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## A SURVEY OF A GROUP OF EMPLOYEES EXPOSED TO ASBESTOS DUST\*

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**T**HE dangerous dust diseases, silicosis and asbestosis, are being widely studied at present. It has been estimated that there are more than 750,000 silicotics in the United States while there are only 35,000 to 40,000 persons engaged in the asbestos industry in the world. In the United States in 1929 a total of 9,237 persons were said to be employed in the manufacture of asbestos products other than steam packing and pipe and boiler covering. While it employs a relatively small number of persons, the asbestos industry has had a remarkably rapid expansion and by reason of the widespread and varied uses of its products which include "matches, filter pads, paints, roofing, high pressure jointing, electrodes, brake linings, clutch rings and insulating material in a great variety" the industry occupies an important, increasing, and permanent place in our economic establishment.

Asbestos is described chemically as a hydrated silicate of magnesia containing little iron and almost no calcium. It is a fibrous mineral which can be split up into flexible fibers for spinning and weaving. When it is processed some of these fibers are fragmented. The fine fragments are inhaled by the workers. It is the particles smaller than 10 microns which

are the cause of the distinctive pulmonary fibrosis called asbestosis. Gardner writes that "these asbestos particles are phagocytosed as they are caught on the irregular walls of the terminal bronchioles. The phagocytes for the most part migrate directly into the substance of the adjacent walls and there stimulate growth of connective tissue cells. There results a collar of fibrous tissue about the terminal bronchioles which contracts and constricts the tubes. The constriction produces collapse of the distal alveoli (atelectasis). The collapsed area becomes fibrous from mechanical causes (collapse induration). In asbestosis unlike silicosis there is little or no transport of dust into the lymphatic system and no nodule formation." "Intervening units (between the affected lobules) not being involved still contain air and permit the passage of x-rays. Consequently the roentgenogram fails to show massive homogeneous shadows." The appearance on the film has been frequently likened to ground glass.

This paper reports the results of a survey of 210 persons exposed to asbestos dust. The conditions imposed upon the survey did not permit the thoroughness of study to be desired, but all of the employees were given a brief, general clinical examination which included taking their past

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health and occupational history and a physical examination. No laboratory examinations were made. All had a single film made of the chest.

The dust concentrations are not equal in the various departments. In the preparation department the processes of grinding, crushing, and mixing are carried out. Here the quantity of dust is greatest and consists almost

dred and twenty-three, 58.5 per cent, were regarded as showing lung-fields that were normal, except for a small primary tuberculous focus in one. Of the 210 films, fifty-three, 25.2 per cent, were regarded as showing definite or questionable evidence of asbestosis; of the fifty-three, 20 films were classed as questionable. Had stereoscopic retakes been allowed, it is believed that this number could have been greatly reduced. The indispensability of a competent roentgenologic technic needs to be emphasized. Thirty-three films, 15.7 per cent, showed definite asbestosis; in twenty-five, 11.8 per cent, the process was moderate in extent; and in eight, 3.8 per cent, more advanced. In the remaining 34 films various types of thoracic pathology were noted, none of which were ascribable to asbestos dust.

Table 2 presents the normal lung group and shows the distribution of the group in the various age-periods; the incidence of cardiovascular abnormalities seen in the films and dyspnea according to age-periods; the number with chest expansions averaging approximately  $\frac{1}{2}$  inch,  $1\frac{1}{2}$  inches,  $2\frac{1}{2}$  inches and  $3\frac{1}{2}$  inches; the total number of employees in each department whose lungs were normal, and the numbers and lengths of exposure to asbestos dust of those in the several departments.

Table 3 shows the incidence and extent of asbestosis from increasing periods of exposure in the several departments. In this table employees are placed in the department where they work at present. It is obviously a practical impossibility to trace the transfer of each individual from department to department and as the

TABLE 1

	NUM- BER	PER CENT
Total examined.....	210	
Normal lungs.....	123	58.8
Pulmonary fibrosis, linear type.....	9	4.3
Heavy linear shadows in the cardiophrenic angle.....	11	5.2
Cardiovascular pathology.....	24	11.4
Pleural adhesions.....	7	3.3
Azygos lobes.....	2	0.9
Bony pathology.....	4	1.9
Pleuro-pericardial adhesions.....	5	2.3
Bronchiectasis.....	3	1.4
Asbestosis questionable.....	20	9.5
Asbestosis moderate.....	25	11.8
Asbestosis advanced.....	8	3.8
Primary pulmonary tuberculosis:		
Primary foci.....	6	2.8
Calcified lymph nodes.....	5	2.3
Secondary pulmonary tuberculosis:		
Minimal.....	2	0.9
Moderately advanced.....	4	1.9
Far advanced.....	0	0.0

entirely of asbestos particles. In the other departments the material processed is a mixture of asbestos and cotton. Here the proportion of asbestos particles is less and the total dust is also less.

Table 1 summarizes the various types of pathology noted in the films. Of the 210 persons examined, forty-five were negroes. The films of one hun-

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presents the normal lung shows the distribution of n the various age-periods; e of cardiovascular abnor- n in the films and dyspnea o age-periods; the number expansions averaging ap- ½ inch, 1½ inches, 2½ ½ inches; the total number es in each department s were normal, and the d lengths of exposure to st of those in the several s.

shows the incidence and sbestosis from increasing exposure in the several s. In this table employees in the department where t present. It is obviously impossibility to trace the each individual from de- o department and as the

management states that something like 95 per cent of employees continue in the department in which they began, it has been assumed in the discussion that the employee has been at his present work throughout his exposure.

From this analysis it appears that of 9 persons exposed for more than 15 years to dust concentrations effective in producing disease, four, 44 per cent,

sufficient in a great percentage of these cases to produce asbestosis. Attention is called to the fact that in the same department, that is, where the concentration of dust is the same, some exhibit the disease after a short exposure while others, after much longer exposures, escape. Nor is the incidence of disease always as great among those who have been

TABLE 2  
ANALYSIS OF GROUP OF EMPLOYEES WITH NORMAL LUNGS

	AGE					TOTAL
	15-24 years	25-34 years	35-44 years	45-54 years	55-64 years	
Number in each age period...	36	57	22	6	2	123
Dyspnea.....	1	6	1		1	9
Cardiovascular abnormalities.....		2	3	2	2	9
Chest expansion.....	0-1	1-2 in.	2-3 in.	3-4 in.	Not re- corded	
Number in each grade.....	2	67	48	3	3	123
Years of exposure.....	1-2	2-5	5-10	10-15	15-20	
Departments:						
Preparation.....	4		1			5
Carding.....	6	4	4	2		16
Mule spinning.....	5	1	4	1	2	13
Spooling.....	3	2	4	1		10
Twisting.....	11	1	5	1		18
Winding.....	19	1	7	3		30
Ring spinning.....	1			1		2
Weaving.....	8	2	8	1	1	20
Maintenance.....	4	3	2			9
Total.....	61	14	35	10	3	123

escaped asbestosis; of 32 persons exposed for more than 10 years to similar concentrations, fourteen, 43 per cent, escaped; of 70 persons so exposed for more than 5 years forty-five, 64 per cent, escaped, and of 28 persons exposed for more than 2 years and less than 5, twenty-four, 85 per cent, escaped. Prolonged exposure to disease-producing concentrations of dust alone does not seem to have been

exposed for equal periods in departments where concentration of dust is greater as among those who work in departments where it is less.

The incidence of disease increases with the duration of exposure and the concentration of effective dust, but not directly or constantly. No length of exposure or concentration of dust produced the disease in more than 60 per cent of persons exposed in any

department. It seems to be true everywhere, that some workers are not affected however long the exposure or high the concentration. These facts suggest differences in susceptibility. As to what deficiencies in defense or possible reinforcements of the attack exist in those in whom asbestosis occurs, other than the recognized difference in the compe-

were made to observe the behavior of respiration in response to the changing ventilatory demands of graded physical exercise. Dyspnea here means that the persons replied "yes" when asked, "Do you have any shortness of breath under ordinary circumstances?" This "yes" is understood as meaning that these persons when engaged in usual activities were with

TABLE 3  
ANALYSIS OF EFFECT AND DURATION OF EXPOSURE IN VARIOUS DEPARTMENTS

DEPARTMENTS	DURATION OF EXPOSURE																TOTAL										
	0-2 years				2-5 years				5-10 years				10-15 years					15-20 years									
	Number of employees	No asbestosis	Questionable	Moderate	Advanced	Number of employees	No asbestosis	Questionable	Moderate	Advanced	Number of employees	No asbestosis	Questionable	Moderate	Advanced	Number of employees		No asbestosis	Questionable	Moderate	Advanced	Number of employees	No asbestosis	Questionable	Moderate	Advanced	
Preparation...	3	3									7	2	3	2		1											3
Carding.....	8	7	1			8	6		2		13	5	1	3	4	7	1	3	2	1	1	1				1	12
Mule spinning.	5	5				3	3				8	6		2		3	2		1			4	2		2		5
Spooling.....	3	3				2	2				6	5		1		3	2		1								1
Twisting.....	15	15				1	1				9	7	1	1		3	2		1			1			1		2
Winding.....	20	20				3	3				9	8		1		6	4		1	1							1
Ring spinning.	1	1				1	1				1	1		1		1	1										1
Weaving.....	10	10				5	4	1			12	9	1	2		5	1	1	3			1	1				5
Maintenance...	6	6				5	4	1			5	3	1		1	3	1	1	1			2	1			1	3
Total.....	71	70	1			28	24	2	2		70	45	8	12	5	32	14	7	9	2		9	4	2	2	1	33
Number with dyspnea.....		1					3					7	2	3	2		2	3								1	24
Cardiovascular disease.....		3	1				2					2	4	2	1		2	5	1	1							24

tency of the protective mechanisms in different individuals, no conjecture is ventured.

As of silicosis, dyspnea may be said to be the characteristic symptom of asbestosis. The dyspnea here reported does not refer to more frequent, more forceful or embarrassed operations of the respiratory mechanisms objectively manifest. No tests

greater or less frequency conscious of an unaccustomed sense of inadequacy attending the ventilatory process. This experience was not infrequent among persons with lungs roentgenologically and by physical examination normal, occurring in 8.1 per cent. The experience was more than twice as frequent among those with definite asbestosis. Six of the 33 asbestotics

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 This "yes" is understood  
ng that these persons when  
in usual activities were with

18.1 per cent), stated that they had  
some shortness of breath; three of the  
25 moderate cases and three of the 8  
more advanced. But the most ad-  
vanced cases showed no special respira-  
tory effort during examination and

of the twenty-four with dyspnea  
showed cardiovascular pathology in  
the films and also had high blood  
pressure, but none of the five had  
definite asbestosis. Dr. William S.  
McCann reminds us: "Respiration is

IN VARIOUS DEPARTMENTS

TABLE									
Number of employees	10-15 years				15-20 years				TOTAL
	No asbestosis	Questionable	Moderate	Advanced	No asbestosis	Questionable	Moderate	Advanced	
1				1					3
7	1	3	2	1	1				12
3	2		1		4	2		2	5
3	2	1							1
3	2		1		1		1		2
6	4	1	1						1
1	1								1
5	1	1	3		1	1			5
3	1	1	1		2	1		1	3
32	14	7	9	2	9	4	2	2	33
		2	3						1
		2	5	1	1				24

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no cyanosis and none declared lack  
of or impaired ability to carry on at  
their jobs. Among the thirty-three  
asbestotics, dyspnea was twice as  
frequent in those under 45 years of  
age, 42.1 per cent, as in those over  
45 years of age (21.4 per cent). Five

not a function of the lungs alone but  
of the heart, blood and tissue ability  
to absorb oxygen, and also to undergo  
oxygen want such as the trained  
muscles of athletes withstand oxygen  
want."

Decreased chest expansion may be



FIG. 1.—Moderate asbestosis. Heavy pectoral muscles exaggerate the appearance of fibrosis.

said to be the cardinal sign of asbestosis. Among the normal lung group, 56 per cent had an expansion under 2 inches, 44 per cent above 2 inches. In the group with definite asbestosis, 69.6 per cent, had a chest expansion of less than 2 inches, 30.4 per cent, had an expansion above 2 inches. The proportion of those with the lower degree of expansion was increased about 24 per cent among the asbestotics. Chest expansion depends not only on lung distensibility but on the mobility of the bony and soft tissues of the thoracic cage and of the diaphragm. It is often astonishing how training and practice can rapidly increase chest expansion. The individual learns to exercise fully anatomic capacities which were present prior to the training.

From the foregoing findings it appears that the assumption that a sense of air want and restricted chest expansion are due to an existing asbestotic involvement of the lungs roentgenologically manifest, should not be made too hastily.

Studying the compatibility of asbestosis with length of life and work it is to be noted that: One employee with advanced asbestosis above the age of 55 who had worked in dust more than 15 years was still able to work. One employee, 54 years old, with advanced asbestosis who had worked in dust more than 10 years was still able to work. Three employees with moderate asbestosis and above the age of 44 who had worked in dust more than 10 years were still able to work. Of this group of 5 asbestotics above the age of 44 (three with moderate asbestosis and two with advanced asbestosis), one com-

plained of shortness of breath. Of the eleven with moderate asbestosis and the three with advanced asbestosis who had worked more than 10 years, one, (7.1 per cent), complained of shortness of breath; these fourteen men had chest expansions which compared favorably with the normal lung group. Sixty-six and two-thirds per cent of these 14 asbestotics had a chest expansion under 2 inches, whereas 56 per cent of the normal lung group had the same limits. But 78.9 per cent of those with definite asbestosis who had worked in dust under 10 years had chest expansion under 2 inches and 26.3 per cent complained of shortness of breath. The older persons, whether with moderate or more advanced asbestosis, appear better adjusted to the disease.

The average exposure for the entire group with asbestosis was 10.2 years, for those with moderate asbestosis 10.3 years, and for those with advanced asbestosis, paradoxically, 10.0 years. If the entire group with asbestosis is divided into those below and those above 40 years of age, the exposure of those with moderate asbestosis below 40 years of age was 9.5 years and above 40 years of age, 12.4 years. For those with advanced asbestosis the corresponding averages were 9 and 11 years respectively.

Advanced asbestosis may exist in late age-periods with working ability not impaired below the level of continued employability in the department where the disease was incurred. No very rapid development of the disease was noted. Only 2 cases occurred where the exposure had been less than 5 years. As a rule 5 or more years of exposure was required

shortness of breath. Of those with moderate asbestosis (10 per cent), complained of shortness of breath; these fourteen had chest expansions which compared favorably with the normal lung expansion—six and two-thirds per cent. Of those with advanced asbestosis (10 per cent), complained of shortness of breath; these fourteen had chest expansions which compared favorably with the normal lung expansion—six and two-thirds per cent. Of those with advanced asbestosis (10 per cent), complained of shortness of breath; these fourteen had chest expansions which compared favorably with the normal lung expansion—six and two-thirds per cent.

For those with advanced asbestosis may exist in periods with working ability reduced below the level of employability in the department where the disease was incurred. The rapid development of the disease was noted. Only 2 cases were noted where the exposure had been 5 years. As a rule 5 or more years of exposure was required

to cause the disease. No conglomerate or massive lesions such as occur in silicosis where infection is superimposed were found in these asbestosis cases. The progression of the disease in this group was very slow.

losis seen in these films. If it can be assumed that most of these infiltrations formed in the late teen age or before 25 years of age, then exposures to asbestos dust varying from 5 to 15 years had produced no evidences of

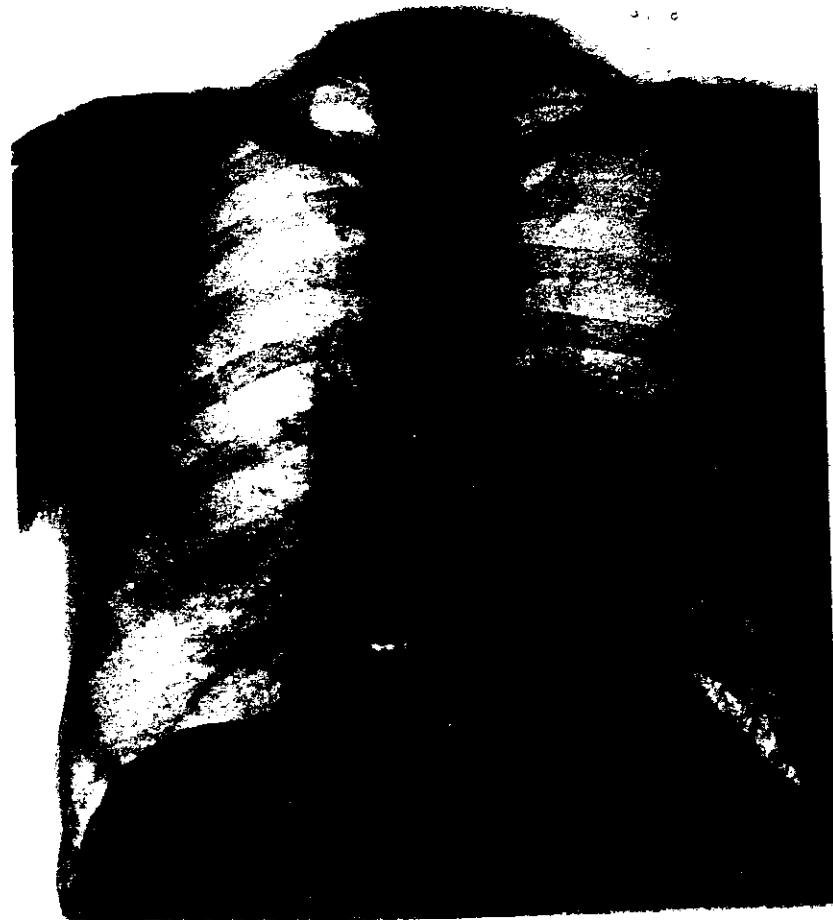


FIG. 2.—Advanced asbestosis, emphasized at left base. Upper lung fields emphysematous.

The evidence presented as to the effect of asbestosis upon tuberculosis in this survey is somewhat limited. Apical tuberculous infiltration was noted in the films of 17 employees; there was no other evidence of tubercu-

activation to be seen in the films. Four of these apical tuberculous infiltrations were found in asbestotics, two with moderate and two with more advanced processes. Six lesions with clinical significance were observed: 2

minimal and 4 moderately advanced (American Sanatorium Association Classification). One moderately advanced lesion was found in a man 24 years old who had been exposed to asbestos dust in the winding department for 6 years. The lesion appeared "soft" and unstable; there was, however, no evidence of accompanying asbestosis. The disease in this moderately advanced case was clinically manifest, though the employee regarded himself as in good health. One of the moderately advanced lesions was found in an employee 37 years of age who had worked in the winding department for 9 years and showed no evidence of asbestosis. A



FIG. 3.—Lateral position. (Same case as Fig. 2.)

ment for 6 years. The lesion appeared "soft" and unstable; there was, however, no evidence of accompanying asbestosis. The disease in this moderately advanced case was clinically manifest, though the employee re-

third employee with a moderately advanced tuberculous lesion had worked in the twisting department for 10 years but had no asbestosis. The fourth, an employee 37 years of age who had worked in the weaving de-



self as in good health. moderately advanced lesion in an employee 37 years of age who had worked in the twisting department for 9 years and had no evidence of asbestosis. A

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partment had moderate asbestosis. The tuberculous lesion in this case could satisfy rigid criteria of a healed lesion. Three of these lesions were active and were accompanied by clinical manifestations. The one lesion associated with asbestosis was healed and the employee apparently was in good health. One of the two minimal lesions was in a man 24 years of age who had worked 15 months in the twisting department and whose films did not show asbestosis; one in a man 37 years of age who had worked 12 years in the winding department and

The films were studied to discover any accentuating effect of a focus of tuberculosis on the surrounding asbestosis. No convincing evidence of such an effect was seen. Tuberculosis and asbestosis were coincident in only 5 employees. The average duration of exposure for the five was 10.4 years and for the entire group with asbestosis 10.2 years. No accelerating effect of tuberculosis on asbestosis could be inferred.

Twenty-four films showed abnormalities of the heart and aortic shadows (Table 4) and eleven of the

TABLE 4  
GROUP OF 24 EMPLOYEES WITH ABNORMALITIES OF THE HEART OR AORTIC SHADOW

	AGE				
	15-24 years	25-34 years	35-44 years	45-54 years	55-60 years
Number of employees in each age-period.....	0	7	9	5	3
Dyspnea.....	0	1	2	1	1
Hypertension.....	0	6	8	4	3
Years of exposure.....	0-2	2-5	5-10	10-15	15-20
Number of employees.....	4	2	9	9	
Asbestosis.....			3	2	

had no asbestosis. One of these minimal lesions was apparently healed.

It is felt that no evidence of an aggravating effect on tuberculosis by asbestos dusting is to be found in these cases. Only one of the six clinically significant lesions was accompanied by asbestosis and that lesion had every appearance of being healed. The incidence of pulmonary tuberculosis (2.8 per cent), is regarded as comparable to the incidence in many other industrial groups in which the association is close and prolonged and whose general standards of living and hygiene are not as good as might be desired.

twenty-four abnormalities were found in the 45 negro employees. A Wasserman test was not allowed. Ten of these negroes were under 45 years of age and one over 55 years of age. In this group of 24 employees with cardiovascular changes, three had a normal blood pressure and the rest had hypertension. Five of the group with cardiovascular abnormalities had definite asbestosis, three of these were negroes under 35 years of age (Table 5).

Waring and Black in an admirable paper discuss, "The Syndrome of Obstruction in the Lesser Circulation" (*Am. J. Med. Sci.*, May, 1934) and

Fig. 2.)

with a moderately advanced tuberculous lesion had worked in the twisting department for 10 years and had no asbestosis. The employee 37 years of age who had worked in the weaving de-

give as its clinical features, cyanosis, dyspnea, polycythemia, and right ventricular preponderance.

The blood was not examined in the cases here described and no electrocardiograms were made. Cyanosis and dyspnea were not observed in any of the 5 asbestotics with cardiovascular disease. In view of the pathology characteristic of asbestosis, namely, constriction of the terminal bronchioles with no perilymphatic or perivascular fibrosis as in silicosis, less obstruction

tions in the group does not appear to be excessive.

To make a scientific appraisal of the effect on the employees in this plant of exposure to asbestos dust, it is necessary to know how many employees during the 15 to 20 years covered in the study have died or quit and how many of these had asbestosis. This knowledge is not available. Certainly it might add greatly to the gravity of the picture. The most that could be done was to note the effect

TABLE 5  
ASBESTOSIS WITH CARDIOVASCULAR LESIONS

	EMPLOYEE NO. 61	EMPLOYEE NO. 92	EMPLOYEE NO. 131	EMPLOYEE NO. 138	EMPLOYEE NO. 167
Age.....	44	53	27	30	30
Race.....	White	White	Black	Black	Black
Blood pressure.....	174/96	170/110	158/104	130/92	134/90
Years of exposure....	13	8	7	10	7
Asbestosis.....	Moderate	Advanced	Moderate	Advanced	Moderate
Dyspnea.....	No	No	No	No	No
Chest expansion.....	2.5 in.	1.5 in.	1.5 in.	1.5 in.	1.5 in.
X-ray pathology....	Enlarged aortic shadow	Enlarged aortic shadow. Enlarged left ven- tricle	Enlarged aortic shadow. Enlarged right and left ventri- cles	Enlarged heart shadow. Both ven- tricles en- larged	Enlarged aortic shadow

of the lesser circulation would seem to be expected in asbestosis than in silicosis and consequently less strain on the right heart.

The frequency of respiratory infections was investigated. Each employee was asked, "Have you had severe colds, 'flu,' or pneumonia and how often?" None said they had had pneumonia, six said they had had "flu," eight mentioned having had colds since being exposed to asbestos dust, and one spoke of having frequent colds. The reported respiratory infec-

on those now present in the plant, after varying periods of exposure.

#### SUMMARY

1. In addition to duration of exposure and concentration of effective dust, it appears that individual response to the inhalation of asbestos dust is an important factor in the production of asbestosis.
2. Asbestosis is infrequently found before 5 years of exposure to industrial concentrations of asbestos dust. In

the group does not appear to be. A scientific appraisal of the employees in this exposure to asbestos dust, necessary to know how many during the 15 to 20 years the study have died or quit many of these had asbestosis. Evidence is not available. Certainty might add greatly to the picture. The most that has been done was to note the effect

RESPIRATORY LESIONS

	EMPLOYEE NO. 133	EMPLOYEE NO. 167
Age	30	30
Race	Black	Black
Years of exposure	130/92	134/90
Severity of disease	10	7
Stage of disease	Advanced	Moderate
Heart shadow	No	No
Aortic shadow	1.5 in.	1.5 in.
Enlarged heart shadow	Enlarged	Enlarged
Enlarged aortic shadow	Both ventricles enlarged	

are now present in the plant, during periods of exposure.

SUMMARY

In addition to duration of exposure, concentration of effective dust appears that individual response to the inhalation of asbestos is an important factor in the development of asbestosis. Asbestosis is infrequently found after years of exposure to industrial concentrations of asbestos dust. In

this group even under dusting which continued 15 years or more, the disease did not progress to an extent of involvement attended by marked clinical manifestations or disability.

3. Roentgenologically advanced asbestosis was not incompatible with ability to work at the process in which it was incurred. Continued work entailing exposure to disease producing concentrations of asbestos dust slowly increases the extent of fibrosis and so is to be advised against.

4. The evidence presented in this study warrants the opinion that with the reduction of dust concentration now feasible by available dust eliminating devices, the incidence of sig-

nificant asbestosis would in time approach the vanishing point.

5. No activating or aggravating effect of asbestos dust or asbestosis on tuberculosis was observed.

6. The evidence of this study, as to the effect of asbestosis on the lesser circulation, is inadequate for forming more than impressions. It does not suggest any marked tendency on the part of asbestosis, with the degree of involvement observed to obstruct the lesser circulation.

7. No increase of respiratory infections was reported in this group.

8. There is some evidence which suggests that asbestosis develops more rapidly in younger persons than in older.