANING

The cleaning of buildings by hand or machine may be considered a dusty operation. This is particularly true when sand blasting either by air or steam is employed. The seriousness of the hazard somewhat depends upon the type of material being cleaned. Naturally, this is additive with the dust from the sand used for blasting purposes.

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Nesmith, N. Y.

ELIMINATING DUST IN ROCK DRILLING

(The drill operates through a dust collector consisting of a metal cap connected by a hose line to a suction tank and dust catcher.)

MINING

The more common forms of mining are coal, feldspar, glass, sand, metals, mica, refractory materials, and talc. In any form of mining, dust is produced in the use of drills and excavation machinery. This is true even in open-pit work. The exposure varies according to the rock encountered. As in other cases, the use of wet tools does not entirely eliminate the generation of dust.

SAND AND GRAVEL DIGGING—FLINT AND SPAR MILLING

These two operations are oftentimes associated. Underwater sand and gravel production is relatively non-hazardous but the sizing and screening operation, even though upon moist material, may be a source of dust generation as the fine particles will collect on machines, ledges, and parts of the buildings and later be swept into the air.

When flint and spar milling is carried on either in conjunction with sand and gravel digging or with any other source of raw stock, the hazard varies, as has been previously stated, according to the composition of the material being handled. Practically all operations are sources of dust contamination. Primary crushers, either gyratory or jaw, produce dust; secondary crushers, screens, jigs, air separators, conveyers, and other types of machinery generally produce dust in air to a greater or less extent. Bagging, packaging, and shipping either as individual items or as bulk may produce dust. Spoil heaps unless salted down may generate dust when the ordinary land breezes blow over them.

CONCRETE PRODUCTS AND ARTIFICIAL-STONE MANUFACTURING

Mixing operations are dust producers in this type of industrial activity. Finishing operations if by sandblast or hand tools also produce dust.

BRICK MANUFACTURING

In the manufacture of brick as well as tile and terracotta articles there are several sources of dust generation. The clay-drying department, whether natural material is used or a mixed slip is used, produces dust when the dried materials are thrown into the air through handling. The dropping on the floors of small quantities of material allows it to become dry and then be dispersed in the air by workers walking or by transportation. Mixing operations give off dust. The operation of pug mills and brick molders may generate dust through the drying of the waste material. Storage departments may be a source of dust occasioned through the handling of material.

CEMENT AND LIME MANUFACTURING

When operating in conjunction with a quarry or mine, previous sources of dust listed under such headings apply. In addition, all crushing operations produce dust. The charging operations to burners either hand or mechanically done will create dust. The operations of the finishing and packing department where bags and barrels are packed, closed, crated, and shipped are a source of dust generation.

FOUNDRIES

The exposure to dust in foundry operations varies only slightly according to the type of foundry. A non-ferrous foundry may be little if any different on an overall exposure from a ferrous foundry. Sand-conditioning operations produce dust. The use of sand cutters or blenders, screens, riddles, slingers, grab buckets, and other conditioning machinery or operations may create dust. In molding processes the general work on the molding floor or the use of sand throwing and blowing machines may produce a hazard. The application of parting compounds to the mold may create a dust. This situation is naturally more serious when the parting material used is of high free-silica content.

Shake-out procedure, rattling and tumbling with or without air, sand-blasting, grinding, and snagging are dust-producing operations. Scratch-brushing work may generate dust.

As previously mentioned, sand-blasting generates dust under any circumstances. Charging operations in loading a cupola or any other type of furnace may generate dust in the immediate vicinity and later contaminate the remainder of the premises. The storage of raw stock, such as limestone, coal, sand, and pig stock, may through handling generate additional dust.

METALS REFINING—LEAD

In addition to the exposures enumerated under mining and ore production, there exist in the refining operation dusty exposures. Furnace operations, such as charging and drawing, generate dust. This is particularly true when all or portions of the charging material consist of scrap, such as storage-battery plates. Trucking of such may strew the fine material on the ground or floors where it may be picked up and thrown into the air by walking or by the wind. Skimming, reheating, and sampling operations produce dust. The handling of the collected material in bag houses, flues, or Cottrell precipitators may create a dusty exposure which is particularly serious during the cleaning operations necessary to keep Cottrell precipitators or bag houses operating at proper efficiency. The transportation of materials in leaky containers, non-enclosed mechanical conveyers, or uncovered cars creates a hazard. Hand shoveling may produce dust in serious quantities.

MERCURY, ZINC, AND COPPER REFINING

The items enumerated under lead refining apply here also. In the production of zinc, one added exposure appears which is the dust produced in the blowing out of retort condensers, either by barring down or by "shooting" the condenser with a slug of water.

BATTERY MANUFACTURING—STORAGE AND PRIMARY

In the manufacture of storage batteries an exposure to dust exists in the preparation department. The handling, weighing, and mixing of the lead oxides either by hand or machine generates dust. In the pasting operations, either hand or machine, the material may be spilled upon the machine or the floor, become dried, and later be thrown into the air in the form of dust. The brushing of pasted grids will generate dust in a like manner. On the assembly line even when only hand operations are in progress, dust may be generated.

In the manufacture of primary batteries not only may dust be generated by metal-casting operations, but also in mixing, filling, and sealing.

CHEMICAL MANUFACTURING

It would be impractical to attempt to list all the operations in chemical manufacturing which may be dust producers. Here again the seriousness of the exposure depends upon the material handled and the amount of material that is thrown into the air. Chemical dusts, particularly some dye and dye intermediates, are positive sources of dermatitis where the dust generated lodges upon the skin of employees. It is sufficient to say that dusts are generated in the chemical industry and each individual operation requires study by itself.

In chromic-acid manufacturing the sintering of ore is a dust-producing job. The handling and transportation of the ore prior to the sintering either in furnace or kiln produces dust. The quenching of the sintered material may generate dust as also the crushing of the sintered stock.

ASBESTOS AND ASBESTOS-GOODS MANUFACTURING

Any mining operations and quarry operations are exposures, as previously discussed. In the manufacture of asbestos goods, particularly dusty atmospheres are created in the break-out, opener, and picking operations. The crushing and grinding of the fiber, as well as all spinning and weaving operations, have a tendency to throw asbestos fiber into the air and create a source of dust contamination. Crushing and grinding asbestos products generates dust.

INSECTICIDE MANUFACTURING

The toxicity of any dust generated in insecticide manufacturing varies according to the material being processed. There is a similarity of operations in most insecticide manufacturing. The preparation department, where the raw materials are manufactured, involves dusty processes. The grinding of cakes from filter presses, the mixing of different ingredients, either by hand or machine, the packaging of the insecticides into bags, cartons, barrels, either by hand or mechanically, and the transportation of materials from point to point in the plant generate dust in varying degree.

Nesmith, N. Y.

ROCK DRILL MOUNTED ON TRIPOD AND EQUIPPED WITH DEVICE FOR THE ELIMINATION OF SILICA DUST

(The bottles shown on the tripod measure the amount of silica which would be inhaled by the drill operator.)

PAINT AND COLOR MANUFACTURING

The handling of bulk raw materials, as well as the grinding of filter-press cakes, will generate dust. Mixing and blending operations either wet or dry produce dust. This exposure is inherent in the handling of dry materials, but the spillage of water-wet materials may dry out and later be thrown into the air. Batch weighing when the handling is by hand produces dusty exposures.

GLASS MANUFACTURING

The most hazardous dusty areas in glass manufacturing are located in the raw-materials receiving department and the batch-mixing department. The unloading of glass sand, soda ash, spar, flint, and other materials from box cars or trucks into storage bins produces dust. Even when these materials are mechanically handled, dust is generated. Batch mixing where the various ingredients are drawn from storage bins and weighed preparatory to being transported to the furnaces also produces dust.

POTTERY MANUFACTURING

What has been listed for glass manufacturing also applies to pottery manufacturing. This is true even when a slip system is used. In addition, the grinding and kiln-firing operations are important sources of dust contamination.

ENAMELING AND ENAMEL-WARE MANUFACTURING

In the preparation of enameling material by mixing, grinding, in either bar or ball mill, blending, and solution-making dust is generated. Spray coating or dipping objects may create a dusty atmosphere through the dispersion of the fine droplets in air and drying out at the suspended material. The rimming of articles to produce stripes is a dust producer of high severity. Loading kilns for firing including the operation of continuous tunnel kilns may produce dust in large quantities. In such manufacturing as well as in many others, the transporting, storage, and handling of raw materials may be sources of dust.

TEXTILES

This caption also includes paper, linoleum, felt, hair, and other similar types of manufacturing operations. Such dusts are not generally considered as being toxic, but yet a sufficient number of instances have arisen to make it appear warranted to include them within the scope of this paper. Picking, opening, mixing, blowing, carding, willowing, spinning, and other similar operations produce dust. In linoleum manufacturing the receiving of the raw filler material, such as soapstone, talc, and mica, as well as the storage of these materials and their handling during process work, may produce dust. Both in hair and in hair-goods manufacturing, the dust may also include the spores of anthrax and the origin of such contamination may be particularly prevalent in the blowing and curling operations.

METALLIC-POWDER MANUFACTURING

Where a cupola is operated in connection with such operations, certain exposures previously listed may be found. In stamping the metal, dust may originate. In coating operations dust also occurs. Where an air-float method is used for the separation of fine particles from large, dust may be exhausted into the atmosphere of the place of work in copious quantities.

MISCELLANEOUS EXPOSURES

There are certain exposures where a material may exist in the form of a dust, a vapor, or possibly a spray of fine droplets. The correction of any exposure of this type requires recognition on the part of the engineer of the material to which workers may be exposed and a determination of the point of origin of such material. A few miscellaneous exposures are discussed in the following paragraphs.

Exposure to Mercury. Exposures to mercury may occur in the mining of the ore, the reduction of the ore, and in the amalgamation of gold ores. Exposure is also found in the manufacture of thermometers, vermillion, and other dyes, the felt-hat industry, the treating and handling of furs; incandescent-lamp, radio-tube, and other electrical-apparatus manufacture; explosives manufacture; and laboratory work, including photographic and research laboratories.

The exposure may be from the dust of the salts of mercury, the generation of fine droplets of mercury together with dusts of other nature, and the vapor of mercury which is generated at high temperature as well as small amounts which may be given off at ordinary room temperature.

Exposure to Chromium. The exposure to chromium is usually found in the generation of the dust of the salts of chromium. There are certain processes in the manufacture of chromic acid and chromium salts from chromium ores which produce dust. The manufacture of paint pigments containing chromium, yarn dyeing and calico printing, the use of bichromates in dye preparation, the chrome process of leather tanning may also have dusty operations. In electroplating with chromium many fine droplets of chromic acid may be thrown into the air by the bubbles of hydrogen disengaging at the surface of the liquid in the electroplating tank.

Exposure to Benzol. Exposure in the case of benzol is usually due to the vapor of the material. The operations of its production, its use in artificial-leather manufacture, in degreasing operations, and in others may result in an exposure. Information may be found in the report on benzol which was published several years ago by the National Safety Council.

Exposure to Lead. As lead is used in widely varied operations and in widely varied forms, it would be relatively impossible to list all of the operations which might include an exposure. The exposure usually exists in the form of dust of the material itself or its compounds or in the form of fumes which may be generated at points where the material is handled at temperatures above its melting point.

Dusty operations may occur in lead mining, lead refining, lead smelting and sintering, the manufacture of plumbers' supplies, foundries, battery manufacture, both storage and dry, pottery operations, glass manufacture, certain printing trades, rubber-tire manufacture, and paint manufacture. In addition, dusty exposures may occur in the chemical-manufacturing trades which involve the manufacture or use of lead or its compounds.

Exposure to Arsenic. Exposure to this material may often be found in the dusty operations surrounding the refining of copper ores and the manufacture of insecticides containing arsenic, either in the form of the oxide or other salts.

Exposure to Radium and Radioactive Substances. The exposure to this material while not by any means general has been recognized in isolated sections and attained for itself relative prominence. The exposure may exist in the inhalation of dust from radium-bearing materials or the exposure to and the inhalation of emanations from radium. In general, this exposure is produced in the mining and handling of radium ore, the refining of the ore, the collection of radium emanation, and the use of the material in producing luminous dials for watches, clocks, and instruments.

CONCLUSION

One should not necessarily conclude that every operation listed in this paper is an absolutely dangerous source or point of origin of a toxic dust. It should not be a foregone conclusion that the operations listed in this paper include all of the possible sources of toxic dusts. The operations discussed, however, are typical of those where known cases of exposure have occurred. To the engineer unfamiliar with sources of air pollution, even in the so-called non-hazardous industries, the listing may seem far-fetched and ambiguous. It should not be assumed that an exposure listed in this paper is prima facie evidence that trouble is inevitable, but to an engineer interested in protection against the more important sources of air contamination by dust generation from ordinary industrial procedure, the listing will provide a basis upon which he may work. All in all, it is best for any engineer to proceed upon the basis that any dust of any type in any concentration creates an industrial exposure and to suppress the dust at its origin.