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Part III

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William B. Fulton  
**ASBESTOSIS**

Part II. The Nature and Amount of Dust  
Encountered in Asbestos Fabricat-  
ing Plants.

Part III. The Effects of Exposure to Dust  
Encountered in Asbestos Fabricat-  
ing Plants on the Health of a Group  
of Workers.



BUREAU OF INDUSTRIAL STANDARDS  
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DEPARTMENT OF LABOR AND INDUSTRY

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by

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## ASBESTOSIS—PART III.—The Effects of Exposure to Dust Encountered in Asbestos Fabricating Plants on the Health of a Group of Workers.

Complete physical examinations were made of sixty-four persons (48 men, 16 women) employed at the time in the plants listed in Part II of this report. Of this number seven men without previous exposure were used as controls. Selection of the workers was restricted to those employed in textile manufacture. Those workers longest employed were chosen because the necessity of including a sufficient number from this group is evident. Attention was also paid to the group with exposures of shorter duration and to the particular operation at which the worker was employed. Table VIII shows their age distribution.

TABLE VIII. DISTRIBUTION BY AGE OF ALL PERSONS EXAMINED

| Group            | Number of Persons Examined | Number in Age Group |       |       |       |             |
|------------------|----------------------------|---------------------|-------|-------|-------|-------------|
|                  |                            | Under 30            | 30-39 | 40-49 | 50-59 | 60 and over |
| Controls .....   | 7                          | 1                   | 2     | --    | 1     | 3           |
| Asbestosis ..... | 14                         | --                  | 7     | 6     | --    | 1           |
| Negative .....   | 43                         | 15                  | 12    | 11    | 3     | 2           |
| Totals .....     | 64                         | 16                  | 21    | 17    | 4     | 6           |

Asbestosis was found in fourteen persons (12 men, 2 women), or 25 per cent of the exposed group. Forty persons were diagnosed as negative and the remaining three doubtful. Of the latter group, one individual had previous exposure to silica dust which may have been the primary or contributing cause and, as a result, has been eliminated from any further consideration. The cases having asbestosis were divided into those having slight and moderate pulmonary fibrosis, no advanced cases having been found. The estimation of the degree of involvement depended on the amount and extent of fibrosis seen roentgenologically and in the clinical findings.

The present, past, and family medical, and previous occupational histories were secured from each worker. Direct questions, which might influence the individual's replies in regard to his subjective symptoms, were avoided in obtaining chief complaints. The predominant subjective symptoms in the positive group were cough and dyspnea. Other major subjective symptoms were dry throat and frequent colds. One individual in this group had no subjective symptoms.

Objectively, the major symptoms were again cough and dyspnea. Thirteen persons of those diagnosed positive for asbestosis complained of cough, and eight of dyspnea. Other frequently elicited objective symptoms were frequent colds, palpitation, weakness, precordial pain, and pharyngeal dryness. No objective symptoms could be obtained from one individual in the positive group.

Occurrence of acute respiratory infections was particularly observed in the past medical history. Frequent coryza or other upper air-passage infections which did not result in a loss of time of three or more working days, were listed as objective symptoms. Pneumonia during the course of employment occurred in three of the positive and seven of the negative group. The past medical histories were otherwise negative except for an attack of pleurisy in one individual of the exposed group diagnosed as negative.

Family histories and, in particular, tuberculous contacts were noted. Two workers with asbestosis had roentgenological evidence of healed tuberculosis and negative family histories. Two others who showed evidence of healed tuberculosis, and who did not have asbestosis, also had negative family histories.

Physical examinations were made with the workers stripped to the waist. Mean variations in the present and greatest weight were less in the asbestosis group than in the group diagnosed as negative and in the controls. Five-minute oral temperatures showed a maximum elevation of  $0.5^{\circ}\text{C}$ . Four persons having asbestosis had an elevation of temperature and eleven in the negative group showed it. Elevation of body temperature in the control group was absent. The mucous membranes of the nose and throat of the entire group were essentially negative. The conjunctivae did not appear to be irritated. Tenderness over the antra and frontal sinuses was not found. Deflected nasal septa were common, and diseased tonsils were noted in a few cases. The external auditory canals did not show evidence of plugging or irritation.

Clinical examination of the thorax included inspection, palpation, percussion, and auscultation of the heart and lungs. A tendency to increased anterior-posterior diameters of the chest in the positive exposed group was noted. In the positive group the respiratory murmur and vocal resonance were impaired in five cases. Crepitant, subcrepitant, sibilant, and sonorous rales occurred in nine of the asbestosis cases, the two latter types being predominant.

The recognition of cyanosis presented a difficult problem. When it occurred the skin had an unhealthy leaden hue, with variations in the degree of intensity in the three individuals in the positive group showing this physical sign.

Roentgenological examinations, made of all workers, included fluoroscopic examination, stereoscopic anterior-posterior and oblique skiagrams of the chest. In addition to noting gross chest pathology, the movement of the diaphragm was measured in centimeters during the fluoroscopic examination. Right and left oblique exposures of the chest aided in the interpretation of the films and particularly in the detection of thickened pleura. The hila, trunk, and lung markings of the fibrotic lungs were increased in prominence. In some films the lung fields showed a slight tendency toward beading and nodulation. A small area in the distal third of the lung in one

film suggested atelectasis. Increased aeration, such as one sees in emphysema, occurred in a few cases. Thickened pleura and adhesions were noted in a few cases. The average movement of the domes of the diaphragm of the positive group was less than that of the negative exposed or control groups. Three of the positive and two of the negative group were found with roentgenological evidence of healed tuberculosis. Further evidence of pulmonary disease in four of the positive group was clubbing of the fingers.

The occurrence of asbestos bodies and the presence of B. tuberculosis were determined in a single specimen of sputum obtained from each person. Each employe was instructed in the proper method of obtaining the sputum specimen, and was requested to collect a morning sample. An equal volume of antiformin was added to each sample. After complete digestion of the mucus, the mixture was centrifuged for three minutes at approximately 2000 r. p. m. and the supernatant liquid decanted. Distilled water was added to the solid centrifuged portion, and the mixture recentrifuged for three minutes. A drop of the deposit was transferred to a microscope slide and examined for the presence of asbestos bodies under both 8 mm. and 4 mm. objectives.

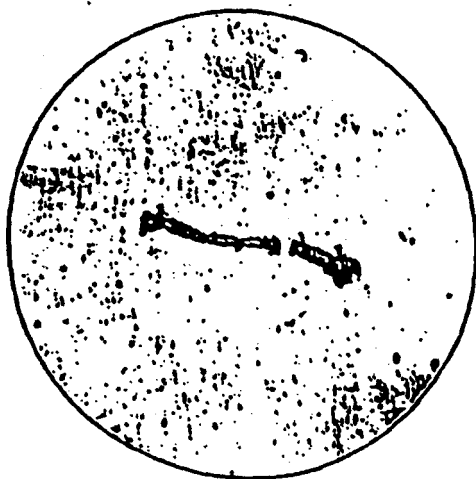


FIGURE 3. PHOTOMICROGRAPH OF ASBESTOS BODY. MAGNIFICATION 600 DIAMETERS

The greater percentage of sputum specimens were of a whitish color, but a few were muco-purulent. The asbestos bodies were a pale yellowish brown color and varied in size, shape, and number. The largest asbestos body found measured 117 microns in length. The bodies occurred singly, clumped, and as fragments. When present singly or in clumps, they presented a bead-like appearance or a dumb-bell shape, with bulbous ends tapering into a narrow strand at a position midway between the ends. Figure 3 is a photomicrograph of a single asbestos body. In one specimen an average of two or three asbestos bodies or fragments of bodies were seen in

each low-power field, while in others, only one or two bodies were found in the entire specimen. Table IX gives the occurrence of asbestos bodies in a single specimen from each person. Merewether (74) reports that the presence of asbestos bodies cannot be taken at present as indicating anything more than previous exposure to asbestos dust. This is in accord with our findings for it will be noted that they were found in a specimen obtained from one of the controls who at the time was suffering from an acute bronchitis, productive of a muco-purulent sputum. This worker had been employed as a packer foreman in the magnesite department for fifty years. His only exposure to asbestos dust was a rare visit to other parts of the plant.

TABLE IX. OCCURRENCE OF ASBESTOS BODIES IN SPUTUM

| Group                   | Number   |          |         | Percentage                       |          |         |                             |          |         |
|-------------------------|----------|----------|---------|----------------------------------|----------|---------|-----------------------------|----------|---------|
|                         |          |          |         | Based on Total Number of Persons |          |         | Based on Specimens Examined |          |         |
|                         | Asbestos | Negative | Control | Asbestos                         | Negative | Control | Asbestos                    | Negative | Control |
| Asbestos Bodies present | 7        | 10       | 1       | 50.0                             | 33.3     | 14.3    | 50.0                        | 47.0     | 21.0    |
| Asbestos Bodies absent  | 5        | 11       | 2       | 30.7                             | 30.3     | 42.9    | 41.0                        | 53.0     | 79.0    |
| No Sputum               | 2        | 21       | 2       | 14.3                             | 50.0     | 42.9    | ---                         | ---      | ---     |
| Total                   | 14       | 42       | 5       |                                  |          |         |                             |          |         |

A single sputum specimen obtained from each individual was stained and examined for the presence of *B. tuberculosis*. Both direct smears and centrifuged antiforminized specimens were found to be negative.

Clinical examination of the heart showed the apical impulse to be displaced in a few cases. Apical systolic murmurs were heard in five of the positive and two of the negative groups. The blood pressure was determined with a standard mercury sphygmomanometer. Hypertension, although present in a few cases in each group, occurred only in the older workers. Roentgenological evidence of enlargement of the heart was not found. However, the cardiac silhouette in two individuals having asbestosis was found to be top normal in size.

Electrocardiograms of fifty-six of the workers were made following a thirty-minute rest period during which the subject was in a reclining position, while eight were taken with the subject in a sitting position following a short rest period. The most consistently positive electro-cardiographic finding in the entire group was low voltage. It was found to be present in seven of the positive and

eighteen of the negative groups, compared with four of the controls. Right predominance was not present in the tracings of the control group, but did occur in two tracings of individuals with asbestosis and three of the negative group. Left predominance was most frequently found in the tracings of individuals in the advanced age groups. Katz and Slater (62) found eighty-six per cent of individuals with a second positive wave of the Q-R-S complex to have changes in the heart muscle. Our findings show that six of the exposed group had a second positive wave of the Q-R-S complex; two of these had asbestosis, and four were negative, as compared with an absence of this finding in the control group. The P-R interval was increased in the tracings of two exposed persons found to be negative.

A functional test of the individual's response to effort was performed by having him place one foot on a chair and then raise his body twenty-five times in thirty seconds. The pulse rate was determined immediately before and after exercise, and again at the end of a two-minute rest period. The respiratory rate was determined immediately before and two minutes after the exercise test. Table X gives the results of the functional test. Greater variations were seen in the rate of respiration following exercise in the exposed group as compared with the controls than were seen in the pulse rate. Individuals with a pulse rate of 10 above the normal resting rate, two minutes after exercise, were considered abnormal.

TABLE X. FUNCTIONAL TEST OF RESPONSE TO EFFORT

| Group             | Pulse <sup>1</sup> |            | Respiration <sup>2</sup> |            |
|-------------------|--------------------|------------|--------------------------|------------|
|                   | Number             | Percentage | Number                   | Percentage |
| <b>CONTROLS</b>   |                    |            |                          |            |
| Male .....        | --                 | --         | 2                        | 25.6       |
| Female .....      | --                 | --         | --                       | --         |
| <b>NEGATIVE</b>   |                    |            |                          |            |
| Male .....        | 5                  | 18.8       | 10                       | 61.3       |
| Female .....      | 2                  | 11.3       | 4                        | 25.5       |
| <b>ASBESTOSIS</b> |                    |            |                          |            |
| Male .....        | 1                  | 8.3        | 8                        | 66.6       |
| Female .....      | --                 | --         | 1                        | 50.0       |

<sup>1</sup> Pulse rate 10 above normal resting rate two minutes after exercise.

<sup>2</sup> Respiratory rate 2 above normal resting rate two minutes after exercise.

Asbestos warts are thought to be produced by a fiber of asbestos which has become lodged in the skin, largely through the irritation and overgrowth of the horny and malpighian strata (27). These growths are usually found on the hands but may also develop on the feet. Forty per cent of the exposed group had one or more of these papillomas on their hands.

Four blood counts and urinalyses were made on each individual. Haemoglobin was determined by the Haden and Hauser colorimetric method and expressed as grams of haemoglobin per 100 cc. of blood. Smears for differential counts were stained with Wright's stain and 200 cells studied microscopically using a 2 mm. oil immersion objective. Practically no change was observed in the blood picture of the three groups. Comparable average variations did not occur in either the erythrocyte or leucocyte count. In two individuals with moderately advanced pulmonary fibrosis, the total leucocyte counts were 10,800 and 11,400 with corresponding increases in the percentages of polymorphonuclear leucocytes. Changes in the percentages of other types of white cells were not observed.

Urine specimens were collected from each worker at the time of physical examination. Specific gravity, albumin content, and the presence of sugar were determined and a microscope examination made of a centrifuged portion. Urinalyses were essentially negative except for a trace of albumin in four of the positive and thirteen of the negative exposed groups, as compared with two of the controls.

A brief summary of the clinical findings of three asbestos mill workers and the accompanying illustrations (Figures 4 to 7 inc.) are presented to show the two stages of asbestosis encountered in this study.

Case number A-8730—White male; aged 30 years.

Chief complaints—Cough.

Objective symptoms—Occasional frontal headache (2) Epistaxis rare (3) Dry unproductive cough (4) Coughing attacks precipitated by strenuous exercise.

Past Medical History—Usual childhood diseases. Traumatic orchitis, 1934.

Occupational History—Began working at 16 years of age. Milkman, 2 years. Mule spinner, worsted mill, 2 years. Ice man, 1 year. Mule spinner, asbestos fabricating plant, 9 years.

Physical Examination—Apparently healthy adult male. Height 62 inches. Weight 122 pounds (greatest weight 122 pounds). Skin clear. No cyanosis. Asbestos warts on both hands. Pulse rate before, immediately after, and two minutes after exercise, 84, 100, 72. Respiration rate immediately before and two minutes after exercise, 20, 22. Chest, normal shape; percussion normal; breath and voice sounds normal; sibilant and sonorous rales both bases. Heart, apical impulse, 5th interspace mid-clavicular line; no murmurs. Blood pressure 134/90.

Fluoroscopy—Diaphragmatic movement, right dome, 2.5 cm.; left dome, 1.5 cm.

X-Ray—Thoracic cage is negative. The trachea is in the midline. The cardiac silhouette is within normal limits of size. The arch of the aorta is not widened. The domes of the diaphragm are somewhat irregular on the left side but fairly irregular on the right. The pleura appears to be slightly thickened on the left side, and is more clearly shown in the oblique view. In the right apex there is possibly an old healed tuberculous process giving the appearance of an apical cap. The hila are increased in prominence. The trunk markings and linear markings are increased in prominence.

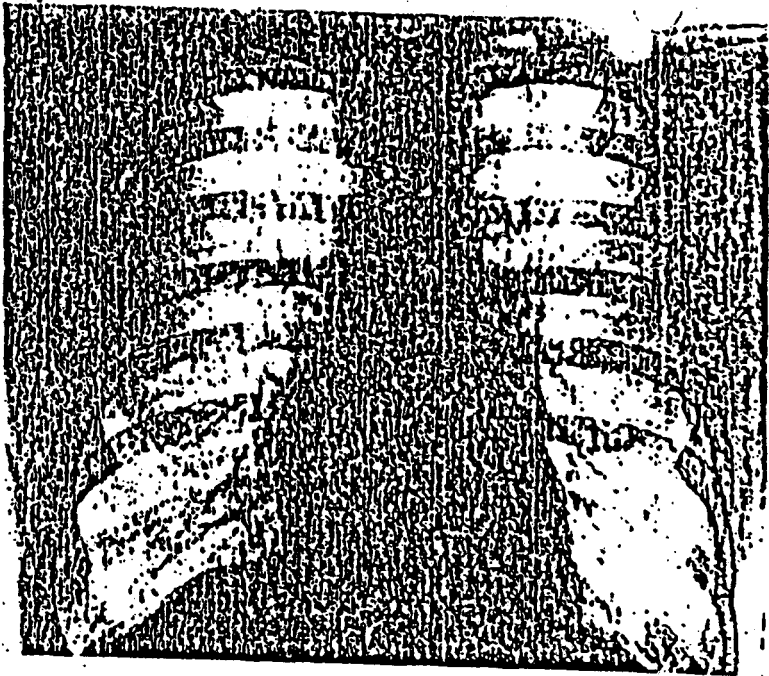


FIGURE 4. CASE NUMBER A8730.

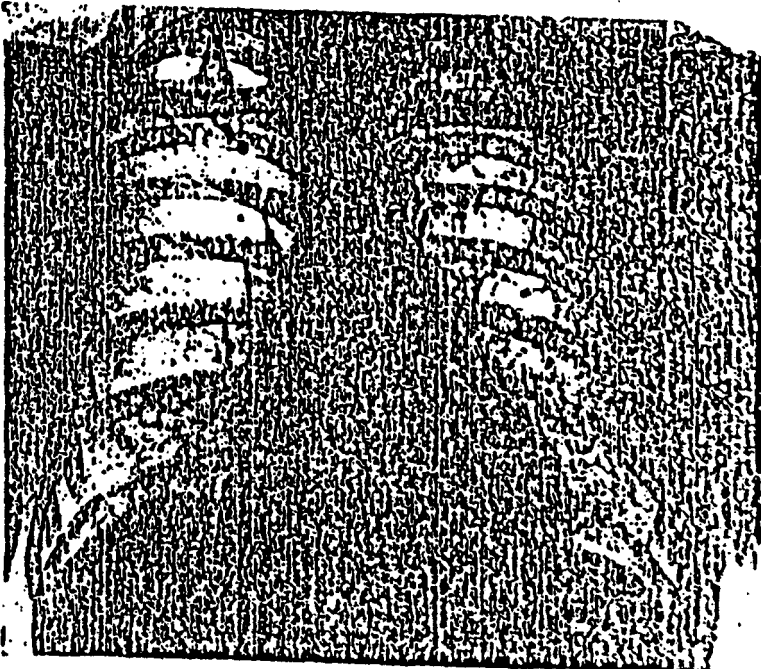


FIGURE 5. CASE NUMBER 447.

Electrocardiogram—Cardiac rate 72, P-R interval 0.16 second. Voltage 4 mm.

Diagnosis—Asbestosis, slight.

Case Number 447—White male; aged 47 years.

Chief Complaints—(1) Cough; (2) Shortness of breath.

Past Medical History—Usual childhood diseases. Gonorrhea, 1922.

Occupational History—Farmer until 29 years of age. Laborer steel works, 2 years. Laborer grain mill, 1 year. Preparation room, asbestos mill, 15 years.

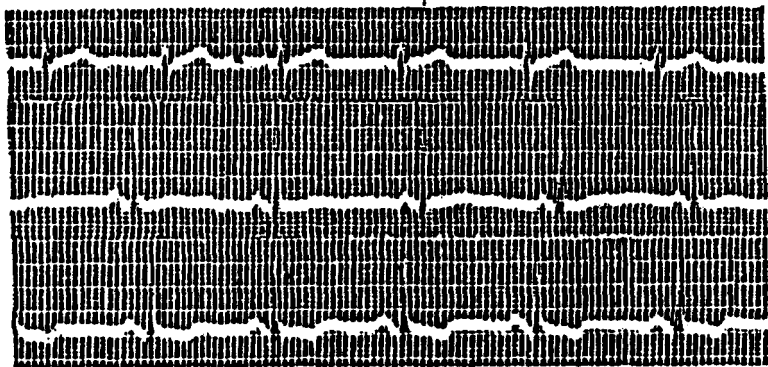


FIGURE 6. ELECTROCARDIOGRAPHIC TRACING OF CASE NUMBER A8730

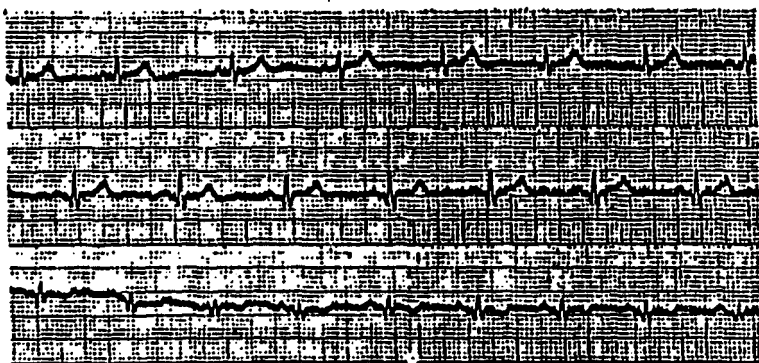


FIGURE 7. ELECTROCARDIOGRAPHIC TRACING OF CASE NUMBER 447

Physical Examination—General appearance fair. Skin clear. Height 59 inches. Weight 120 pounds (greatest weight 125 pounds). No clubbing of fingers. No asbestos warts. Nail beds not cyanotic. Chest, normal shape; percussion normal; respiratory murmur within normal limits; vocal resonance muffled; distant and numerous rales. Heart, no apparent enlargement; no murmurs. Pulse rate before, immediately after, and two minutes after

functional exercise test, 76, 118, 76. Respiration rate before and two minutes after functional exercise test, 14, 18. Blood pressure 134/90.

Phonuroscopy—Diaphragmatic excursion; right dome, 1.7 cm.; left dome, 2.5 cm.

X-Ray—The thoracic cage is negative. The trachea is in the mid-line. The cardiac silhouette is within normal limits. The domes of the diaphragm are regular. The ribs and trunk markings are increased in prominence. The lung markings are also increased in prominence.

Electrocardiogram—Cardiac rate 60. P-R interval 0.16 second. Voltage 3.5 mm. Low voltage of all Q-R-S complexes.

Diagnosis—Asbestosis, moderate.

TABLE XI. INCIDENCE AND DEGREE OF ASBESTOSIS WITH RELATION TO OCCUPATION, DUST CONCENTRATION, AND YEARS OF EXPOSURE

| Occupation                       | Average Concentration Millions of particles per cubic foot | Years of Exposure | Total Number Examined | Negative | Asbestosis |          |          |          |
|----------------------------------|------------------------------------------------------------|-------------------|-----------------------|----------|------------|----------|----------|----------|
|                                  |                                                            |                   |                       |          | Alight     | Moderate | Advanced | Doubtful |
| Preparers and Carbers            | 41.20                                                      | 0-5               | 3                     | 2        | --         | --       | --       | 1        |
|                                  |                                                            | 6-10              | 3                     | --       | --         | 3        | --       | --       |
|                                  |                                                            | 11-15             | 5                     | 1        | 1          | 3        | --       | --       |
|                                  |                                                            | 16-20             | 2                     | 1        | 1          | --       | --       | --       |
|                                  |                                                            | over 20           | 1                     | 1        | --         | --       | --       | --       |
|                                  |                                                            | Total             | 14                    | 5        | 2          | 6        | --       | 1        |
| Weavers and Spinners             | 16.87                                                      | 0-5               | 3                     | 3        | --         | --       | --       | --       |
|                                  |                                                            | 6-10              | 4                     | 3        | 1          | --       | --       | --       |
|                                  |                                                            | 11-15             | 4                     | 3        | --         | 1        | --       | --       |
|                                  |                                                            | 16-20             | 5                     | 3        | 2          | --       | --       | --       |
|                                  |                                                            | over 20           | 2                     | 2        | --         | --       | --       | --       |
|                                  |                                                            | Total             | 18                    | 14       | 3          | 1        | --       | --       |
| Winders, Twisters, Waspers, etc. | 4.61                                                       | 0-5               | 4                     | 4        | --         | --       | --       | --       |
|                                  |                                                            | 6-10              | 7                     | 6        | 1          | --       | --       | --       |
|                                  |                                                            | 11-15             | 6                     | 6        | 1          | --       | --       | 1        |
|                                  |                                                            | 16-20             | 1                     | 1        | --         | --       | --       | --       |
|                                  |                                                            | over 20           | 4                     | 4        | --         | --       | --       | --       |
|                                  |                                                            | Total             | 22                    | 21       | 2          | --       | --       | 1        |
| Total                            |                                                            |                   | 54                    | 40       | 7          | 7        | --       | 2        |

The principal factors now thought to determine incidence and degree of the pneumoconioses are nature and concentration of the dust, length of exposure, and individual susceptibility. The in-

idence of asbestosis with relation to occupation, concentration of the dust, and length of exposure in the fifty-six persons examined in this study is indicated in Table XI. Obviously the examination of such a relatively small group prevents the formation of definite conclusions as to the influence of these factors. Nor is it possible from our findings to establish the maximum safe concentration of asbestos dust in the air. However, the results of this investigation show the necessity of a reduction of the dust concentrations in those operations, shown in Part II of this study, where there is continuous exposure to high concentrations.

#### SUMMARY

(1). The concentration of dust in asbestos fabricating plants depends primarily on the grade of asbestos; mill fiber gives rise to a higher concentration than crude fiber. Operations arranged in decreasing concentration of dust are preparing, carding, weaving, spinning, twisting, winding, and warping.

(2). The average particle size of asbestos dust is stated in two diameters, longitudinal and transverse.

(3). Petrographic analyses of dust encountered in asbestos fabricating plants collected in the workers' breathing zone shows it to contain no free silica.

(4). Fourteen, or 25% of fifty-six workers employed in the textile department of a fabricating plant in Pennsylvania had both clinical and roentgenological evidence of asbestosis.

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