The American Ceramic Society

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Christine Schnitzer

Christine Schnitzer
Product Manager
Ceramic Information Center

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735 Ceramic Place
Westerville, Ohio 43081-8720
614 • 890 • 4700
TWX: 7101109409

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CERAMIC ABSTRACTS

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vestigation of aluminum dust as a possible respiratory hazard resulted from the appearance in 1934 at the Occupational Disease Clinic, Berlin, of a patient who had been spraying aluminum bronze for nearly a year and who showed signs of a lung disease of a not very clear character. Early in 1934 an Italian doctor of the throat and nose clinic at the University of Rome published his observations upon the effect of aluminum dust on the air passages. The present research includes (1) the components and properties of the substance (which does not occur in nature in metallic form but is the result of mechanical and chemical processes), (2) 30 citations of previous studies on the injurious effects derived from the preparation of aluminum and its industrial uses, (3) the detailed case-history of the patient, with laboratory findings and Roentgen studies, (4) an intensive investigation of 70 workers in aluminum works, and (5) a critical analysis of the Italian data. The hazards were found to be completely negative, both in the processes of making aluminum and from inhalation of the dust. K.R.

Inhalation of dust and control of dust hazards. W. C. Jones. *Concrete, Cement Mill Ed.*, 46, 200–201, 216–17 (1938).—Many persons inhale excessive dust into their lungs, with coal and iron-ore dust coloring the lung tissue. In most cases, however, these changes are of no more importance than callouses on the hands. Only two dusts actually cause diseases on inhalation, silicon dioxide (usually quartz) and asbestos. Only particles below 10 μ are effective, and these must be breathed in high concentration and over a long period of time. A safe maximum concentration is 5 million particles of quartz dust per cu. ft. The exposure of each man should be reduced to particle-hours to be comparable. The length of time necessary to develop silicosis is controlled by (1) concentration of dust, (2) proportion of free silica, (3) length of exposure, and (4) general health of the employee. It is unusual to have silicosis develop in less than seven years. Dust should be removed at the source. W.D.F.

Occupational diseases of the lungs in agricultural workers. Richard Fawcett. *Brit. Jour. Radiol.*, 11, 378–92 (June, 1938).—In 1936, 749,700 persons were employed in the agriculture of Great Britain, forming one of the largest working groups. F., as a country practitioner in the hills of the Lake District, early became familiar with the agricultural types of asthma, bronchitis, and pneumonia which usually ran a protracted course among these workers; recovery, when occurring, appeared largely due to potassium iodide and creosote administration. The infections the working people are subject to are listed as organic matter (microfungi and bacteria) existing in grasses, straw, grain, fruits, the soil, and in the excreta of farm animals; only occasionally does inorganic matter affect them, *e.g.*, men carting siliceous stones. The details of fungi infection and the procedure in identification are briefly and clearly given; types of fungi predominantly affecting six special groups of farm hands, *e.g.*, hay or grain workers, stablemen, gardeners, etc., are described, with the resulting symptoms and injury. Nine points to be considered in a doctor's study of such cases are systematically presented for case-history record. Special comment is made upon the agricultural groups, with citations from case reports; 13 large-size radiographic reproductions of chest phenomena in the various fungi invasions concerned are interpreted for the lay reader. F. emphasizes these occupational diseases as rare, seldom reaching radiological departments or diagnosis. Yet common microfungi, often innocuous, do become pathogenic under certain conditions. The incidence of harmful infection is more common and more widespread than is generally realized. 19 references. K.R.

Practical significance of silicate research. A. Dietzel. *Sprechsaal. Ber.*, 14 [5] 101–04 (1936). J.F.H.

Prevention of disease in industry. D. Hunter. *Ind. Chemist*, 13, 134–36 (1937).—The main principles underlying the prevention of disease in industry are (1) protection of workmen by law such as workmen's compensation acts, (2) medical inspection under state support, (3) education as to the nature of the danger, (4) importance of cleanliness (cleanliness of work places, bodily cleanliness, and general hygiene), and (5) reduction of manual operations. H.E.S.

Preventive measures in the use of crystalline silica. M. M. Shafer. *Ind. Med.*, 7 [8] 472–75 (1938).—S. presents the subject systematically under three major aspects: (*A*) medical, (*B*) engineering, and (*C*) managerial. He suggests that, before any protective measures in the use of crystalline silica are resorted to, the fact be established that a silica hazard exists. Data involved include (1) a definite exposure to dust known to contain a certain percentage of silica and (2) sufficient dust exposure, as estimated by dust count and dust composition, to cause silicosis if the exposure is continued over a sufficiently long period of time. In emphasizing (*B*), S. states that it is entirely the problem of the engineer to prevent silicosis. The medical director can only check the adequacy of the engineer's methods of control. K.R.

Recovery metabolism of silicotics. A. Böhme. *Arch. Gewerbepath. & Gewerbehyg.*, 8, 601–10 (1938).—B. records the metabolism studies and muscular tests applied to silicotics in varying stages of the disease to improve their greatly impaired respiratory capacity and muscular action, if possible, and at least to record the success or failure of such efforts. Tables show a comparison of the metabolism of normal persons after 15 bendings of the knees (as in climbing stairs), after taking food, and after rest with the metabolism of the silicotics (four having a lessened industrial capacity of 80% and six lessened to 50 or 60% capacity). Items tabulated include age and vital capacity after food and after rest; respiration, minute volume, and O_2 requirement; the respiratory quotient, conversion rise in %, and these values after rest; and the O_2 needs (cc./min.). In the severest forms of silicosis, the total variation in the 10-min. recovery periods was higher than the highest shown in normal persons. Acid absorption had not returned to normal after 10 min., while in normal persons it was completed in 3 or, at most, 6 min. The minute values of respiration in the most severely ill subjects was markedly raised after the work attempted, and even after the 10 min. rest, it did not attain its previous value. The higher the lessened capacity for work in percentage value, the more the records varied in severe silicosis. Experiments on early or middle-period silicotics showed fewer certain, unmistakable results, their working capacity being still much higher. K.R.

Research laboratories of Mellon Institute. Harry S. Coleman. *Ind. Eng. Chem., Anal. Ed.*, 10 [9] 550–58 (1938).—The design, construction, and equipment of the research laboratories in the new Mellon Institute building are described in detail. Illustrated. F.G.H.

Research laboratory of the Columbia Chemical Division of the Pittsburgh Plate Glass Co. Anon. *Ind. Eng. Chem., Anal. Ed.*, 10 [8] 329–30 (1938).—The physical equipment is briefly described. Illustrated. F.G.H.

Safety and hygiene in the foundry: I, Medical aspects. R. R. Jones. *Trans. Amer. Foundrymen's Assn.*, 8 [2] 554–64 (1937).—The more important industrial health problems associated with the foundry industry are those related to (*a*) general physical characteristics of the building, (*b*) housekeeping practices, (*c*) drinking water supply and lunchroom and toilet facilities, (*d*) exposure to extreme temperatures, (*e*) exposure to toxic or irritating dust, fumes, and gases, and (*f*) medical supervision. Success in the control of industrial health hazards is primarily dependent upon the employer's attitude toward the problem. Discussion. J. A. Britton et al. *Ibid.*, pp. 576–88. H.E.S.

Hermann August Seger. Anon. *Bull. Amer. Ceram. Soc.*, 17 [11] 463–64 (1938).

Silicate research and engineering. W. Eitel. *Z. Ver. Deut. Ing.*, 80 [2] 37–41 (1936).—The conditions and status of silicate research as carried out in the Kaiser Wilhelm Institute in Berlin with regard to glass, ceramics, cements, mortars, and concrete and the relation to application in practical engineering are explained. M.H.

Silicosis among grinders. J. L. A. Grout. *Brit. Jour. Radiol.*, 11, 368–71 (June, 1938).—This interesting

time labor limit in the German hard-coal industry for dry atmospheric localities, is an arbitrary limit. In general, working capacity seems to be lowered by high temperatures to 60% values. The physiological reactions of men continually vary when climatic conditions grow constantly worse. Injury to health from dry and high temperatures alone can not be definitely established, the relation to humidity present always being a factor. Omitting the heat factor, a humidity of 25° seems endurable. In regard to the elimination by the skin or lungs under high and humid conditions, results appear personal and individual. Greater water elimination occurs in men acclimated to hot humid air than in those not inured. Men habitually rather than occasionally at work eliminate larger quantities of water. Rising temperatures in a dry climate and rise in humidity increase elimination of water through the skin. Individuals showed, in their elimination through the skin, none of the expected correspondences which might be traced back to these changing environal states. In this investigation, bodily temperatures generally rose very little proportionally under higher outside temperatures and increased humidity. Blood pressure, respiratory frequency, and pulse frequency showed no quantitative relation to selected climatic conditions. Fourteen diagrams and two tables are given. 18 references. K.R.

Dust content in an asbestosis lung and the behavior of the so-called asbestosis bodies. S. Sundius and A. Byoden. *Arch. Gewerbepath. & Gewerbehyg.*, 8, 26–70 (1937–1938).—This research upon the effects of asbestos dust when breathed in by industrial workers in asbestos was carried out by the State Geologist and the State Chemist of the Swedish Geological Survey. They indicate the differences between the asbestosis lung and the silicotic, the former being due to the action of a basic silicate (isotropic), accumulating in yellowish or reddish-brown needle-like masses, and the silicotic being due to quartz (SiO_2) degenerative action, exhibited in nodules and other quite different manifestations. Asbestosis was first identified in 1906 by an English physician, Montague Murray, of the English Compensation Committee of Industrial Diseases. The chief research studies since that time are reviewed by these authors in their cumulative value. Their own procedure in isolating asbestos dust and its accompanying "asbestosis bodies" by treating the affected lung substance with hydrogen peroxide, also by purely mechanical action upon a "heavy" solution, is given together with the ascertained percentage values derived chemically from the eight or more mineral components of asbestos. For the entire lung, approximations were 5.6 g. asbestos bodies, 0.8 free asbestos needles, and 1.4 total asbestos content. Total dust respired by the given lung was about 2.5 g. Some of the bodies built up in needle form were composed of titanium oxide (TiO_2). Intensive study and analysis of the coverings of the bodies seem to indicate that they are blood derivatives after the mineral has entered the lung. The fibrosis ultimately and generally distributed through the lung following the dust inhalations appears to have definite relation to the presence of the asbestos needles and their movements about the lung under the mechanical stimulation due to respiratory movements. 12 photomicrographs. K.R.

Heinrich Ries. Axon. *Bull. Amer. Ceram. Soc.*, 17 [12] 490–91 (1938).

History of glass industry at New York World's Fair. Axon. *Bull. Amer. Ceram. Soc.*, 17 [12] 489 (1938).

Hygienic dangers of nonferrous metals. H. Berger. *Metallwirtschaft*, 17 [32] 803–07 (1938).—B. discusses the dangers in handling Pb, Hg, Zn, Cd, As, Yb, Se, Te, Cr, Ni, Cu, Mn, light metals, W, Tl, and Os due to inhalation of dust or vapors or contact with each individual metal and means for eliminating or at least minimizing the risk. M.H.

Lung findings in foundry workers. O. A. Sander. *Amer. Jour. Pub. Health*, 28, 601–609 (1938).—Of the various occupations in foundries, sandblasting is the most hazardous if done without protection; otherwise sand chipping and grinding of large castings are the most dangerous in regard to the health of the employees. Data obtained during a four-year survey are as follows:

Years exposure	No. employees	Silicotic (%)
1–5	1174	0.5
6–10	812	3
11–15	602	6
16–20	532	10
21–25	365	15
26–30	268	22
31–40	215	21
41–50	47	21

From this data, S. concludes that simple silicosis as seen in foundry workers is only very slowly progressive, so much so that no visible changes appeared in four years observations, and is only rarely sufficiently advanced to cause symptoms and incapacity for work. Control of the foundry hazard is best accomplished by elimination at its source of the dust generated by sandblasting, sand chipping, sand grinding, and shake-out operations. Preemployment and periodic examinations are essential to prevent tubercular individuals from carrying on a dusty trade and to discover new infection and reactivation cases as they arise. B.C.R.

Selenium as a potential industrial hazard. H. C. Dudley. *U. S. Pub. Health Repts.*, 53 [8] 281–92 (1938).—D. points out those industries which may have unrecognized hazards due to the possession of selenium-bearing materials. Increasing uses and applications of the element and its compounds necessitate the warning that in certain combinations selenium is toxic. Hence, industrial plants where these substances are utilized will need to afford their workers adequate protection. Selenium is obtained as a by-product from electrolytic refining of copper; this is the chief commercial source. Its first use was largely confined to the glass and ceramic industries, where it was used as a glass decolorizer and for the production of red glass and glazes. Rubber manufacturers next made heavy demands on domestic copper refineries; recent increased uses have not only exhausted domestic supplies but have required importation in larger and larger quantities. The ceramic industry alone has utilized more than 170,000 lb. According to D., new sources of supply will have to be opened. The occurrence and location in 21 states of 15 minerals, with the selenium parts per million, are tabulated. The selenium content of the earth's crust has been approximated at 0.005%; nearly all sulfur and sulfide deposits contain it; certain western phosphate rocks show amounts of even 55 parts to the million. In a large number of soil samples taken from areas surrounding smelters near Butte and Anaconda, Mont., Kennet, Calif., and Copper Hill, Tenn., selenium was found; it decreased in quantity with distance from the smelter. Extensive animal experimentation by ingesting selenium compounds shows that such substances, when soluble, have toxic effects, both acute and chronic. Early cellular destruction occurs in the liver, with later pathological characteristic changes throughout the organism. Guinea pigs experienced severe metamorphoses in the liver and, after inhalation of hydrogen selenide, hypertrophy of the spleen. Men employed in copper refineries which extract or purify selenium display the symptoms, respiratory and gastric, which characterize metal poisoning generally. The excretion of selenium in the urine, however, is conclusive evidence of selenium absorption by workers. D. gives in detail the procedure for urinalysis in detecting and estimating selenium in the urine. In the tabulation of industries with possible selenium hazards, the glass and ceramic industries are in the secondary group, i.e., they utilize selenium and its compounds as basic materials in manufacturing processes. The immediate sources of hazards involved in this group are given as melting pots and furnaces, the fumes of Se and SeO_2 being given off. The sampling of vapors and gaseous constituents of industrial plant atmospheres and contaminations of laboratory workrooms is explained in detail in connection with

168

tests and indicating just how closely the sampling represents the true character of a batch of material being tested. F.P.P.

Volumetric analysis of copper. M. SUGITA AND Y. YAMAMOTO. *Jour. Soc. Chem. Ind. Japan*, 41 [2] 34B (1939).—Copper can be reduced to the cuprous ion in an alkaline solution with sodium sulfite. This cuprous ion can be titrated with potassium permanganate solution. After the reduction is complete, the solution is acidified to expel the excess sulfur dioxide gas. An addition of a small amount of chlorine ion in the form of sodium chloride is necessary to avoid the precipitation of cuprous oxide. The sample of solution containing about 0.18 g. of copper should be treated as follows: pour the test solution into a 300-cc. flask, dissolve it in a small amount of water, and make it slightly acid, either with sulfuric acid or sodium hydroxide solution; add 50 cc. of 10% solution of sodium sulfite and 6 cc. of 10% solution of sodium chloride; boil and redissolve the yellow precipitate in the flask (double salt of cuprous sulfite and sodium sulfite) and make the solution colorless; add 50 cc. hot sulfuric acid (prepared at this time by mixing 20 cc. of 36 *N* sulfuric acid and 30 cc. of 6 *N* sulfuric acid). The white precipitate of cuprous chloride is formed, and sulfur dioxide gas is expelled violently. Boiling is continued for 15 to 20 min. to expel sulfur dioxide gas completely and to expel excess hydrogen chloride. To fill the flask with carbon dioxide, 30 cc. of 3% sodium carbonate solution are added. Heating is discontinued and the solution is titrated with 1/10 *N* potassium permanganate solution which contains about 3% sodium carbonate. The presence of Pb^{++}, Sn^{++}, Mn^{++}, etc., has no effect; therefore, no preliminary separation of these metals is needed. M.V.C.

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Making alkali metal silicates. C. R. MCDANIEL (Diamond Alkali Co.). *U. S.* 2,153,372, April 11, 1939 (March 7, 1935).

Production of polysilicates. DESSAUX FILS. *Fr.* 836,732, Oct. 3, 1937; *Chem.-Ztg.*, 63 [19] 173 (1939). D.A.S.

General

Air conditioning in industry: I. W. L. FLEISHER, A. E. STACEY, F. C. HOUGHTEN, AND M. B. PEARSDALE. *Heating, Piping & Air Conditioning*, 11 [2] 107–11 (1939).—This study was conducted in the research laboratory of the American Society of Heating and Ventilating Engineers at the Pittsburgh Experiment Station of the U. S. Bureau of Mines. The physiological reactions of men while carrying on light work in atmospheric conditions including effective temperatures from 77° to 92°F with relative humidities of 60, 75, and 90% were investigated. The history of previous investigations is dealt with. Two charts. J.L.G.

Appearance and prevention of silicosis and asbestosis. ENRICO C. VIGLIANI. *Rass. Med. Applicata Lavoro Ind.*, 9, 387–94 (1938); *Chem. Abs.*, 33, 2244 (1939).—A review is given.

Asbestosis. R. R. SAYERS AND W. C. DREESEN. *Amer. Jour. Pub. Health*, 29 [3] 205 (1939).—In a study of the North Carolina textile mills using asbestos fiber, a hydrated magnesium silicate containing no quartz, pulmonary asbestosis was the principal defect found. Exposures ranged from 0.10 to 76 million particles/cu. ft. Persons exposed from 5 to 10 years to dust concentrations exceeding 5 million particles/cu. ft. showed definite evidence of asbestosis. Data so far obtained indicate that 5 million particles/cu. ft. is the maximum safe concentration. B.C.R.

Ceramic filters. "ANON. *Chem. Age* [London], 40, 45 (1939).—A new range of porous ceramic filtering materials has been introduced by a Glasgow firm. These ceramic materials are resistant to corrosive fluids and are made with a pore size ranging from below one micron up to several hundred microns, the distribution of pores and pore density being exactly regulated. The materials are produced in a great variety of shapes—they can be sawed, cut, or ground to suit individual requirements—and their mechanical strength and durability are very high. The materials, quartzite, biscuit porcelain, and diatomaceous or kieselguhr bodies, are described as follows: (1) Quartzite filters in the form of square or circular tile, of different thicknesses and sizes, and hollow cylinders from 2 in. to 8 in. in diameter and up to 24 in. long are produced in several grades, varying from coarse-grained bodies of extreme permeability down to a close-grained type with a pore size as low as 10 microns but of such high pore density that it ensures rapid permeability. The high rates of flow obtainable with these filters are exemplified by the P27 grade which gives a flow of 1700 gallons of water/sq. ft./hr. at 5 lb. pressure. Quartzite filters are particularly suitable for industrial filtering and aerating operations of liquids and gases, especially where resistance to corrosive fluids is essential and in reactions between liquids and gases, as it presents the gaseous reactant in the form of minute bubbles, thus giving the maximum surface for reaction. (2) Biscuit porcelain is used in filtering operations where it is necessary to separate extremely minute particles from acidic or other corrosive liquors. It resembles porcelain in color and composition, but differs from it in that it is highly porous. Its pore dimension can be regulated in size from 15 microns down to below 1 micron. The nature of its ingredients and the temperature at which it is fired ensure resistance to acids by the more siliceous bodies or to caustic alkalis (where the alumina content predominates). Biscuit porcelain is also used for electrolytic processes in the filtration of oils and concentration of rubber latex. (3) Diatomaceous or kieselguhr bodies, while less resistant to corrosive chemicals than either biscuit porcelain or quartzite, combine small pore size with high permeability and are used for the filtration of neutral, or nearly neutral liquids. They are usually employed in the form of candles or hollow cylinders of small diameter, closed at one end or with both ends open, up to a length of 12 in. A.B.S.

Floors for industrial purposes. R. FITZPATRICK AND F. M. LEA. Read before Inst. Chem. Eng. and Inst. Struct. Eng., London, Jan., 1939; abstracted in *Chem. Trade Jour.*, 104, 79–80, 112 (1939). L.R.B.

Industrial impairment of health and poisoning in the metal-working industry. FABITAG. *Oberflächentech.*, 16 [4] 35–38 (1939).—F. discusses the danger of silicosis in men working with sandblasting. Poisoning by nitrous gases in pickling, etching, and coloring processes, by Cr salts in Cr plating, by Pb in Pb welding, by CO in oxyacetylene welding, and by toxic gases developed in nitriding and hardening processes is also discussed. M.L.H.

Life and work of Henry LeChatelier (1850–1936). P. PASCAL. *Bull. Soc. Chim. Mem.*, [5] 4 [10] 1537–1555 (1937); see *Bull. Amer. Ceram. Soc.*, 16 [4] 155–63 (1937); *Ceram. Abs.*, 16 [10] 318–22 (1937). D.A.S.

PATENTS

Repairing cement for ceramic objects. E. ROSENTHAL. *Brit.* 500,375, Feb. 22, 1939 (Aug. 12, 1937).

Satin white pigment and process of making. L. [illegible] WORK. *U. S.* 2,145,149, Jan. 24, 1939 (Feb. 4, 1935). The process comprises treating finely divided clay with sulfuric acid, producing thereby a solution containing aluminum sulfate together with coloring impurities and an insoluble clay residue, removing coloring ingredients from the solution, and reacting the so-purified solution with hydrated lime in the presence of the clay residue.

Tile for use in sewage filters. J. E. TOCKER. *Brit.* 500,378, Feb. 22, 1939 (Sept. 15, 1937).

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Asbestosis*

R. R. SAYERS, M.D., F.A.P.H.A., AND
W. C. DREESSEN, M.D.

Senior Surgeon, and Passed Assistant Surgeon, U. S. Public Health Service, Washington, D. C.

ASBESTOS is well adapted for use as a textile material because of its fibrous nature. On account of this, as well as its non-combustible and excellent insulating properties, it has come to be used in ever increasing quantities during the past 20 years. Hence, it is not surprising that Gloyne and Merewether [1] should refer to pulmonary asbestosis as a "modern disease."

The first record of a case of asbestosis seems to have been made by Montague Murray in 1900. The first complete description of the disease and of the "curious bodies" seen in lung tissue and sputum appeared in 1927 when Cooke [2] and McDonald [3] reported 2 cases of asbestosis and listed their reasons for believing that asbestosis bodies originate from asbestos fibers that reach the lungs. Their papers aroused general interest in the subject and numerous others appeared soon afterward. Hoffman [4] appears to have been the first American to call attention to the magnitude of the asbestosis problem. In 1918 he reported that 13 deaths from asbestosis had occurred among asbestos textile workers, and about the same time Pancoast, Miller, and Landis [5] reported on 17 cases of asbestosis. Mills's [6] paper was the first pathological report on asbestosis published in the United States, and in the same year, 1930, Lynch and Smith [7] reported on asbestosis bodies found in the sputum of asbestos workers.

The Public Health Service was requested by the State Board of Health and the Industrial Commission (Administrator of the Workmen's Compensation Act) of North Carolina to assist them in making an engineering and medical study of the health hazards in the asbestos textile industry of that state. The objectives of this study were:

1. To make a medical study of the effects of long-continued inhalation of asbestos dust on the human body.
2. To identify the manufacturing processes that create dust, and to recommend practices for reducing the dust exposure of workers.
3. To find out what concentrations of asbestos dust can be tolerated without injury. It is the purpose of this paper to review briefly the principal findings of this study.[8]

ENGINEERING FINDINGS

The main asbestos raw material used for textiles is Canadian chrysotile, which is a hydrated magnesium silicate containing no quartz.

The textile manipulations of asbestos are very similar to the production of cotton or woolen goods. The crude fiber is sent first to the preparation department, then, in the order named, to the carding machines, spinning frames, winding bobbins, twisting ma-

* Read before the Industrial Hygiene Section of the American Public Health Association at the Sixty-seventh Annual Meeting in Kansas City, Mo., October 28, 1938.

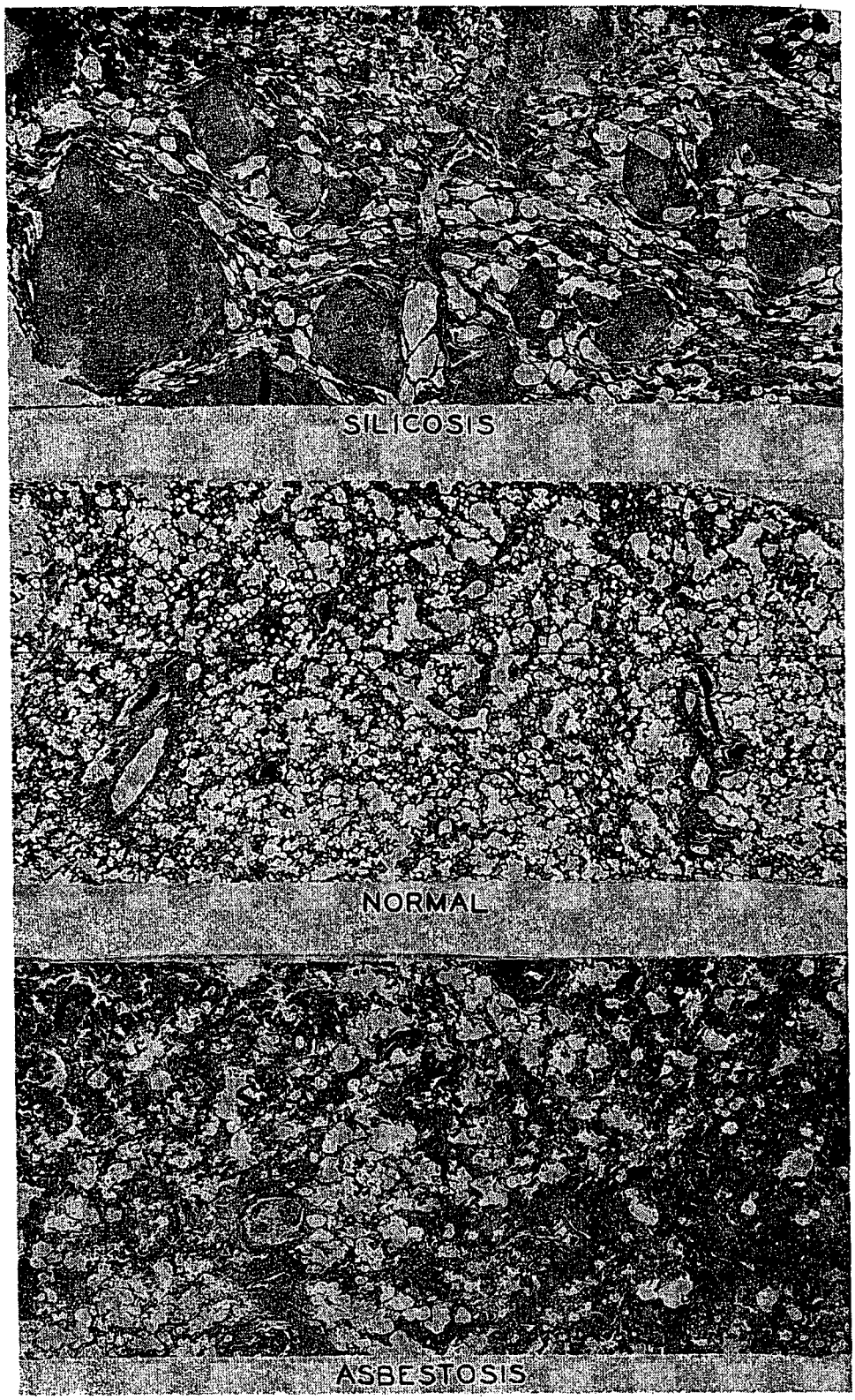


FIGURE I—Photomicrographs of Lung Sections Showing the Presence of Nodular Fibrosis and Emphysema in a Silicotic Lung and Diffuse Fibrosis and Emphysema in an Asbestotic Lung. A Section of a Normal Lung Is Shown for Comparison. Magnification 16 X.

Nodular Fibrosis
ysema in an
mparison.

TABLE I

Summary of Results Showing the Exposure of Asbestos Textile Workers Under Controlled and Uncontrolled Working Conditions

Equipment	*Number of Duct Connections*	*Volume of Air Handled (CFM)*	*Dust Concentration With Exhaust (MPPCF)*	*Dust Concentration Without Exhaust*
Willowing (opening)	*2	625–1,000	3.6	11.1–36.0
Piling †	1	1,025	2.0	5.4
Picking	3	2,570	6.7	34.3–74.3
Carding (primary)	3	1,420	2.0	72.3
Carding (roving)	4	1,440		
Spooling	‡1	46.5	2.9	13.1
Weaving (broadloom)	2	1,300	.7	4.7–49.7
Brusher calenderer	3	1,650	1.0	11.1

* Equipped with pneumatic conveyor.
† Exhausted bin or compartment.
‡ Individual cone for each spool and connected to exhaust manifold.

chines, spooling frames, and finally to the looms and miscellaneous fabricating devices.

In all, 242 dust counts were made in estimating the exposure of these asbestos workers. Only summary engineering findings, or dust concentrations as they relate to medical findings, will be discussed. Summarized results of dust concentrations under controlled and uncontrolled conditions appear in Table I. It will be noted that 74.3 million particles per cubic foot (m.p.p.c.f.) is the maximum concentration of dust encountered. Even this maximum figure is much lower than is frequently encountered in other siliceous trades where it has not been uncommon to encounter maximum dust concentrations of 1,000 m.p.p.c.f.

The dust in asbestos plants is made up of particulate matter and fibers. The median size in microns of particulate matter ranged from 1.85 to 2.40. Particles were smallest in the carding and preparation processes, and largest in weaving. The median length of fibers in microns ranged from 7 to 16.3. As might be expected, the longest (400 μ) were noted in case of weaving and the shortest in preparation.

TABLE II

Median Length of Fibers Sampled With an Owens Jet Apparatus

Activity	*Median Length of Fibers in Microns*
Willowing	7.0
Picking	9.5
Carding	8.8
Twisting	12.8
Weaving (broadloom)	16.3

TABLE III

Size Frequency Distribution of Particulate Dust Suspended in the Air of Asbestos Textile Plants

Nature of Process Where Sample Was Taken	*Median Size (in Microns)*	*Geometric Standard Deviation*	*Percentage Frequency of Each Particle Size Group (in Microns)* 0 to 0.49	0.5 to 0.99	1 to 1.49	1.5 to 1.99	2 to 2.49	2.5 to 2.99	3 to 3.49	3.5 to 3.99	4 to 4.49	4.5 to 4.99	5 or More	Total
Preparation	1.85	1.56	3	21	37	22	10	4	2	1	0	0	0	100
Carding	1.35	1.57	1	9	24	25	9	16	4	5	1	3	3	100
Mule spinning	1.80	1.33	0	1	25	38	28	4	1	1	1	0	1	100
Twisting	1.22	1.74	5	30	24	14	9	5	4	5	0	1	3	100
Weaving (broadcloth)	1.55	1.31	1	4	43	27	10	3	2	3	4	0	3	100
Weaving (tape)	2.40	1.64	0	3	11	24	14	12	7	13	7	3	6	100

The significance of dust concentrations and physical characteristics of these air contaminants will be referred to in the course of subsequent discussion.

The workers who were found particularly liable to develop severe forms of asbestosis were the willowers, pickers, carders, mule and ring spinners, twisters, and cloth weavers. Their exposure was found to be as follows:

	Dust concentration MPPCF
Willowers	11.1–36.0
Pickermen	34.3–74.3
Carders and tenders	29.1
Mule spinners	2.6– 7.9
Ring spinners	3.2– 8.3
Twisters	3.2–13.2
Cloth weavers	
Dry	4.7–49.7
Wet	4.7–11.1

MEDICAL FINDINGS

Medical examinations were made of 541 men and women representing practically all the employees at the time of study. Five-sixths of them were native born Americans of Anglo-Saxon stock and the remainder were Negro males. The three factories studied had been in operation from 6 to 16 years. About 15 months before the study, approximately 150 workers were replaced by new ones with little or no asbestos experience. As a consequence, there was an abnormally large percentage of workers with less than 5 years' employment in the asbestos textile industry and an abnormally small percentage who had worked 10 years or more in the industry. More than 200 had worked at comparable occupations in cotton or woolen textile plants, but exposures to pneumoconiosis producing dusts were inconsequential.

Characteristics of asbestosis—Pulmonary asbestosis was the principal physical defect found on examining the 541 persons. This disease, a form of pneumoconiosis caused by long continued inhalation of asbestos dust, is characterized pathologically by diffuse interstitial pulmonary fibrosis and the presence of asbestosis bodies in the lungs. Clinically, the chief symptoms are progressive dyspnea, variable cough, substernal chest pain, blood streaked sputum, decreased chest expansion, emaciation, weakness, clubbed fingers, or curved nails. Late in the disease, the dyspnea becomes distressing, cyanosis may occur, and there may be severe paroxyms of coughing productive of tenacious sputum. The characteristic chest X-ray shows granular or ground glass markings with more or less obliteration of usual linear pulmonic markings, localized in mid-lung and bases. The grainy appearance may become quite generalized with evidence of emphysema usually in the apices. Nodular or nodulo-conglomerate shadows of silicosis are not observed, but whether this is due to a peculiarity of asbestos dust or to rare occurrence of extremely high dust exposures, it is impossible to say. Shagginess of the heart shadow is not infrequently observed and seems to be most common in workers exposed to a high proportion of fiber (e.g., twisting, broadcloth weaving). By fluoroscopy, diminished excursion of diaphragm is seen. Peaking deformities of diaphragm, however, occur less frequently than in silicosis.

Asbestosis bodies found in the lungs and sputum are characteristic. There is good evidence that these bodies originate as a cellular response to inhaled fibers.[9] Asbestosis bodies consist of a core of asbestos fiber surrounded by iron-containing protein deposits. They are golden yellow in color, and do not stain with ordinary histologic stains but become brilliant blue when treated with potassium ferrocyanide. They are variable in form and size and characteristically are slender, elongated, segmented structures with bulbous ends which give them a dumbbell or drum-

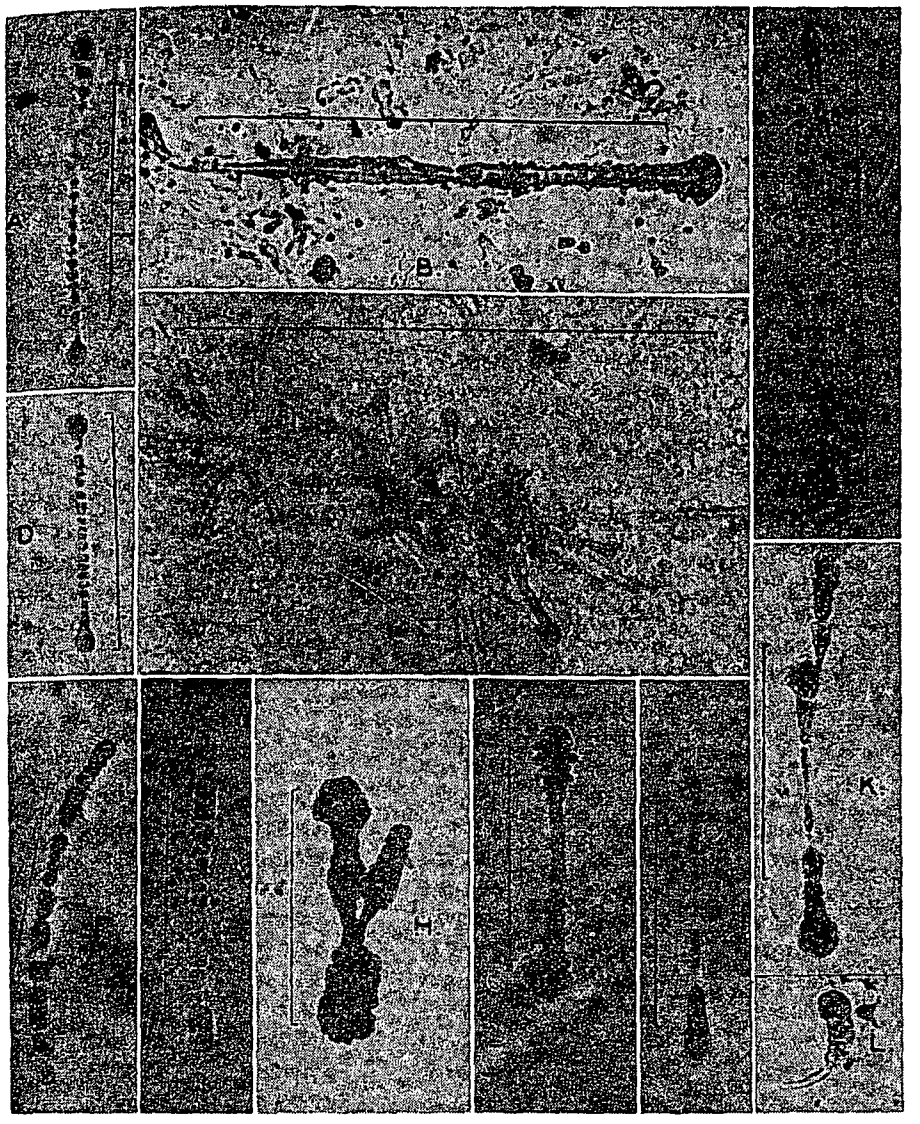


FIGURE II—Photomicrographs of Asbestosis Bodies Found in Sputum. Enlarged 530 Times (Except E, Which Is Enlarged 310 Times). A Scale, Ruled in Units of 50 Microns, Has Been Drawn Beside Each Asbestosis Body.

stick shape (Figure II). Occasionally a forked or Y-shaped body is observed. They range from 10 to 180 μ in length, averaging about 35 μ.

It has been suggested that damage to the lungs occurs while the body is being formed, but once the body is formed the fiber in the core is rendered inert by its coating of iron.[10] The finding in the sputum of clumped asbestosis bodies in radial pattern or rosette (Figure II E), which is common in lung sections, has been suggested by Stewart, Tattersall, and Haddow[11] as a clear indication of disintegration of lung tissue whether by a process of simple suppurative broncho-pneumonia, or as a result of secondary tuberculous infection. In either case, they feel that it strongly indicates a definite underlying asbestosis.

On single sputum specimen analysis

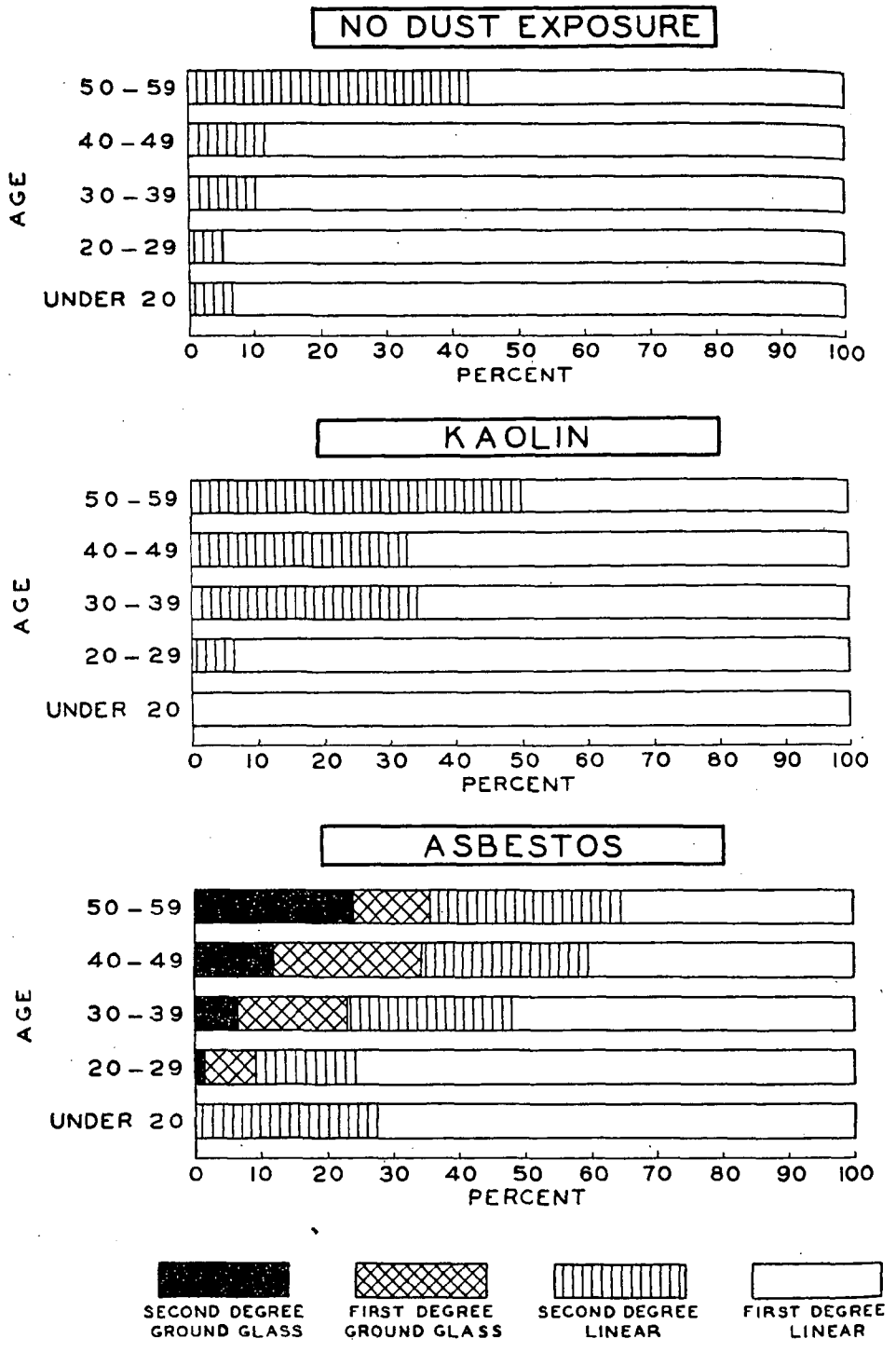
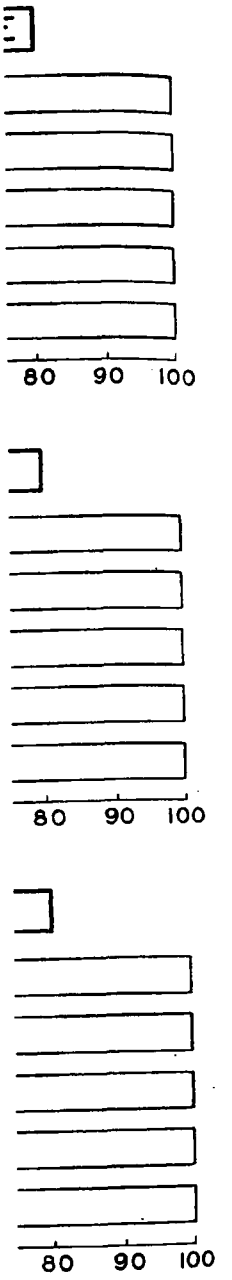


FIGURE III—Percentage of Males, Classified by Age, Who Had Certain Lung-Field Markings; 229 Men Had No Previous Industrial Dust Exposure, 80 Had Been Exposed to Kaolin Dust, and 357 Had Been Exposed to Asbestos Dust.



Certain Lung-Field
e, 80 Had Been
estos Dust.

of each case, the incidence of asbestosis bodies increased with increasing dust exposure. They were found in sputum of 46.9 per cent persons whose condition was diagnosed as asbestosis, whereas 24.3 per cent of essentially normal asbestos-exposed persons had bodies in the sputum. They were not observed in any of the persons surveyed with less than 3 months' exposure. Since they may be found in the sputum before significant fibrotic changes have occurred, their presence is interpreted as merely showing evidence of exposure.

X-ray interpretations—During the development of a typical pneumoconiosis, the lung field appearances of chest roentgenograms pass through a series of rather well defined phases. Beginning with the normal adult film with its linear pulmonic markings, the first next appreciable change is an exaggeration of these markings. Then a ground glass or granular appearance is noted which gradually obliterates the linear markings, followed by nodular and nodulo-conglomerate markings. The lung field appearances in asbestosis do not appear to proceed beyond the ground glass or granular phase. Classification of all films was made according to phases. The apparent small amount of involvement of lungs makes it difficult to evaluate the severity of the case from an X-ray film only. The difficulties of interpretation of the chest films emphasize the importance of careful technic. As a form of pneumoconiosis, asbestosis strikingly indicates the necessity for clinical study of a case before diagnosis can be made. The film of a patient severely ill with asbestosis may have markings which would appear insignificant alongside a typical silicotic film of a man who is actively at work.

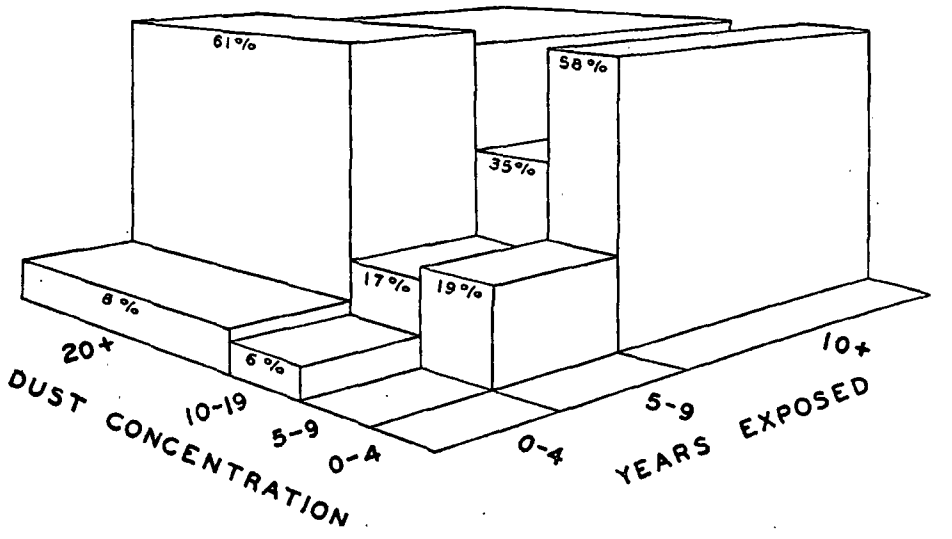
In the interpretation of asbestotic films the physician must be aware of exaggerated markings attributable to advancing age. This is illustrated in Figure III. One group comprising 229 men had never been employed in a dusty trade; the other included 80 men engaged in mining and refining of kaolin by wet methods. The percentage of men who have second degree exaggeration of linear lung markings increases with advancing age. It is significant that in this entire group of 309 men there were no cases of ground glass lung field markings, even though this change is observed in the asbestos workers. It appears that the reason why the incidence of the ground glass type of pulmonic marking is correlated with age is that older people have been exposed to dust for the longest time.

Occurrence of asbestotic lung changes—In Figure IV the heights of vertical bars represent the percentages of asbestos workers in different exposure groups who had ground glass lung field markings of either first or second degree. Seventy-six controls have been excluded from this tabulation and a number of workers whose dust exposure was not known have also been omitted.

Considering the four dust exposure groups, one at a time, there is a consistent and regular increase in the percentage of persons with these ground glass markings with increasing length of employment. Age, of course, also increases with length of employment, but these fibrotic changes cannot be ascribed to advancing age because the previous figure (III) showed that fibrotic changes of this degree are not to be expected in workmen of comparable age who are not exposed to siliceous dusts. Note the absence of cases with ground glass markings in the group exposed to less than 5 m.p.p.c.f.

Obviously, there are great differences between individuals in the time that elapses from their first exposure to asbestos dust and the time fibrotic evidence is observed in the X-ray film. In some persons this was much less than 5 years and in others it appears to be more than 10. Some of the difference

FIGURE IV—Percentage of Asbestos Textile Workers, Classified by Average Dust Concentration (Measured in Million Particles per cu. ft.) and Duration of Exposure, Found to Have Ground-Glass Lung-Field Markings.



is probably due to total amount of asbestos dust inhaled. Difference in amount of physical exertion may play an important rôle—a person in a sedentary job having a smaller need for oxygen inhales less air and consequently fewer particles of asbestos.

It was noted that the relation between dust exposure and the incidence of ground glass lung field markings was not a simple one. Even when length of employment was disregarded, it was found that incidence of these markings was proportionately lower at 10 to 19.9 m.p.p.c.f. than it was at the next higher or next lower concentrations. Although it is probable that these differences represented sampling errors due to small numbers of exposed persons, it may be that asbestos fiber excites a different and possibly more severe reaction than asbestos particles.

On account of large labor turnover, as well as the short time that the plants had been in operation, no exact estimate of incidence of asbestosis can

TABLE IV

Occurrence of Asbestosis in Relation to Dust Concentration and Length of Employment
Percentage With Asbestosis

Dust Exposure, Million Particles per Cubic Foot		*Years in Asbestos Industry*		
		0 to 4.9	*5 to 9.9*	*Over 10*
0 to 4.9	Affected	2	1	0
	Exposed	84	19	5
	Percentage	*2%*	*5%*	*0%*
5 to 9.9	Affected	0	6	13
	Exposed	70	37	19
	Percentage	*0%*	*16%*	*68%*
Over 10	Affected	8	22	21
	Exposed	134	43	36
	Percentage	*6%*	*51%*	*58%*

be made. Table IV shows, however, that the percentage of persons with asbestosis increases greatly with increasing length of employment. Lanza, McConnell, and Fehnel [12] reported a similar trend. The incidence also increases with increasing dust concentration. For the reason that there are but few cases with more than 15 years' exposure, the percentages in Table IV are necessarily minimal estimates of prevalence of asbestosis even though several of the former employees are included.

SAFE LIMITS OF EXPOSURE TO ASBESTOS DUST

For practical purposes it is useful to have a definition of safe working conditions. Ideally, a threshold concentration of dust should be the highest dust concentration that would not produce pneumoconiosis in originally healthy workmen during their entire working life. Below 2.5 m.p.p.c.f. the interpretation of Table IV offered no difficulties, since none of 39 persons exposed to that concentration had asbestosis, although only 6 had been employed more than 5 years. Three doubtful cases of asbestosis fell in range 2.5 to 4.9 m.p.p.c.f.

Because clean-cut cases of asbestosis were found in dust concentrations exceeding 5 m.p.p.c.f., and because they were not found at lower concentrations, 5 m.p.p.c.f. may be regarded tentatively as the threshold value for asbestos-dust exposure.

A supplemental engineering study [13] was made in an asbestos textile factory in which dust control equipment had recently been installed. This showed that means are already available for reducing the dust exposure of a majority of asbestos textile workers to less than 5 m.p.p.c.f. The basis of this control was exhaust ventilation near source of dust.

TABLE V

Percentages of Workers Exposed to Certain Concentrations of Asbestos Dust in Asbestos Textile Factories Where Dust Control Measures Are Used to a Limited Extent and in Factories Where Effective Dust Control Is Practised

Dust Concentration Million Particles per Cubic Foot	Limited Use of Dust-Control Measures *	Extensive Use of Dust-Control Measures †
Over 10	48	7
5 to 9.9	28	17
2.5 to 4.9	15	32
Under 2.5	9	44

* Data from Table IV.
† Data from reference 13.

CONCLUSIONS

As in other forms of pneumoconiosis, occupational history, and clinical and X-ray (or pathologic) findings must be in harmony before a sound diagnosis can be made. The occupational history should be a reflection of manufacturing processes since the job designation refers to a stage in manufacture. The occupations which were found particularly liable to induce severe forms of asbestosis were willow, pick, card, spin, twist, and cloth weave. Confirmation of the hazardous nature of some of these occupations is the frequency with which the occupational designation of carder, weaver, or spinner is encountered in autopsy reports of cases.[14–18] The following are the outstanding findings determined in this study:

1. In a study of 541 employees of North Carolina textile mills, pulmonary asbestosis was the principal physical defect found.
2. The most serious forms of the disease were observed in carders, spinners, weavers, twisters, willowers, and pickers.
3. Exposures ranged from 0.10 to 76 m.p.p.c.f.
4. Dust contaminants of air in asbestos textile plants are both particulate and fibrous.
5. It is imperative that findings of occupational history, clinical examination, and X-ray film all be considered in making diagnosis of a case.
6. Definite clinical and roentgenographic

evidence of asbestosis is observed in exposed persons after 5 to 10 years of work in exposures exceeding 5 m.p.p.c.f.

7. It appears that if asbestos dust concentrations in the air breathed are kept below 5 m.p.p.c.f. new cases of asbestosis will not appear.

8. Methods for controlling the dust below this tentative threshold are already available for most of the processes in the industry.

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