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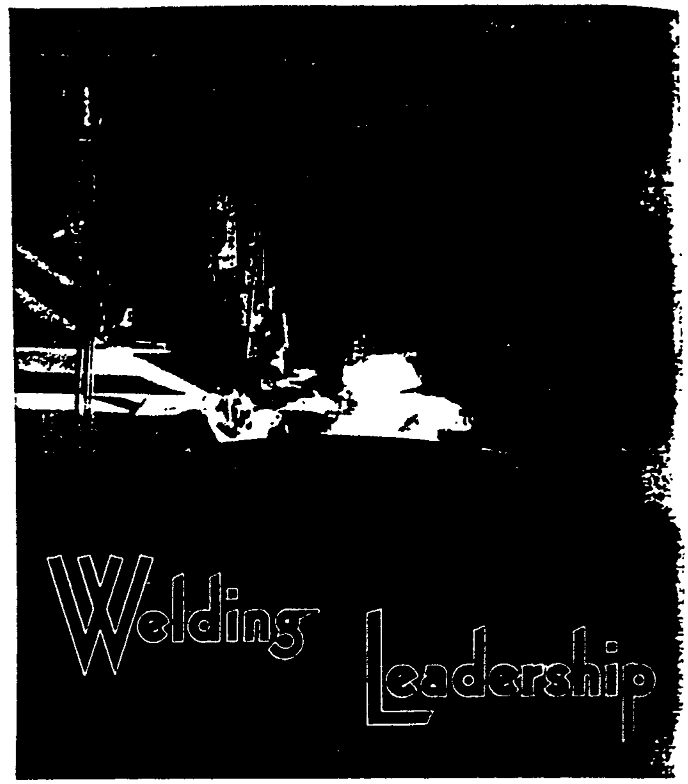
400,000 feet of welding in one contract



THE quantity and the quality of the welding to be done by The Babcock & Wilcox Company in fabricating 14,500 feet of plate-steel pipes for Hoover Dam require the exercise of those abilities constituting welding leadership.

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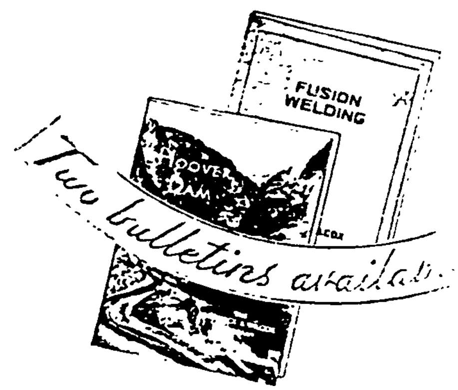
Details of this project, contained in a new bulletin now available, provide further evidence of the resourcefulness of The Babcock & Wilcox Company . . . an organization with every facility for the production of superior fusion-welded pressure vessels of every size and type.



Two publications, one describing the complete fusion-welding technique . . . and the other, containing a brief description of the Hoover Dam project as a whole and featuring the part to be completed by this Company, will be sent upon request. Simply ask for Bulletins S-4 and S-10.

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G-31

BABCOCK & WILCOX

DUST *in* INDUSTRY

The Sampling and Analysis of Industrial Dusts

By J. J. BLOOMFIELD[1]

THE abundant evidence at hand showing that the inhalation of certain industrial dusts is an important factor in the causation of pulmonary disease has emphasized the significance of the quantitative aspects of this problem. A knowledge of the dust content of the industrial atmosphere is required not only for the purpose of determining the extent of the hazard involved in various manufacturing processes, but is also useful in measuring the efficiency of protective devices which may be used in the elimination of the dust hazard. The object of the present contribution is to describe the underlying factors involved and the technique employed in the study of the quantitative phases of the industrial dusts which may produce injury to the respiratory system. Such dusts are produced by the numerous industrial operations involving the drilling, crushing, and grinding of mineral matter such as talc, quartz, granite, slate, and cement.

The properties of a given dust which determine its capacity to produce pulmonary pathology are the nature of the dust, that is, its chemical and mineralogical composition, its particle size, and finally the quantity of the dust dispersed in the atmosphere.

One of the outstanding results of the last 20 years of research in the field of dust inhalation is the demonstration of the fact that, in general, the degree of health hazard associated with the inhalation of any dust, all other factors remaining constant, is dependent upon the mineralogical composition of the dust. For example, it is now well established that the inhalation of certain types of dust, such as granite dust, will in time produce fibrosis of the lungs, frequently associated with tuberculosis. In other cases exposure to dust may result in the production of a far lesser degree of fibrosis without subsequent tuberculosis; this is true of cement dust. And finally, there are certain types of dusts which produce little or no lung fibrosis, as typified by marble dust. In general, it has been found that those dusts which are high in quartz content are the ones which produce a disabling fibrosis of the lungs most readily. Hence the necessity for knowledge concerning the chemical and mineralogical composition of a dust is obvious.

So far as the size of the dust particles is concerned, it is apparent that in order for any given dust to produce injury to the lung it must gain access to the parenchyma of the lung, the site where the harmful effects of the dust take place. It is known that not all of the particles of inhaled dust gain access or are retained by the human lung. For this reason it is essential to determine the size of the dust particles present in the industrial atmosphere.

With reference to the quantity of dust present in the air of a workroom, it is apparent that when the dust concentration is high the exposed person will inhale a greater quantity in a given period of time than he will when it is relatively low, and since the rate of production of the disease is partially dependent upon the total amount of dust inhaled, this latter fact plays an important rôle in determining the time of onset of the end result. The need for the evaluation of the quantity of dust in the industrial atmosphere is obvious.

NATURE OF DUST

Research on the problem of industrial-dust inhalation has demonstrated that so far as their fibrosis-producing qualities are concerned, dusts may be divided into three groups: (1) those composed completely of combined silica, that is, silicates, such as pure asbestos; (2) those containing free silica in the crystalline form known as quartz (granite contains approximately 35 per cent of quartz), and lastly, (3) dusts containing free silica in a non-crystalline form such as diatomaceous earth. In general it has been found that the harmfulness of a quartz-containing dust is in direct proportion to its quartz content. For this reason in attempting to evaluate the harmfulness of a dust it is of the utmost importance to ascertain its quartz content. This should be done by a chemical and mineralogical analysis.

We find in practice that samples of dust settled out of the atmosphere at the breathing level of the worker serve admirably for these chemical and mineralogical determinations. It is our practice to have such analyses made by an expert geologist. Only in this way is it possible to determine accurately the amount of quartz present in a given sample. Table 1 presents the quartz

TABLE 1 PERCENTAGE OF QUARTZ PRESENT IN VARIOUS INDUSTRIAL DUSTS

Kind of dust	Percentage of quartz
Rock-drilling dust (bituminous-coal mine)	54.0
Granite-cutting dust	35.2
Rock-drilling dust (anthracite mine)	31.0
Brass-foundry dust	19.0
Dust from raw mills in cement plant	6.5
Slate-mill dust (Vermont red slate)	3.0
Silverware-polishing dust	1.7
Anthracite dust	1.5
Bituminous-coal dust	1.2
Cement dust	less than 1.0
Slate-mill dust (Vermont green slate)	trace
Talc-mill dust	none
Marble-cutting dust	none

[1] Sanitary Engineer, U. S. Public Health Service, Washington, D. C.

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content of dusts obtained in various industries which we have studied.

It is quite evident that, judged by quartz content, rock-drilling occupations in the coal-mining industry and certain occupations in the granite-cutting industry and in brass foundries may be considered as hazardous. That this is true is evidenced by the high rates of illness and death from silicosis and tuberculosis in some of these industries.[3]

PARTICLE SIZE OF DUST

It has been demonstrated that particles of a size greater than 10 to 12 microns in the longest dimension are very seldom found in the lungs. This absence of larger particles is partly due to the fact that the number of such particles greater than 10 microns in size present in industrial air is, as compared with the lower sizes, comparatively small, and, due to gravity and the protective action of the mucous surfaces of the upper respiratory tract, these larger particles do not penetrate to the terminal portions of the respiratory tract. Hence we need only concern ourselves with those dust particles that are less than 10 microns in the longest dimension.

In order to ascertain whether or not an industrial dust is capable of gaining access to the lungs, it is necessary

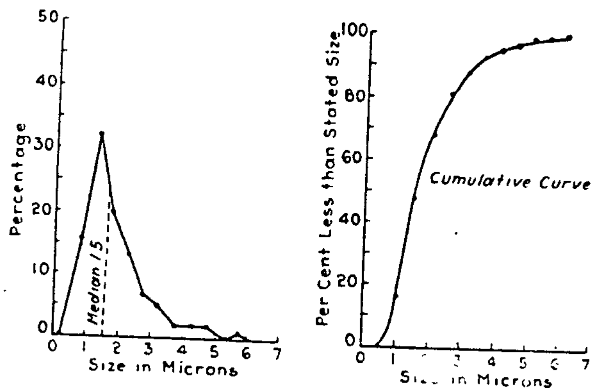

FIG. 1 PARTICLE-SIZE DISTRIBUTION OF TALC DUST

to make particle-size studies of the dust under consideration. In practice the samples for such studies may be obtained by the use of the Owens jet dust counter.[3] This apparatus projects the atmospheric dust directly on a microscope cover slip. This cover slip may then be properly mounted and examined by any one of several methods. Such samples may be studied microscopically, using a magnification of 1000 diameters (oil-immersion objective), and the horizontal diameter of a representative number of particles measured by means of a calibrated filar ocular micrometer.[4] In another method a photomicrograph of the dust is made at a high magnification (1500 to 2500 diameters); from this either an enlarged print may be made, or the negative may be enlarged by means of a stereopticon. The particles revealed on the enlarged print or screen may be measured by means of a millimeter scale. The particle-size dimensions are grouped in classes according to size, from which a percentage distribution curve is easily obtained. Fig. 1 presents the particle-size distribution of talc dust from the air of a workroom in which talc

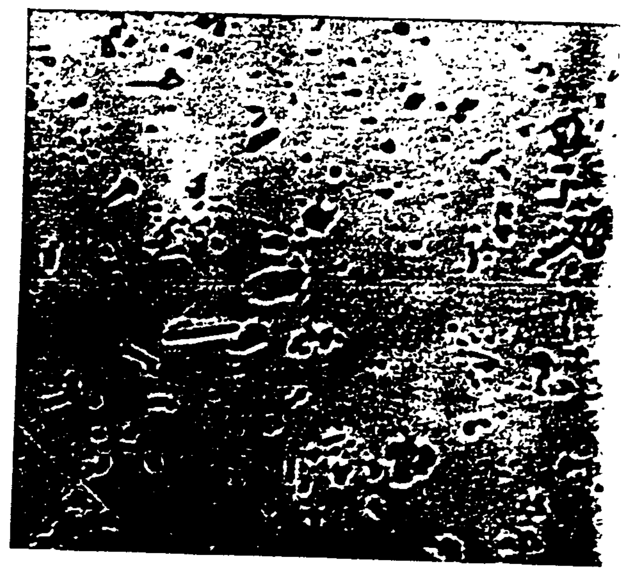

FIG. 2 PHOTOMICROGRAPH OF TALC DUST OBTAINED WITH THE OWENS JET DUST COUNTER. X650

was being ground to a very fine state of subdivision. The measurements, from which the data for this figure were obtained, were made by means of a filar ocular micrometer at a magnification of 1000 diameters. With this magnification it is possible to measure particles as small as 0.5 micron in diameter, while particles smaller than 0.5 micron are easily distinguished at this magnification, and, although not measured, their presence is recorded. For routine particle-size measurements the photomicrographic method as described by Green[5] has a decided advantage over the direct microscopic measurements, in that the task is less tedious and the particles are measured with more ease and accuracy. However, for all practical purposes the filar-micrometer method should fulfil the required needs.

An examination of Fig. 1 shows that only 16 per cent of the particles were found to be less than 1 micron, the major portion (65 per cent) being between 1 and 2.5 microns in size. The median size of the dust was found to be 1.5 microns. Fig. 2 is a photomicrograph of the same specimen of dust.

QUANTITY OF DUST

As pointed out earlier, a knowledge of the quantity of

[2] Russell, A. E., Britten, R. H., Thompson, L. R., and Bloomfield, J. J., "The Health of Workers in Dusty Trades. II. Exposure to Siliceous Dust (Granite Industry)." Public Health Bulletin No. 187, July, 1929.

[3] Owens, J. S., "Jet Dust Counting Apparatus," *Jl. Ind. Hygiene*, April, 1923, p. 522.

[4] Hatch, Theodore, and Choate, Sarah P., "Statistical Description of the Particle Size Properties of Non-Uniform Particulate Substances," *Jl. Franklin Inst.*, March, 1929.

[5] Green, Henry, "A Photomicrographic Method for the Determination of Particle Size of Paint and Rubber Pigments," *Jl. Franklin Inst.*, vol. 192, no. 5, p. 637, Nov., 1921.

dust dispersed in the industrial atmosphere is very important, since with any given dust the rate of production of the injury will be dependent upon the total quantity of dust inhaled.

The author feels that from the hygienic viewpoint the particle count is at present the best index of the degree of atmospheric pollution. The decision as to the size range of the particles which should be included in the dust count is a question requiring careful consideration. Obviously the size of the smallest visible particle will depend on the magnification and type of illumination used in the microscope, the refractive properties of the dust, and, to some extent, on the visual acuity of the observer. We must bear in mind that our chief interest in this problem is in its industrial and hygienic aspects. Primarily we are interested in differentiating between the dust content in ordinary normal atmospheres, not known to be harmful, and certain industrial dusts which are known to be associated with lung damage. This difference is sharply marked as far as the dust particles between approximately 1/2 and 10 microns in diameter are concerned; but the difference between such normal and abnormal air is masked and lost when we include in our determination the particles of ultramicroscopic size which are present in vast numbers in all air.

So far as the upper limit of particle size is concerned, it has been demonstrated by the South African studies that particles greater than 10 microns in the longest dimension are of negligible importance. The data concerning the lower size limit of potentially hazardous dust is not so conclusive. The only available data which throw some light on this point are found in the work of Moir,[6] of South Africa, who examined microscopically 120 dust particles obtained from two specimens of silicotic lung and found that only 13 per cent of the particles were less than 0.5 micron and about 36 per cent of the particles less than 1 micron in diameter. The majority of the particles (60 per cent) were between 1 and 3 microns in size. The median size of the dust was found to be 1.2 microns in diameter. Practically the same results were obtained by Watkins-Pitchford,[7] who examined and measured the silica particles in sections of silicotic lungs illuminated by polarized light. Drinker,[8] in comparing the size frequency of the particles measured by Moir with the particles found by him in the sputum of men employed in ore mills, found a close correspondence. The findings of Moir and Watkins-Pitchford have also been corroborated by Mavrogordato,[9] who examined dust both with light and dark ground illumination, in sections of human and animal silicotic lungs as well as the dust recovered from these lungs. As a result of his work and that of his colleagues in South Africa, Mavrogordato says: "In the damaged lungs, as far as simple silicosis is concerned, the lesions are discreet, localized, and associated with visible particles; whereas, if the ultramicroscopical particles were an important agent, one would expect the simple disease to be generalized and to show no particular association between lesions and visible particles."

In connection with the lower limit of particle size of dust of pathologic significance, the following pertinent question arises: Aside from the evidence direct or indirect of the non-retention of minute particles of dust by the lungs, what evidence is there that appreciable percentages of ordinary industrial dusts ever fragment into those minute sizes less than 0.5 micron in diameter? It is a well-known fact that in most of the fine-grinding operations in use today, such as in the preparation of paint pigments, considerable energy must be expended to obtain a product the particle size of which is less than 0.5 micron in average diameter, and this not in an industry where dust is an evil by-product but where finely divided dust is the chief aim of the whole industrial process.

The best answer to the question just raised, namely, What is the particle-size distribution of industrial dust? would be data of actual measurements of such dust. Unfortunately we have but scant published data to date on the particle-size frequency of dusts in the air of industrial establishments. In 1929, Fehnel[10] reported some particle-size dust measurements in connection with a dust study of hard-rock drillers in New York City. As a result of his study, Fehnel reported the findings on three samples, which showed the dust, which was less than one micron in size, to vary from 1 to 15 per cent. Most of the dust in these hard-rock drilling operations was, according to Fehnel, between 2 and 5 microns in size.

Badham,[11] in studying the dust hazard among sand stone workers in Sydney, measured some 16,000 particles of dust in the air of work places and found that 67 per cent of these particles were about 1.5 microns in size. From his study Badham states: "It would appear that below 10 microns there is no selective action by the dust cells of the lung, and that the particles found in the lung have the same size-frequency as those in the air breathed...."

In a particle-size study of 10 samples of aerial industrial dusts made by the filar-micrometer method at a magnification of 1000 diameters, the author found that practically all of the dust was less than 5 microns in size. Only 1 per cent of the particles was less than 0.5 micron, 18 per cent were less than 1 micron, and the majority of the dust (73 per cent) was found to be between 1 and 3 microns in diameter.

From all of the evidence just presented and in the ab-

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[6] Moir, J., "Report on a Specimen of Dust From Silicotic Lungs," General Report of the Miners' Phthisis Prevention Committee, Pretoria, 1916, Appendix 9, pp. 138–140.

[7] Watkins-Pitchford, W., "The Situation, Outline and Dimensions of Mineral Particles Visible by Polarized Light in Sections of Silicotic Lungs, Mounted in Canada Balsam." General Report of the Miners' Phthisis Prevention Committee, Pretoria, 1916, Appendix 8, pp. 135–138.

[8] Drinker, Philip, "The Size-Frequency and Identification of Certain Phagocytosed Dusts," *Jl. Ind. Hygiene*, vol. 7, no. 7, July, 1925.

[9] Mavrogordato, A., "The Value of the Konimeter," Publication of the South African Institute of Medical Research, no. 17.

[10] Fehnel, William J., "A Study of Silica Dust in Hard Rock Drilling in New York City," *Jl. Ind. Hygiene*, vol. 11, no. 2, Feb., 1929.

[11] Badham, Charles, Reyner, H. E. G., and Broose, H. D., "Dust Sampling in Sydney Sandstone Industries," Report of the Director-General of Public Health, New South Wales, Dec., 1927, p. 74.

sence of conclusive proof to the contrary, it is apparent that we need only be concerned with those dust particles between 1/2 and 5 microns in size, and from a practical standpoint the lower limit of particle size may well be taken at about one micron. The method of dust counting which we have used, the description of which follows, is capable of revealing particles as small as one micron quite readily, and in the hands of a trained person smaller particles may be enumerated.

Many methods have been devised and used for the purpose of determining the quantity of dust in air. These methods have already been fully discussed in an excellent review of this subject by Dr. Greenburg.[12] Suffice it to say that for the purpose of dust sampling in either high or low dust concentrations, the Greenburg-Smith impinger apparatus now finds universal favor.[13] This instrument has been used by the United States Public Health Service in all of its dust studies during the past nine years. It is also being used by other workers in this field both here and abroad.

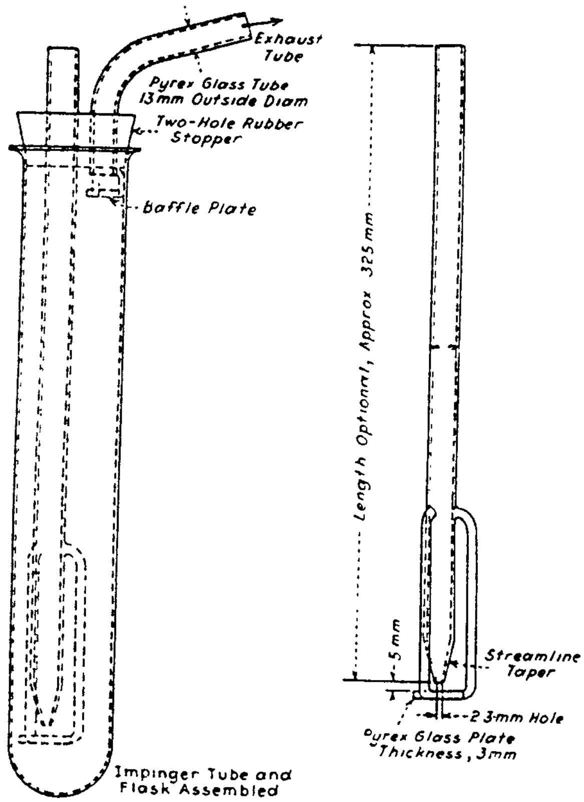
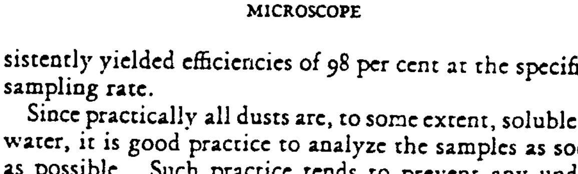


FIG. 3 ESSENTIAL PORTIONS OF THE GREENBURG-SMITH IMPINGER APPARATUS FOR DUST SAMPLING

In this instrument, the air to be sampled is drawn through a glass tube and impinged at a high velocity on a glass plate which is kept beneath the surface of the water or other suitable fluid in the collecting flask. The dust is momentarily arrested, wetted by the collecting fluid, and in this manner trapped.

The impinger apparatus consists essentially of two portions: first, a source of sufficient suction to draw the air to be sampled through the sampling device; and second, the sampling device or impinger itself, which consists of a container and the impinger tube and plate. As a source of suction one may use either an electrically driven pump or a compressed-air ejector device. Fig. 3 depicts the essential portions of the apparatus, which consists of a straight piece of Pyrex glass tubing 13 mm in outside diameter and approximately 325 mm in length. The tube is drawn down in streamline form at its lower end to a tip with a 2.3-mm orifice. A circular glass impinging plate approximately 3 mm in thickness and 25 mm in diameter is attached to the lower end of the impinger tube at a distance of 5 mm from the orifice by means of three glass rods. The collecting medium (distilled water) in the sampling flask is of sufficient volume to keep the impinger plate immersed at a depth of approximately 3 cm. In sampling, the outlet or suction elbow of the sampling flask is connected with the source of suction by means of a suitable length (25 ft) of non-collapsible rubber tubing. The duration of the sampling period should be such as to yield a satisfactory suspension of dust for analysis, and is thus dependent on the concentration of dust in the atmosphere. Under the usual industrial conditions, samples of from 10 to 30 cu ft of air yield sufficient suspended dust for analysis. Since a sampling rate of 1 cu ft per min is maintained, this will require a sampling period of from 10 to 30 min.

The collecting efficiency of the apparatus is dependent upon adherence to the previously cited impinger-tube dimensions and the sampling rate of 1 cu ft of air per min. Experimental tests of this instrument against suspensions of finely divided silica dust in air have consistently yielded efficiencies of 98 per cent at the specified sampling rate.



Sedgwick-Rafter Cell Whipple Disk

FIG. 4 SEDGWICK-RAFTER CELL AND WHIPPLE DISK EYEPIECE FOR USE IN COUNTING DUST PARTICLES UNDER A MICROSCOPE

Since practically all dusts are, to some extent, soluble in water, it is good practice to analyze the samples as soon as possible. Such practice tends to prevent any undue flocculation as well as any solvent action on the dust particles. In the laboratory[14] the dust suspension in the

[12] Greenburg, Leonard, "Studies on the Industrial Dust Problem," Public Health Reports, vol. 40, no. 16, April 17, 1925.

[13] Greenburg, Leonard, and Bloomfield, J. J., "The Impinger Dust Sampling Apparatus as Used by the United States Public Health Service," Public Health Reports, vol. 47, no. 12, March 18, 1932.

[14] For a more detailed description of the dust-counting technique, the reader is referred to a contribution in the Public Health Reports of March 18, 1932.

sampling fluid is filtered through a 325-mesh screen and then diluted so that the number of dust particles in the microscope field is equal to approximately 50 to 75. Two or more 1-cc portions are placed in Sedgwick-Rafter cells for counting (see Fig. 4). The microscope is of the ordinary type, provided with a suitable eyepiece and objective and fitted with an Abbé condenser. A Whipple disk-eyepiece micrometer (Fig. 4) is placed in the microscope eyepiece and the microscope tube length is adjusted so that the side of the ruling in the eyepiece is 1 mm in length. (We employ a 7.5 X eyepiece, 16-mm objective, and a tube length of 178 mm.) As a source of illumination we use an ordinary type of microscope lamp with the iris of the Abbé condenser system adjusted so as to provide a high degree of visibility. In making counts the microscope should be focused throughout the depth of the cell since some of the dust particles may remain in suspension. Since the counting cell is 1 mm deep and the area in the microscopic field is 1 sq mm, each count represents the amount of dust in a cubic millimeter of the sampling fluid. Knowing the original dilution of the sample and the number of cubic feet of air sampled, it is an easy matter to compute the number of dust particles in the sample per cubic foot of air. It is of course necessary to make control dust counts on the sampling fluid.

In Table 2 a summary is presented of the average dust content of the air in certain dusty industries. This table shows that the highest dust exposure was in the slate mills, talc and coal mining, and in the granite-cutting industry. Owing to the high percentage of quartz (35 per cent) present in granite, as compared with the dusts in the other industries listed in Table 2, granite cutting is revealed to be the most hazardous of the occupations we have studied.

TABLE 2 AVERAGE DUST COUNT IN CERTAIN DUSTY TRADES

Industry	Dust count in millions of particles per cubic foot of air
Slate-finishing mills:	
Floormen	1598 0
Loaders	1276 0
Disk-crusher operators	31_.8
Talc mining:	
Jack-hammer drillers	2159.8
Muckers	44 8
Talc-finishing mills:	
Crushers and cylindermen	14.0
Packers	50.1
Marble cutters	32 8
Marble carvers	19.1
Granite quarrying:	
Leyner drillers	144.4
Jack-hammer drillers	112.1
Plug drillers	36.9
Cement mill, average of all operations	26.0
Granite cutting:	
Hand pneumatic-tool operatives	59.2
Machine pneumatic-tool operatives	35.9
Attendant labor	17 0
Anthracite mining:	
Miners and miners' helpers	231.5
Attendant labor	31.1
Bituminous-coal mining:	
Coal cutters and coal loaders	112.3
Attendant labor	3.9
Silverware manufacturing:	
Dusty processes	5.2
Non-dusty processes	1.7
Municipal dust (street cleaners):	
Congested district	4.1
Residential district	1 8
Cotton industry:	
Carding room	3.6
Weaving and spinning room	4.5

A test of the value of any technique is in the results obtained in its practical application to a definite problem. Such a test was offered to us in the study of the health hazards of granite cutters in Vermont. In this study the following investigations were conducted for a period of slightly more than two years on a large group of workers: (1) Examination of the workers to determine

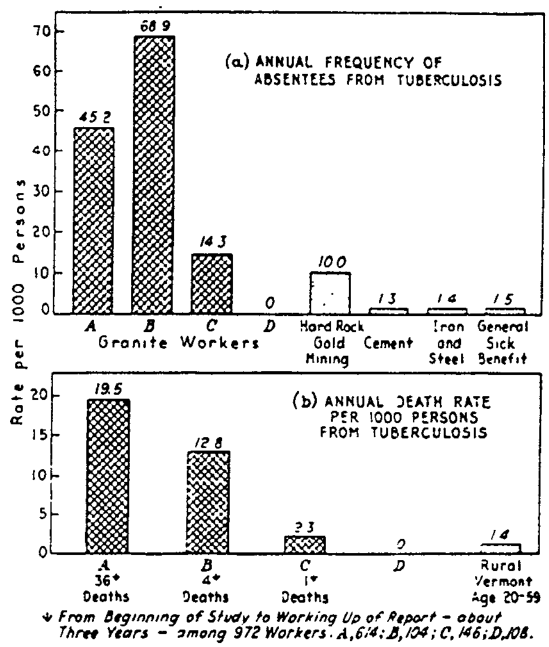


FIG. 5 (*a*) ANNUAL FREQUENCY OF ABSENCES FROM TUBERCULOSIS (EIGHT DAYS AND MORE). (*b*) ANNUAL DEATH RATE PER 1000 PERSONS FROM TUBERCULOSIS

their general physical condition; (2) special physical examinations to determine the prevalence of specific diseases of the respiratory system and the lung pathology resulting from exposure to granite dust; (3) record of the nature and severity of disabling illnesses; (4) occupational mortality statistics, (5) autopsies; and lastly (6), detailed studies of the nature and quantity of the dust exposure in each occupation.

Let us briefly examine the results of this study. The whole group of workers was divided into four subgroups, depending on their average dust exposure. Fig. 5 shows the annual frequency of absences due to tuberculosis and the annual death rate per 1000 persons from tuberculosis among the workers in these four groups. This figure also compares this data with similar information for other industrial groups.

In group A, which included hand pneumatic-tool operators and in which the exposure averaged about 59

(*Continued on page 262*)

and 4 parts of potassium carbonate, which is boiled for 5 min and then rapidly cooled. The fabric is then stentered on a hot-air stentering machine in such a way that it is dried at a low temperature, being afterward heated for two minutes at 170 C and finally soaped.

A catalyst is generally required in the formation of formaldehyde synthetic resins, and this may be acidic or alkaline.

The process adds weight to the material and is claimed to increase the dry strength by 30 to 50 per cent and the wet strength sometimes as much as 100 per cent. This is particularly important for rayon fabrics because of their weak strength when wet. (*Plastics and Molded Products*, vol. 8, no. 11, Nov., 1932, pp. 417, 432–433, *dA*)

THERMODYNAMICS (See Power-Plant Engineering: Boilers and Heat Pumps)

WELDING

High Frequency for Arc Welding

EXPERIMENTS with induction generators operating at frequencies ranging from 500 to 9000 cycles per second have shown that currents of such relatively high frequencies have important advantages for use in metal arc welding and for other arc applications of heat.

There are no surges of more than 10 per cent above normal in either voltage or current when short-circuits are made and broken by wiping the welder's rod holder quickly across the edge of the grounding base. The voltage and current curves (Fig. 5 in the original article) show practically normal conditions immediately after the short-circuit is broken or made.

The machine which the author describes consists of a generator of the double-core type designed to operate at 3600 rpm to produce welding currents at a frequency of 900 cycles per second. The machine is said to have the simplicity and ruggedness of a squirrel-cage motor, although the length of the air gap is almost twice that usually employed in an induction motor. The relatively high speed enables direct connection to gasoline engines of similar speeds, resulting in portable sets, compact and light in weight, and this machine makes a practical welding generator with which metal arcs are easy to strike and hold, and good penetration is obtained. It is particularly good where new heavy-coated rods are used and in other work where reversed polarity of direct current is recommended. With a carbon torch this high-frequency current is also useful. The arc projects so well away from the carbons that it is almost as handy to the work as is a gas flame. In the case of the carbon arcs the no-load voltage used is the same as for metal arcs. The carbon arcs operate at from 45 to 50 volts, with correspondingly lower current per circuit. It should be noted that this generator is operated at low open-circuit voltage, and is comparable to d-c machines in this respect. Metal arcs are easy to strike and hold at from 65 to 70 volts. Arcs of smallest current values can be held successfully with open-circuit voltages below 100.

Among the features of this high-frequency generator that command attention are:

1 Multiple circuits for more than one generator; simple adjustment of circuits.

2 No transients that affect the welding operation.

3 Low open-circuit voltage.

4 Inherent regulation, no external reactance or resistance required.

5 High efficiency.

6 Self-excitation, or optional separate excitation from any d-c source.

7 Weight and cost low; less than one-half the usual d-c machine; comparable to 60-cycle transformer equipment.

8 Three-phase loading of power lines as compared to single-phase 60-cycle transformer sets.

9 Rugged construction of rotor; no windings; no commutator; no brush wear.

10 Optional direction of rotation.

(G. A. Johnstone, Great Lakes Electric Mfg. Co., Chicago, Ill., in *Electrical Engineering*, vol 52, no. 1, Jan., 1933, pp 14–16, 6 figs., *d*)

Articles appearing in the Survey are classified as *c* comparative; *d* descriptive; *e* experimental; *g* general; *h* historical; *m* mathematical; *p* practical; *s* statistical; *t* theoretical. Articles of especial merit are rated *A* by the reviewer

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Dust in Industry

(*Continued from page 233*)

million particles per cubic foot of air, it was found that practically 100 per cent developed an established silicosis within 10 years from the time of beginning employment. Also, in this group the highest rate was found for cases diagnosed on physical examination as having active tuberculosis. Furthermore, a definite relation was established between length of service in the industry and the prevalence of tuberculosis.

In group B were included those workers other than hand pneumatic-tool operators who were also exposed to more than the average plant dustiness. Taking the group as a whole, the average dust concentration was nearly 45 million particles per cubic foot of air. This group showed the same reflection of a dust hazard as group A.

In group C, consisting of those occupational groups exposed to the average plant dustiness (about 20 million particles per cubic foot of air), silicosis developed much more slowly than in the groups just discussed, and there appeared to be very little excess in the rate for tuberculosis, with no tendency for an increase according to length of service. Analysis of occupational mortality over a period of 25 years, however, indicated that some of the occupations in this group may have been exposed to a real dust hazard.

Group D was made up of those occupations in which the dust exposure was less than that of the average plant dustiness. The average exposure for the group was less than 10 million particles per cubic foot of air. Although a certain amount of silicosis was found even in this group there was no indication of serious results, even when the workers had been employed for many years.

It is clear from these data that there exists a high correlation between the dust counts and the effects of this dust exposure on the health of the granite workers. It is obvious, therefore, that the technique of dust analysis described in this paper constitutes a valuable index of the hazardousness of dust inhalation, and one from which the degree of hazard may be judged with practical certainty