T 27.12: 187

PUBLIC HEALTH BULLETIN

No. 187

Vt. Department of Libraries
Law & Documents Unit
111 State Street
Montpelier, Vt. 05602

THE HEALTH OF WORKERS IN DUSTY TRADES

II. EXPOSURE TO SILICEOUS DUST (GRANITE INDUSTRY)

TREASURY DEPARTMENT

UNITED STATES PUBLIC HEALTH SERVICE

WASHINGTON : 1929

TREASURY DEPARTMENT
UNITED STATES PUBLIC HEALTH SERVICE

PUBLIC HEALTH BULLETIN No. 187
JULY, 1929

THE HEALTH OF WORKERS IN DUSTY TRADES

II. EXPOSURE TO SILICEOUS DUST (GRANITE INDUSTRY)

BY

A. E. RUSSELL, Passed Assistant Surgeon
R. H. BRITTEN, Associate Statistician
L. R. THOMPSON, Surgeon
J. J. BLOOMFIELD, Assistant Chemical Engineer
U. S. Public Health Service

(With sections on autopsy material by Dr. L. U. Gardner and on silica by Prof. A. Knopf).

PREPARED BY DIRECTION OF THE SURGEON GENERAL

UNITED STATES

CONTENTS

	Page
Introduction	1
Method of study	2
Object of the study	5
Acknowledgments	6
I. Occupational environment	6
Survey of plants	7
Climate	9
Occupational analysis	9
Chemical and petrographic analysis of dust	13
Survey of extent of plant dustiness	20
II. Factors influencing sickness rates	29
General considerations	29
Physical characteristics of granite workers	32
Years in granite industry (length of service)	34
Age distribution of workers	37
Relation between age and years in granite industry	38
Number of workers in each plant	39
Race and social conditions	41
Alcoholism	44
Presence of epidemics	45
III. General sickness record	46
Incidence	46
Duration of sickness	57
Percentage with cases of specific sickness	62
Relative sickness in the various plants studied	64
Absence from causes other than sickness	65
Sickness prior to development of tuberculosis	66
Mortality during period of study	68
IV. Physical examination findings apart from silicosis and tuberculosis	70
General considerations	70
Chest expansion and vital capacity	72
Bronchitis	73
Hearing	75
Blood pressure in comparison with other studies	77
Changes in weight with length of service	78
Relation between sickness and certain physical factors	79
Other relations	82
V. Silicosis	83
Basis of diagnosis	83
Medical findings	84
Findings based on examination of X rays	86
Percentage with silicosis by length of service	89
Symptoms and physical signs depending on exposure to dust	90
Case histories and X rays	92
Atypical cases	93

	Page.
VI. Tuberculosis complicating silicosis	96
General comments	96
Discussion of two groups of cases	97
History and symptoms	100
Basis of diagnosis	100
Sputum analyses	101
General prevalence of cases of silicosis complicated by tuberculosis	102
Age distribution of cases	103
Tuberculosis by dust count groups and years in granite	105
Tuberculosis in certain occupational groups	108
Morbidity from tuberculosis	109
Racial susceptibility	112
Mortality in study	113
Case histories and X rays	119
VII. Development of concurrent silicosis and tuberculosis	129
VIII. Course of silicosis among workers no longer exposed to silica dust	132
Discussion of literature	132
Results	133
Case histories and X rays	133
Case histories without X rays	133
IX. History of tuberculosis among members of granite-cutters' families	136
X. A pathological study of eight lungs from employees in the granite industry	138
Protocols of the gross and microscopic examinations of these lungs	138
Summary of the gross appearances	157
Microscopic appearances	159
XI. Mortality among granite workers as indicated on death certificates	171
Proportionate mortality from tuberculosis by specific occupation	171
Proportionate mortality from tuberculosis by age	174
Comparison chronologically	177
Trend of mortality among cutters based on death rates	178
Causes of mortality other than tuberculosis	181
Accidents	184
Summary and conclusions	185
Occupational environment	185
Factors influencing sickness rates	188
General sickness record	189
Physical examination findings apart from silicosis and tuberculosis	191
Silicosis	192
Tuberculosis complicating silicosis	194
Concurrent tuberculosis and silicosis	198
Course of silicosis among workers no longer exposed to silica dust	198
History of tuberculosis among members of granite-cutters' families	198
A pathological study of eight lungs from employees in the granite industry	198
Mortality among granite workers as indicated on death certificates	200
General comments	201

THE HEALTH OF WORKERS IN DUSTY TRADES

II. EXPOSURE TO SILICEOUS DUST (GRANITE INDUSTRY)[1]

INTRODUCTION

This bulletin is the second of a series dealing with the health of workers in the dusty trades, the first being Public Health Bulletin No. 176, devoted to the possible hazard of Portland cement dust. As was stated in the preface to that bulletin, the whole investigation represents a new method of approach to the health hazards of industry. In the past our knowledge of the effect of industrial hazards on the health of workers has been gained largely either from the study of occupational mortality statistics or from the physical examination of sample groups of employees in an industry. In these investigations an attempt has been made not only to utilize both of the above procedures as far as possible, but also, by observing groups of workers for a considerable period of time, to learn something of the character and severity of the sickness they experienced, and to correlate such illness with occupational environment.

In order to study the health of workers in the dusty trades, six specific investigations were undertaken, each dealing with a different type of dust. A list of these dusts follows:

1. Calcium dust (Portland cement plant).
2. Silica dust (granite industry).
3. Metal dust (silver polishing).
4. Carbon dust (hard-coal industry[2]).
5. Vegetable dust (cotton-milling industry).
6. Municipal dust (street sweeping).

In the first bulletin dealing with the health of workers in the dusty trades, an effort was made to discuss in some detail the opinions of authorities as to the nature of the pneumonoconioses caused by different types of dust, although no general review of the literature was attempted. In preference to a repetition of this material in the present bulletin, reference is made to pages 5–21 of Public Health Bulletin No. 176.

[1] Submitted for publication Oct. 17, 1928.
[2] Also a modified study in a soft-coal district.

METHOD OF STUDY

In this study, as in all of the others, the work was under the general supervision of Surg. Lewis R. Thompson, in charge of the Office of Industrial Hygiene and Sanitation, and was entirely carried on by the personnel of the section, except as noted. The analysis and method of presentation of the statistical material was under the supervision of Associate Statistician Rollo H. Britten, who had the assistance of Miss Jennie C. Goddard, Miss Lily Vanzee, and others. As referred to later, the occupational analysis and dust determinations in this study, as in the other studies, were made by Assistant Chemical Engineer J. J. Bloomfield.

Originally Surg. J. F. Worley was detailed to the Section of Industrial Hygiene and Sanitation to coordinate the medical work in this and the other dust studies. In this capacity he remained in direct charge from May, 1923, to December, 1924, and contributed much to the organization and conduct of the work.

Passed Asst. Surg. A. E. Russell, who relieved Doctor Worley in the general supervisional work, was also directly in charge of the investigation of the effect of silica dust from its beginning to its termination. In addition to his other office force, he was assisted by Miss Rena A. Jianni, surgeon's assistant, in collection of the morbidity statistics and the making of the X rays.

In order to permit as detailed a comparison as possible from one study to another, a fixed method of conducting the various investigations was carried out, consisting fundamentally of six sections: (1) Examination to determine the general physical condition of the workers under observation; (2) special physical examination to determine the prevalence of specific diseases of the respiratory system and the lung pathology resulting from exposure to the particular dust hazard; (3) record of the nature and severity of the disabling illnesses; (4) analysis of the occupational environment; (5) occupational mortality statistics relating to the specific dust; and (6) autopsies.

Although the method of study carried out in all the investigations was given in detail in the previous bulletin, an understanding of the procedure is so important that it appears well to repeat the outline of method, partly for the purpose of indicating the particular variations which proved necessary in the study of granite dust. These variations were in the nature of an elaboration to throw as much light as possible upon the effect of silica dust, which is obviously of greater importance as a health hazard than any of the other dusts taken up in these studies.

Physical examinations.—The general and special physical examinations (as mentioned above) may be considered as one in this particular study in view of the fact that the officer who made the special examinations of the lungs in all of the studies also made the general physical examinations in the granite industry.

The physical examinations were given for the purpose of determining the general physical condition of the individuals in the various groups and any important physical differences existing, and discovering any abnormal chest condition, particularly with reference to lung pathology. All cases suspicious of pulmonary disease were given special and careful consideration and watched over as long a period as was necessary to establish the diagnosis. With two exceptions, it is believed that every person who had or developed tuberculosis in the plants studied was given such an examination. X rays were taken of the chest in a large number of cases, and sputum examinations were made where possible.

In the beginning of the study, an attempt was made to examine all the employees in the plants where the morbidity records were kept, but owing to the great number of workers who would not submit to an examination, this was found not to be practicable. As many examinations were made in this group as possible, and in addition there was included a large number made in other granite plants in the city. Two other groups were also included: (*a*) Those who had left the industry and were at the time employed in nondusty occupations, and (*b*) persons in the families of granite cutters.

X-ray examinations.—In connection with the physical examinations, about 250 X rays of the chest of these workers were taken. The X rays were made for two purposes: (*a*) As an aid in the diagnosis of individual cases of lung diseases, and (*b*) as an indication of the extent of lung pathology of workers in granite dust of a known percentage of free silica after a given period of exposure. On a number of these cases a series of X rays were taken to demonstrate the progress of silicosis and its complications.

Sputum examinations.—In view of the relation of tuberculosis to the problem of granite dust, every effort was made to secure sputum analyses, and a large number of cases were found to have tubercle bacilli in the sputum. The sputum examinations were particularly important in fatal cases to determine the percentage of cases of advanced silicosis upon which tuberculosis had been grafted.

Autopsies.—Autopsies were performed in each instance where it was possible to obtain the family's consent. Owing to the small size of the city and the excellent social condition of the workers, it was not possible to obtain as many autopsies as desirable, but it is felt that a fair idea of the lung pathology of silicosis and its complications was obtained in the series of autopsies which was possible.

Sickness records.—A sickness record was kept for each person in the group under observation. Arrangements were made with 14 granite manufacturing plants whereby the names of workers who were absent from work would be reported daily. Regardless of the cause of the absence, it was investigated and record was made of it. Information was obtained from the patient as to the nature of his illness and the name of the physician treating him, if there was one. The diagnosis in such cases was checked with the physician, and it is deemed a very accurate account of the condition from which the patient was suffering. In many instances the officer in charge of the study visited the patient with his physician. If no physician was in attendance on a case, the diagnosis of a nurse or the patient's own statement was secured. In the case of minor illnesses, inquiry was sometimes made as to the symptoms and a rough diagnosis based on this. In all cases suspicious of tuberculosis the patient was asked to permit a thorough physical examination, unless this had already been made. Record was also kept of the date of return to work, so that the severity of the cases could be determined. In the case of death of any worker, the physician was consulted and later the death certificate, so that the correct cause of death could be put into the records.

The period of observation was two and one-fourth years. In all, 972 persons were included in the sickness records, although some of these were under observation for relatively short periods. The total number of years of observation on the whole group was 1,346.

Death records of the city.—In addition to a record of deaths occurring in the working population studied a transcript was made of all death certificates in the city for 1900 to 1925, inclusive. All the pertinent data relative to occupation, nationality, cause of death, etc., were included in the transcript.

Occupational environment.—A careful occupational analysis, according to the occupational record form devised by Winslow and Greenburg [3] and used in previous studies by the Public Health Service, was made in each of the plants. In all the dust studies, in order to obtain groups of workers sufficiently large to make the observations trustworthy, it was necessary to include those engaged in several occupations exposed to dust in varying degree. This had the advantage, among other things, of giving a rather adequate control group within the industry itself. A sanitary survey of the plants was also made.

The exposure to dust was, of course, the most important item of the job analysis. All the dust determinations were made by the

[3] Winslow, C.-E. A., and Greenburg, Leonard: A Useful Factory Inspection Form. Public Health Reprint No. 722.

same investigator, Assistant Chemical Engineer J. J. Bloomfield, in each study, and at sufficiently frequent intervals to assure a fairly accurate idea of the dustiness of each specific occupation, the upper and lower limits of variation in dustiness, and the changes which might take place in the same occupation, especially with respect to season.

The impinger dust collector was used in all the studies,[4] although it was supplemented by the konimeter in those occupations in which the count was generally found to be low. The number of particles per cubic foot and the size of the dust particles were determined in each instance. The counts were divided into (*a*) those particles under 10 microns in diameter and (*b*) those particles over 10 microns in diameter. The total weight was obtained as an additional measure of accuracy.

A general chemical analysis and, in addition, a careful petrographic analysis of the dust were made. These studies were conducted at the United States Geological Survey by Mr. C. S. Ross and also at Yale University by Mr. G. A. Cooper under the direction of Prof. Adolph Knopf.

In the granite study the investigation of occupational environment was identical in method with that carried out in the other studies.

OBJECT OF THE STUDY

It should be understood that this study was not one of the granite industry as a whole, nor of the sanitary conditions or the environment of any particular plant or group of plants. It was a study of silica dust of a definitely known composition in its effect on the health of the workers. This point is one of great importance and can not be overemphasized. The fact that the dust was granite and that the study was carried out in a particular locality and in particular plants cutting granite for a specific purpose was incidental. It was necessary, in order to learn more about the effect of a dust with a definitely known percentage of free silica, to carry out the study under conditions where the hours of work, the nature and amount of the dust, and the general working conditions were known; but the study was made to be of general application in connection with the problem of silica dust. At the same time, so far as the information is directly applicable, it is hoped that it will prove of value to the granite industry itself and to the particular plants where the study was made.

[4] Greenburg, Leonard, et al.: Comparative Tests of Instruments for Determining Atmospheric Dusts. Public Health Bulletin No. 144.
Greenburg, Leonard: Studies on the Industrial Dust Problem. Public Health Reports, July 31, 1925.

ACKNOWLEDGMENTS

Fourteen of the granite manufacturers of Barre kindly gave permission to enter their plants and interview their workers, and furnished a daily report of absentees for the morbidity study. They also permitted the collection of dust samples in their plants.

The Granite Cutters' Union was very cooperative, and many of the members presented themselves for examination and study.

The physicians of Barre were of greatest assistance in the study. They cheerfully gave diagnoses for the morbidity records and permitted study of their cases of tuberculosis and silicosis. They referred many interesting cases, and consultations were frequently held.

Doctors McFarland, Woodruff, and Avery were instrumental in obtaining permission to do autopsies, and without their assistance this could not have been accomplished. The Montpelier physicians were also cooperative when any of their patients working in Barre were concerned. The Washington County Medical Society maintained a very friendly and cordial attitude toward the study throughout the period.

Dr. E. J. Rogers, physician in charge of the State tuberculosis work and institutions and member of the State board of health, was also of great assistance. He permitted the study of cases of silicosis and tuberculosis in the institutions and the use of records where necessary.

Doctors Dalton, Whitney, and Kent, of the State board of health, were also of great aid in the study. Most of the sputum analyses reported herein were made at the State hygienic laboratory.

Dr. D. C. Jarvis, consultant of the Office of Industrial Hygiene and Sanitation, contributed much to the study through his familiarity with the subject of silicosis among granite cutters and his assistance in the making and interpretation of the X rays.

Dr. H. K. Pancoast very kindly reviewed the majority of the X-ray films and made many helpful suggestions in regard to the nature of silicosis and tuberculosis.

Acknowledgments are hereby made to the above-mentioned people for their valuable assistance and cooperation throughout the study.

I. OCCUPATIONAL ENVIRONMENT

A special survey was made of the plants in order to obtain a general picture of the working conditions of the persons for whom morbidity records were kept. A discussion of these conditions has been taken up under three headings: Survey of plants, occupational analysis, and investigation of atmospheric dustiness. The floor plan of a typical granite cutting shed is shown in Figure 1.

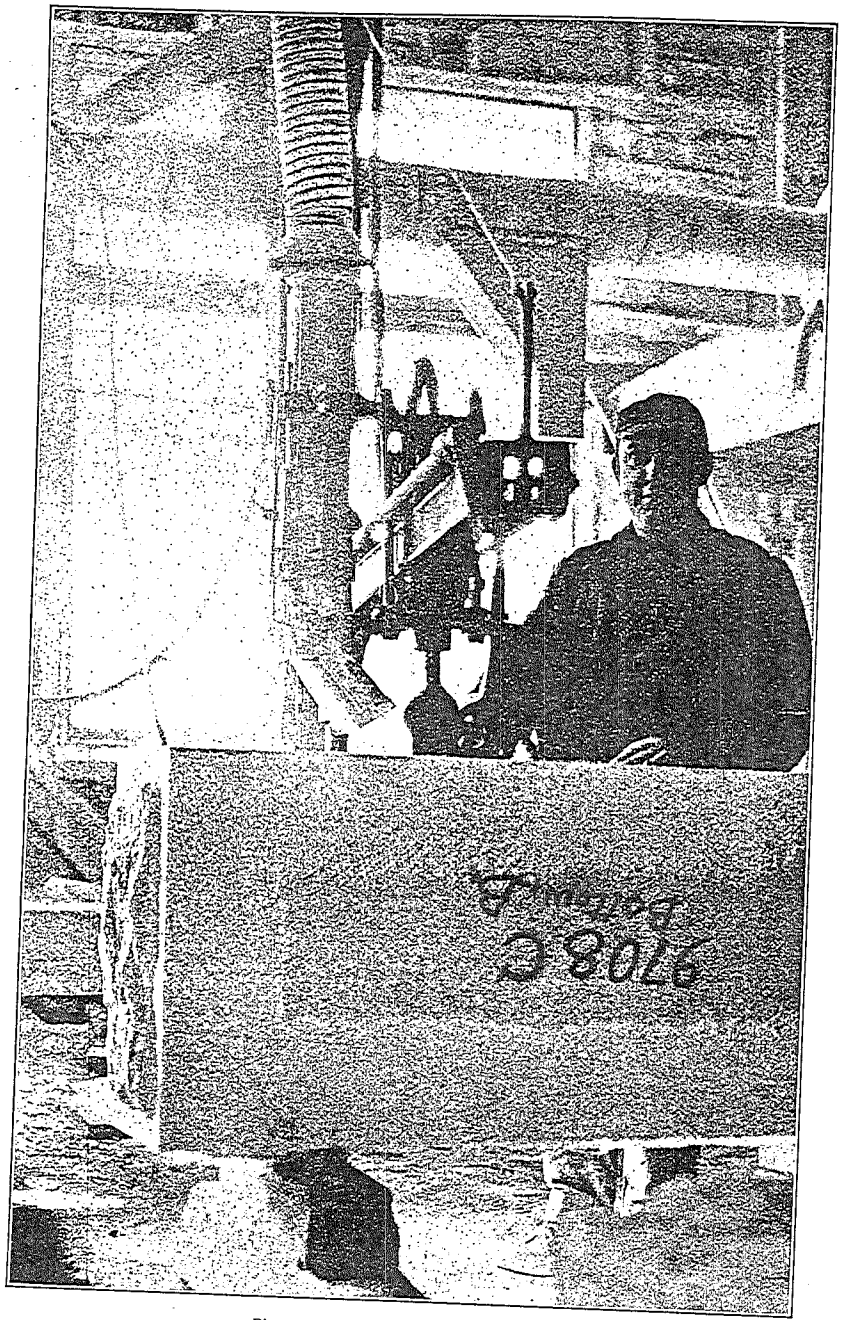


Plate 1.—Surface cutter and his machine

Exhaust is attached to the machine and opens near the cutting hammer.

SURVEY OF PLANTS

Building construction.—The 14 plants dealt with in the report are located in 17 frame buildings of fairly good construction. These buildings, or sheds, are all one story in height. The height of the roof from the floor was noted to be anywhere from 35 to 60 feet, so

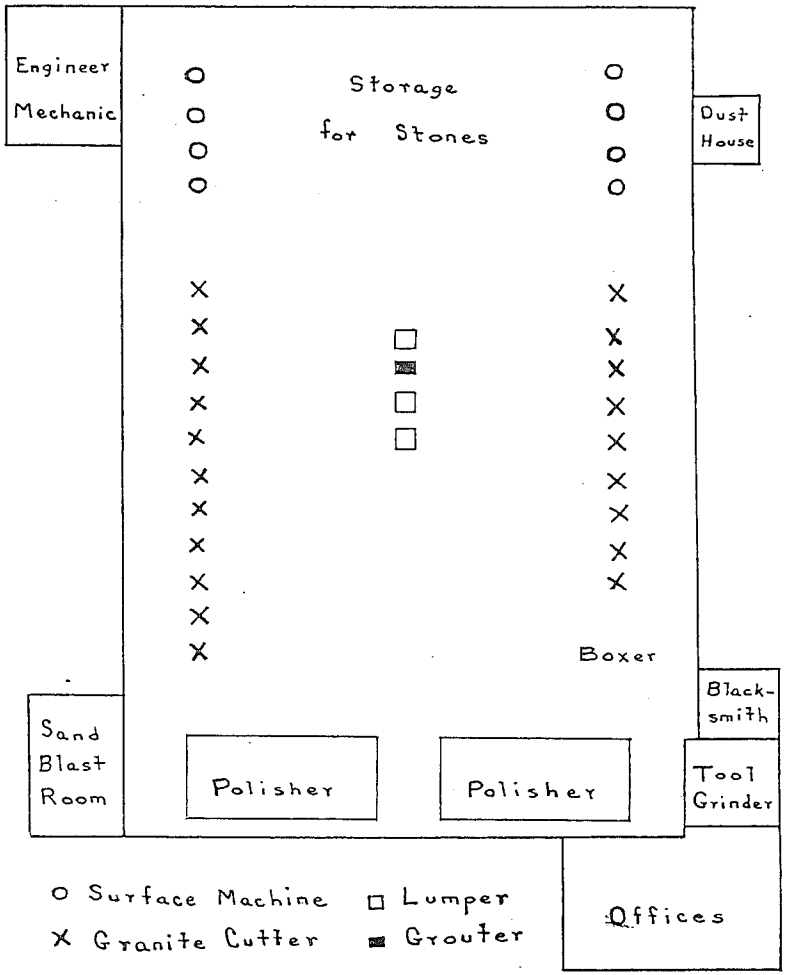


FIGURE 1.—Plan of a typical granite cutting shed

that in general the cubic capacity of the sheds would be ample for any nondusty trade. The land upon which the building is situated serves as a floor in all instances.

Ventilation.—Natural ventilation by means of numerous windows (which, on account of the severity of the climate, were generally kept closed during the winter) was depended on for the removal of dust,

except in the case of sand blasters and inside surface cutters. In connection with the latter occupation, the ventilating systems were not usually designed to meet the particular problem, and in some cases were not properly installed. Plate 1 shows the exhaust system commonly used for removing dust from the surface cutting process. Of a total of 76 inside surfacing machines, 55, or 72 per cent, were not equipped with individual fans.

Heating.—The heating systems were frequently inadequate for the severe winters of Vermont. Some of the plants had hot-air heating units arranged in such a way that only the body of a worker was kept warm.

It seems appropriate to mention at this point the possible hazards in the use of the pneumatic hammer other than the production of dust. Leake [5] in his work among the Indiana limestone cutters showed that the continued use of the air hammer in stonecutting leads to a disorder shown by a blanching of parts of the hands, with cold and numbness; this is not a serious condition, but in all cases is rather disagreeable. It is not so prevalent among granite cutters as among limestone cutters, due to the difference in the size of the tool and method of cutting in the two occupations. However, in each case cold is considered a complicating factor.

Among the granite workers, men did complain regarding the numbness, especially on cold mornings, and for several hours after beginning work there was a noticeable blanching of the hands. It was particularly interesting to note in the morbidity study that there was no time lost which could be connected with this particular industrial hazard.

Illumination.—The sheds were constructed in such a manner that the natural illumination was excellent. Since the hours of work are from 7 a. m. to 4 p. m., there is little need of artificial lighting, except in the winter.

General sanitation.—Drinking water is generally taken from the city water supply, which is of known excellent quality. Modern drinking fountains, however, are rare.

The majority of the toilets in the sheds are of the trough variety, flushed by a continuous stream of running water. In the summer the toilet room is an attraction for flies and in the winter the extreme cold makes it an uncomfortable place. There is usually an insufficient number of suitable toilets provided in the sheds.

A large amount of dust is allowed to accumulate on the floors and stones about the sheds. Currents of air coming in through the doors and windows, or broken connections in the compressed air lines, therefore, increase the amount of dustiness in the plant.

[5] Leake, J. P.: Health Hazards from the Use of the Air Hammer in Cutting Indiana Limestone. Reprint No. 460 from the Public Health Reports, 1918.

Other hazards.—The safety hazards in the granite sheds are few in number. The cranes and derricks offer some possibility for accident, but the men are warned of an approaching crane by a gong alarm. Flying chips of stone and steel are a hazard of some importance, and injuries to the eye from this cause are rather frequent.

There is a possible hazard from excessive noise created by the surfacing machines and some of the hand-pneumatic tools.

In the polishing rooms the floors are constantly wet, owing to the nature of the process.

CLIMATE

A note as to climate is desirable because of its effect on the worker. The average annual temperature for the past 46 years is 41.4° F.[6] For the months of January and February (the two coldest months in the year) the average temperature was 15.8° for the years 1921–1925. These low temperatures have an effect on the workers, because the sheds are supplied with little heat. On many cold days operations are entirely suspended. Moreover, the long cold winter season makes it necessary for the plants to keep the windows closed for a great part of the year, thus doing away with natural ventilation.

For the years 1921–1925 the average humidity was 80.6, the average rainfall 33.8 inches, and the average percentage of possible sunshine 46.4.

OCCUPATIONAL ANALYSIS

Process of granite cutting.—The more recent methods of granite cutting include the use of saws, which cut slabs of varying thicknesses from large blocks. The granite is received by the cutter in large slabs with two comparatively smooth sides, and less cutting with the surface machine is required before the stone is passed to the finisher. The slab is then cut into the desired shape and the hand pneumatic tool operator finishes it into a monument. The lettering and carving of designs are then accomplished by the carver or sand blaster. Owing to the scarcity of carvers, most of this work is done by sand blasting.

In case a stone is not sawed but received in a rough condition from the quarry, much lumping and processing is necessary before it reaches the finisher. The sawing of granite saves time and waste of stone, and through the elimination of the need to use the surface machine reduces the amount of dust produced.

If a polished monument is desired, the stone passes from the saws to the polishing mill, where the surface is rubbed to a bright polish and the necessity of processing with the surface machine is eliminated.

[6] Records at Northfield, Vt., which closely paralleled the weather conditions at Barre, were kindly furnished by the U. S. Weather Bureau, and are the basis of these averages.

Inasmuch as polishing is accomplished with sand, carborundum, and other abrasives which are kept wet, little dust is created. The slab passes to the finishers, and the cut ends are polished with hand or with a portable polishing mill.

If a column or vase is desired the granite is cut with a lathe machine.

Hand pneumatic tools gradually came into use in Barre late in the eighteen nineties. By 1905 the use of hand pneumatic tools was practically universal.

Occupational distribution of workers.—In Table 1 is given the number of workers in each occupation, based on the records obtained throughout the study in the plants carrying morbidity records. The workers have been divided into two classes, those who remained in the same occupation throughout their industrial life in granite, and those who changed from one occupation to another. Such change might be that from hand pneumatic-tool cutter to foreman, etc. It is seen that only 39 of the entire 972 (or 4 per cent) were put down as changing from one occupation to another. This simplifies the treatment of the material very greatly.[7]

TABLE 1.—*Specific occupations of granite workers in specified occupation throughout period in granite industry*

	Number of workers
Using pneumatic tool (68 per cent):	
Hand pneumatic-tool cutters—	
Carvers and letterers	24
General	509
Apprentice	56
Surface machine operators	68
Tool grinders	26
Cutters and sand blasters	3
Nonpneumatic hand-tool cutter	1
Lumpers	66
Boxers	14
Cranemen	6
Tool carriers and tool boys	6
Bed setters	5
Washers	1
Mechanics	3
Laborers	6
Polishers:	
Plant A	18
Others	25
Sand blasters	4
Lumper and boxers	3
Lumper and derrick men	1
Lumper and carrier	1
Blacksmith and tool grinder	1
Bed setter and polishers	2
Blacksmiths	10
Sawyers	10
Engineers	10
Firemen	2
Machinists	9
Foremen, superintendents	9
Truck drivers	4
Draftsmen	1
Miscellaneous, no dust	6
Polisher and sawyer	1
Derrick men	22
Changed occupation: [1]	
Cutter, then foreman	17
Cutter, then grinder—or vice versa	6
Cutter, then other occupations—or vice versa	10
Surface machine operator, then other occupation—or vice versa	2
Other	4

[1] These were classified according to proportion of time in each occupation in the various dust groups discussed on p. 22, 25 in group A, 6 in B, 6 in C, and 2 in D.

The most important occupational group was that of workers using pneumatic tools in one form or another, which comprised 68 per cent of all workers. It is the occupations in which the pneu-

[7] By a specific examination of these 39 records they were assigned to one of the four dust-count groups (see p. 22), primarily on the basis of the occupation in which the greater part of their time has been spent. This classification was made at the beginning of the analysis of the data, independent of information regarding the physical condition or sickness records of the men concerned.

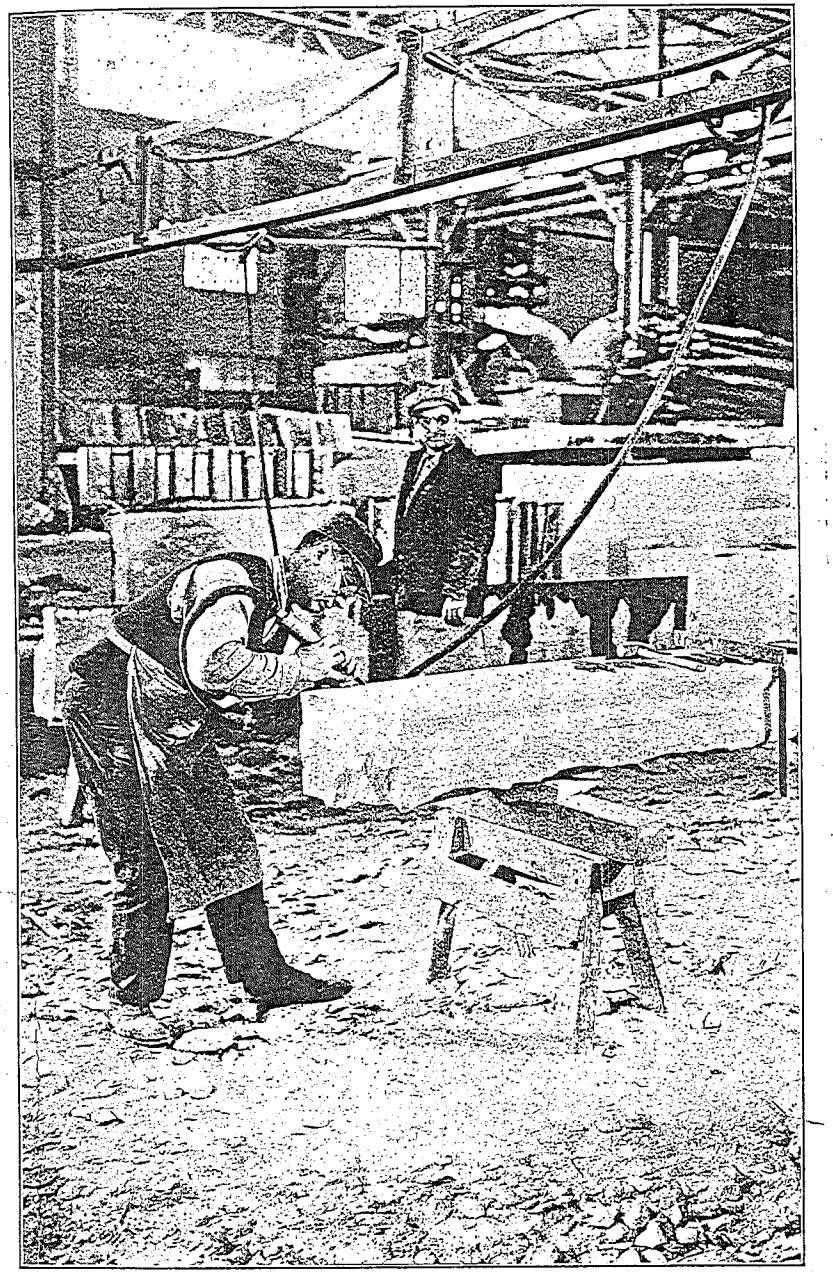


Plate 2.—Hand pneumatic tool worker

No dust is being created because the man is posing—not working—to show the usual position while working and the close proximity of worker's nose to source of dust.

30411°—29——2



Plate 3.—Hand pneumatic tool cutter at work

Note the close proximity of cutter's nose to dust created by this process.

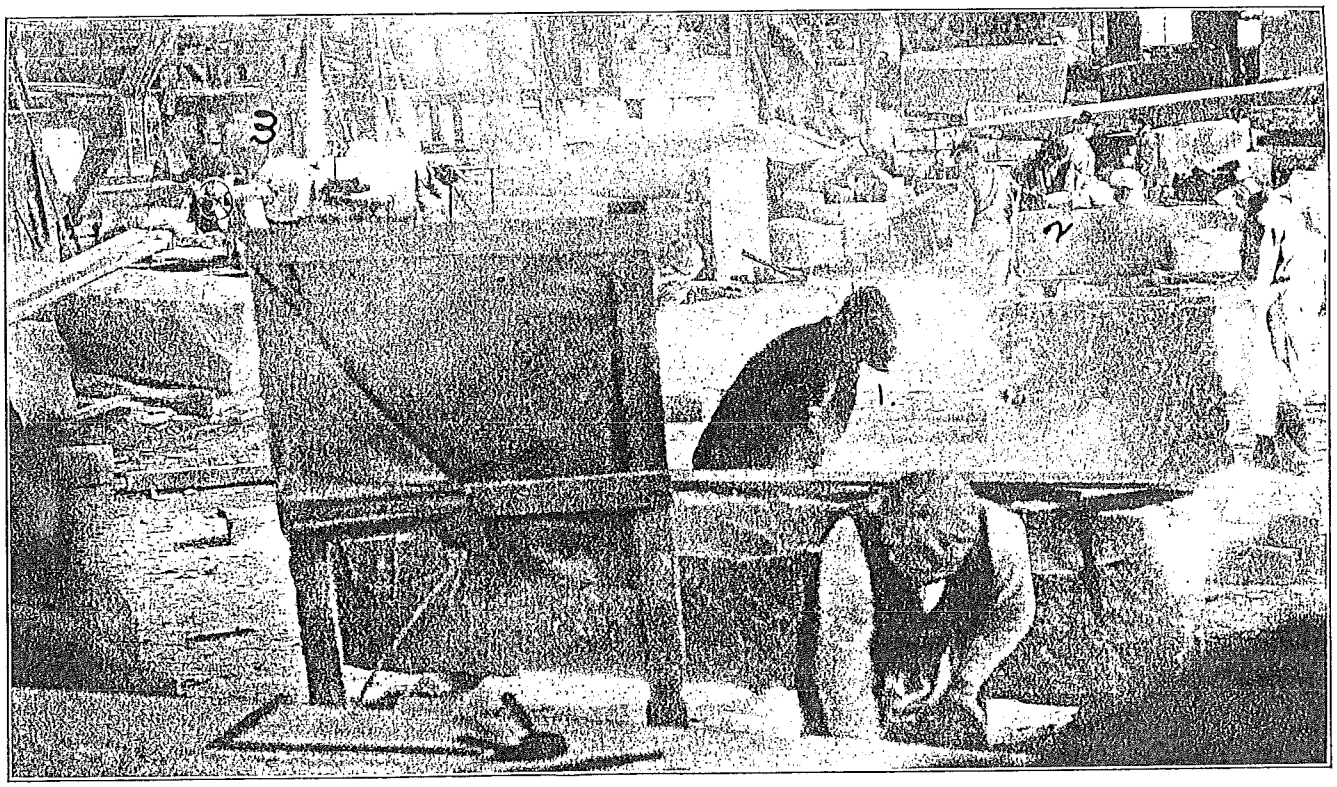


Plate 4.—Group of men cutting granite

Blurred appearance is due to the light shining in a dusty atmosphere.

matic tools are used that create the dust hazard of the industry. (See Plates 2, 3, and 4.) The relatively small number of workers in some of the other occupations may possibly prevent a conclusive statistical analysis. However, the findings of this report relative to atmospheric dustiness show that none of the employees in this industry escapes exposure to a certain amount of dust. This is due to the fact that in most of the plants all the processes are carried on in one shed, no segregation being made between the dusty and nondusty processes.

General description of occupations.—The processes involved in granite stone cutting may be divided roughly into two parts, those occupations dealing with the actual cutting of the stone (incident to which is the production of dust) and the additional labor necessary for the conduct of the former processes. Each worker has been classified according to a specific occupation, but it should be understood that actually these occupations more or less overlap, especially in the smaller plants, where one worker may perform several duties.

First will be discussed the cutting operations. Hand pneumatic-tool workers are those men employing a hand tool driven by compressed air. When the stone first comes into the shed two processes are applied to it—first, the rough edges are lumped off and it is lined up into the desired shape. The men engaged in this occupation are known as lumpers, or, in some instances, liners. In this process the hand pneumatic tool is used to a very small extent. The second process is that of finishing. The workers in finishing a stone use all sorts of pneumatically driven chisels, such as a small 4-pronged pick known as a "diamond point" and various other sizes of chisels. They occasionally employ a bush hammer worked without compressed air, this hammer being composed of several thin steel blades packed side by side. A finisher also does some work with a pointed chisel and ordinary hammer or mallet.

The other occupations involving the use of pneumatic tools are carving and lettering. Carvers employ finely pointed pneumatically actuated chisels for producing ornamental designs and statues, while letterers employ the same means for placing inscriptions on stones.

The next classification in Table 1 takes in surface cutters. The purpose of this operation is to change the stone from a coarse to a fine surface. To do this the cutters use first a large 4-pronged pick hammer and then four grades of bush hammers, which give the stone a rather smooth surface. Except in one plant, all the inside surface-cutting machines were equipped with a suction device for the removal of dust. The outdoor surface-cutting machines are not equipped with devices for dust removal. Plate 5 shows an outdoor surfacer at work. Note the intense dust clouds set up by these workers in cutting stone. During the summer months, when the shed doors

and windows are open, much of the dust generated by the outdoor surfacers is blown into the sheds, thus increasing the amount of dust indoors.

Other occupations coming under the head of granite cutting are sand-blast operators, drillers, and lathe workers. Plate 6 illustrates how a stone pillar is shaped on a lathe. This process creates considerable dust.

The above-mentioned occupations cover all the men listed as granite cutters. These workers spend from five to six hours a day at their respective occupations, the remaining time being consumed in other activities about the shed, during which period they are exposed to the dust suspended in the general shed atmosphere.

There are several other occupations connected with the conduct of granite cutting requiring description. Lumpers, in addition to cutting granite as indicated previously, handle the stone, assist in turning it over for surface cutters and finishers, and occasionally pick up the waste rock known as grout. In certain plants grouter is a specific occupation. These men are exposed to the dust suspended in the shed atmosphere. Stone washers and boxers are those men who are engaged in cleaning and packing stone for shipment. They are exposed to approximately as much dust as the lumpers. Other workers who breathe the general plant atmosphere are cranemen, employed in operating the traveling cranes in the sheds, bed setters, whose duty it is to set the stone for the polishers, and the polishers themselves.[8] Polishers are those workers who apply a fine polish on a stone by hand or machine. This work is done by rubbing a heavy steel disk over the stone, using lead shot and wet carborundum grit as a polishing medium. Plate 7 shows a bed setter placing stones to be polished with the polishing mill.

There are certain additional groups of workers not exposed to the general plant atmosphere. Sawyers are those men operating large vertical or circular saws in cutting large slabs of stone. Tool honers or grinders are employed in some plants, while in others each cutter grinds his own tools. These honers sharpen tools on wet sandstone wheels, and are exposed to a considerable amount of dust of a highly siliceous nature. (See Plate 8.) Several boys are employed to pick up tools scattered all over the shed floor. These boys also deliver the sharpened tools to the various workers. Derrick men operate the boom derricks and work outside. Other occupations connected with the granite-cutting industry are listed in Table 1.

Due to the fact that the various processes are not segregated, all employees are exposed to a certain amount of dust always suspended in the atmosphere. Although this dust is not as concentrated as that

[8] Except in one plant where the polishers were in a separate building and exposed to only slight amounts of dust.

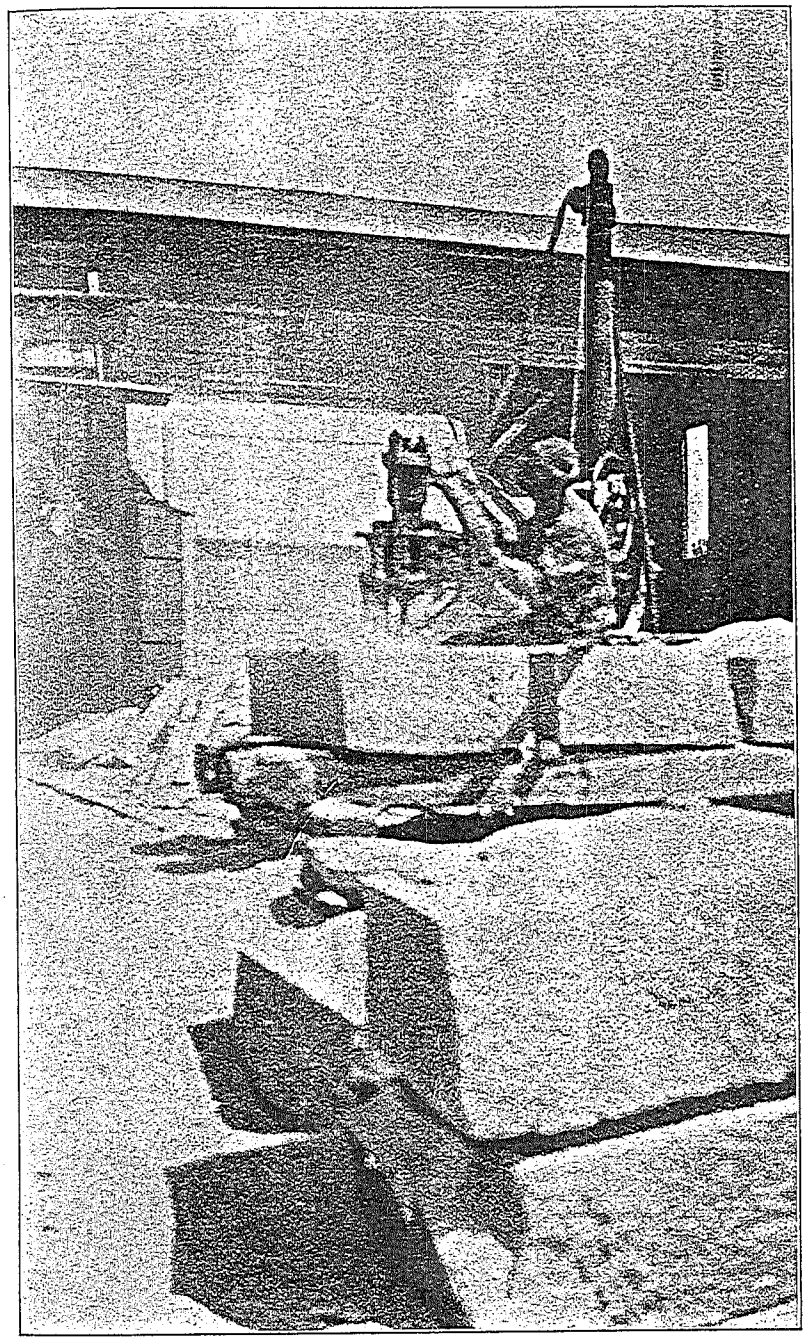


Plate 5.—Dust created by an outdoor surface cutting machine

Machines are not provided with local exhaust devices.

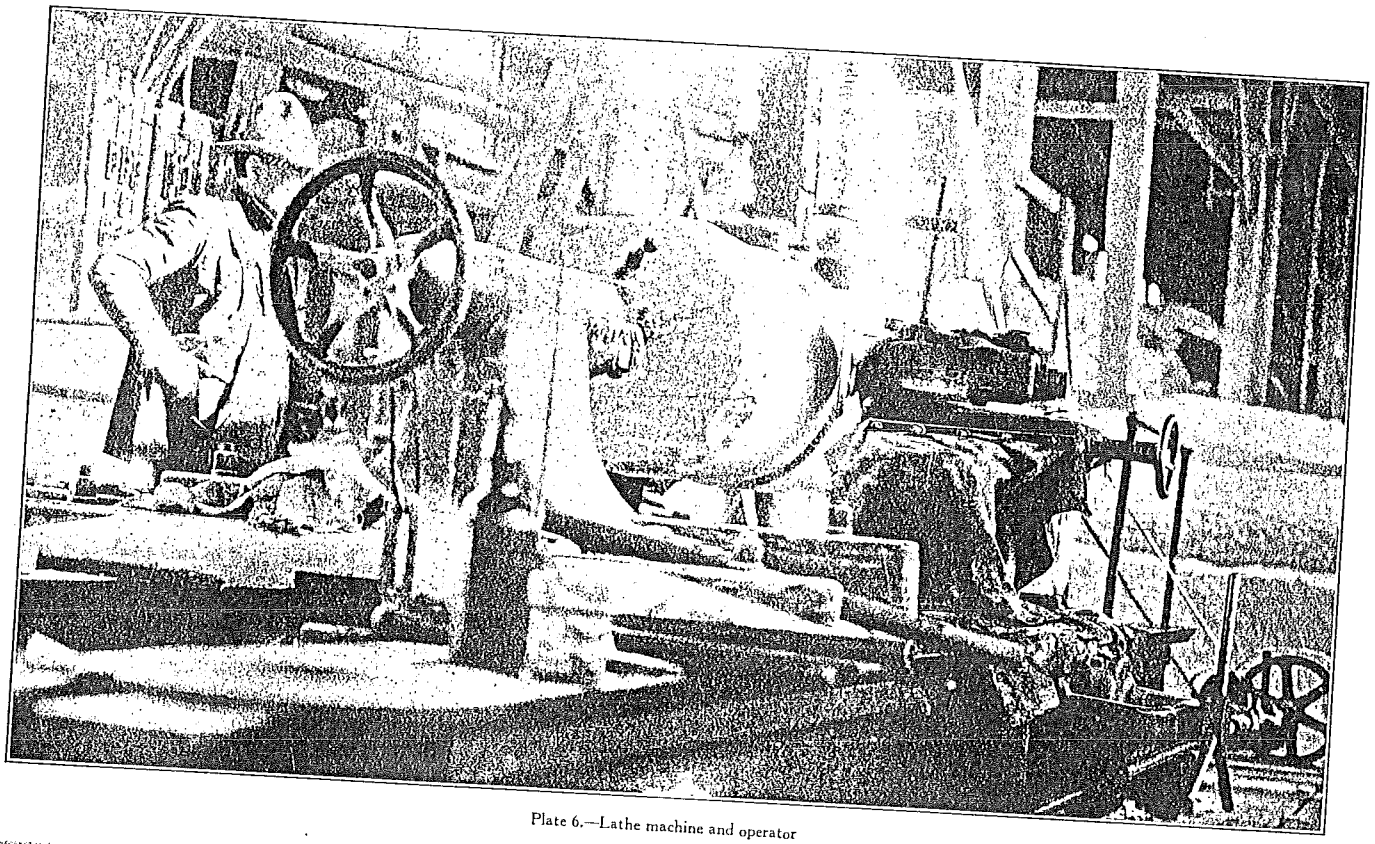


Plate 6.—Lathe machine and operator

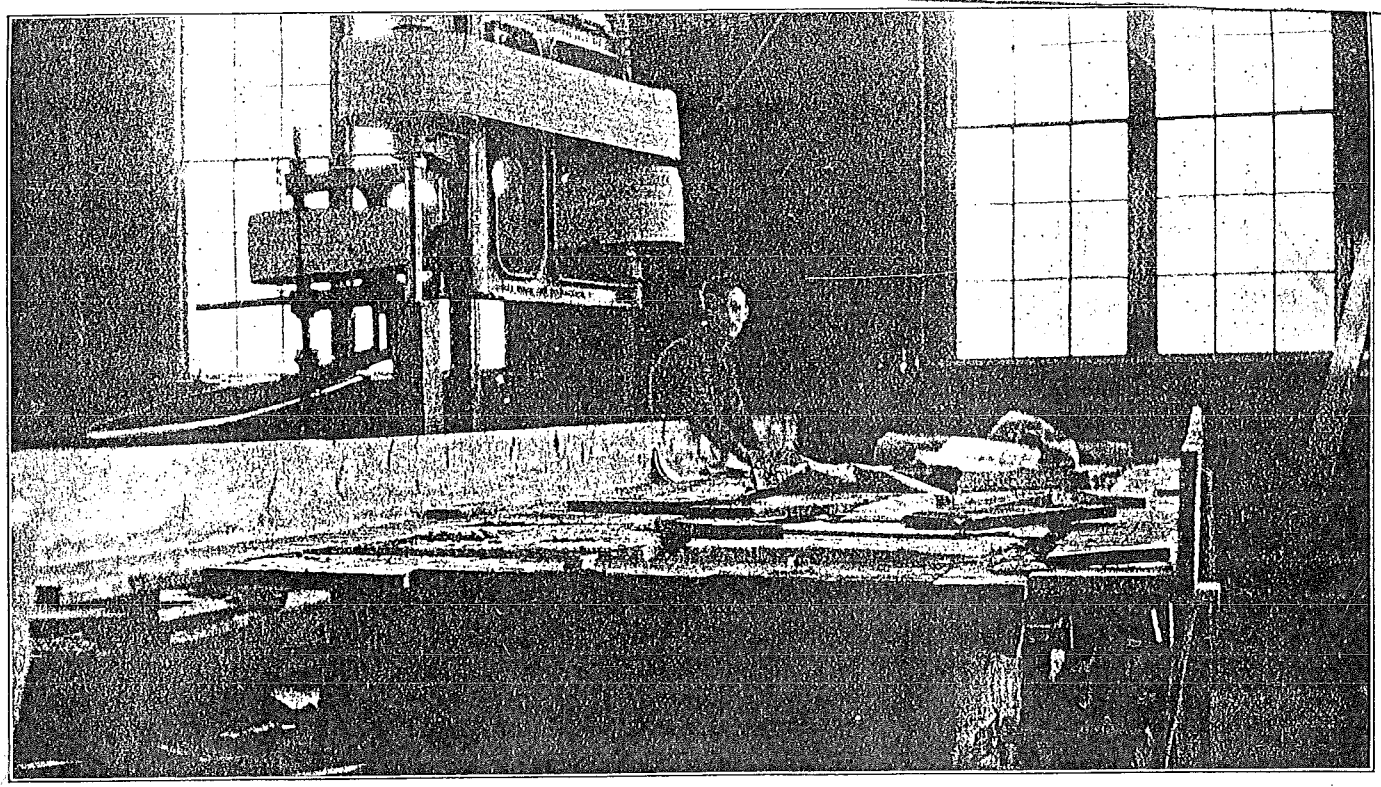


Plate 7.—Polishing mill

Bed setter placing stones to be polished with the polishing mill.

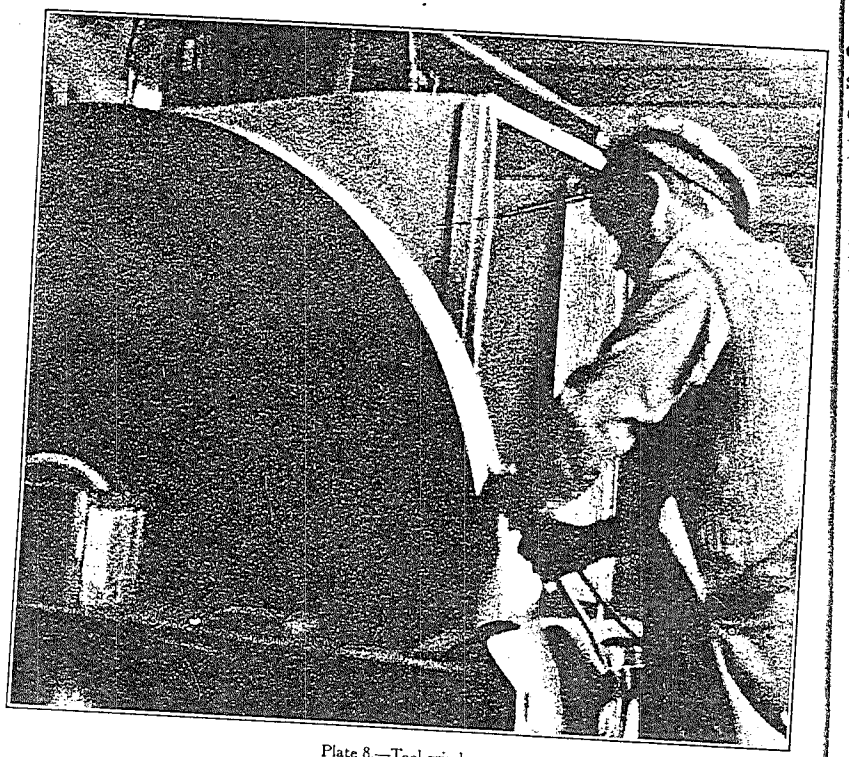


Plate 8.—Tool grinder

Grinding of blades for the bushhammer of the surface cutting machine; a wet process.

close to the men who actually use the pneumatic tools, it is of sufficient quantity, as will be indicated in a later portion of the report (see p. 21), to be considered as a possible health hazard.

Hours and wages.—The working hours in the granite plants were from 7 to 11 a. m. and from 12 to 4 p. m. from March 15 to November 15, when the hours were changed from 7.15 to 11.15 a. m. and from 12.15 to 4.15 p. m. During one half of the year a 5½-day week was observed and during the other half only a 5-day week.

The length of time for which a man must apprentice for the trade of granite cutting is three years. During the time of his apprenticeship he works in the plants along with other granite cutters and his exposure to dust begins with his advent into the industry, being practically the same from the beginning as that of a regular cutter.

The wage of an apprentice granite cutter is:

	Per day		Per day
For the first 6 months	$3.00	For the fourth 6 months	$4.00
For the second 6 months	3.25	For the fifth 6 months	4.50
For the third 6 months	3.50	For the sixth 6 months	5.25

When his apprenticeship is completed the granite cutter receives a minimal wage of $1 an hour, $8 a day. His wage subsequently is in proportion to the skill which he may develop. Carvers and sand blasters are the best paid of all cutters, because more skill is required for their trades; their average wage is about $1.50 an hour, the price paid them depending, however, on the size of the plant and the amount of work that is required of them. Many carvers and statuary cutters contract by the job, and on such a basis they usually make much more.

Foremen and superintendents are usually paid from $40 to $50 a week, though these figures vary according to the size of the plant and the volume of work which they supervise. They are usually selected from among the cutters, because a thorough knowledge of the trades is necessary.

Lumpers, cranemen, derrick men, polishers, bed setters, tool grinders, sawyers, and laborers receive $0.77 an hour, although there are instances in which these workers receive higher wages, depending on their value to their employers.

CHEMICAL AND PETROGRAPHIC ANALYSIS OF DUST

SILICA

The following description of silica has been prepared for this report by Adolph Knopf, professor of physical geology, Yale University, and consultant, United States Public Health Service.

General features.—Silica is the name given to the oxide of silicon (SiO_2). It is the most abundant constituent of the minerals and

rocks that make up the crust of the earth, being present to the extent of 60 per cent.

A distinction is made between free silica and combined silica. Free silica is the term used when the silica occurs in the form of a definite compound having the formula SiO_2. Generally free silica when thus used means quartz, but as a matter of fact there are seven minerals that are composed of free silica. Combined silica is the term given to the silica that occurs in minerals in chemically combined form, being united with certain bases, such as soda (Na_2O), lime (CaO), and a number of others; in short, it is the silica in silicates. This usage of the term "combined silica" is old-fashioned chemistry; according to modern conceptions, it would be more logical to say that so much silicon occurs in a rock, as most of it is present as the constituent of certain acid radicles—SiO_3, SiO_4, and others. According to long-established convention, the chemist reports the silicon present in rocks and minerals as silica; he makes no distinction between free silica and combined silica, even though both be present.

Let us illustrate these principles by means of granite. The average granite is an aggregate made up chiefly of three minerals in the following proportions: Feldspar, 60 per cent; quartz, 30 per cent; and mica, 15 per cent. Chemical analysis shows that this average granite contains 70 per cent of silica. Of this 70 per cent, 30 per cent is present as quartz (free silica) and the other 40 per cent is present as combined silica, being locked up in chemical combination in the other minerals that make up the granite. The feldspar contains 65 per cent of combined silica, and the mica contains 40 per cent of combined silica. From the standpoint of the investigations of silicosis it appears that only the quartz content is significant.

Occurrence of free silica in nature.—There are 10 forms in which free silica occurs. These various silica minerals have accurately defined properties and constitute the most remarkable example of polymorphism known. Four of these minerals are regarded as the principal modifications—quartz, tridymite, cristobalite, and silica glass. To these may be added hydrated silica called opal (SiO_2+H_2O), which consists of silica and a variable amount of water.

Quartz.—By far the most common form of free silica is quartz, which exists in two polymorphous forms—low quartz, so called because it is the modification of silica that is stable below 573° C. and high quartz, which is stable between 573° and 870°.

Quartz is an extremely hard mineral of glassy or vitreous appearance, is without cleavage, and has a conchoidal fracture, yielding fragments that have sharp edges and points. Chemically it is extremely resistant to reagents. It would be about the last thing that the mineralogist would suspect of being dangerous because of chemical reactivity in the lung tissues.

Quartz is an abundant constituent of granite, mica, schist, and other rocks, and is the chief component of sandstone and quartzite. It is also an abundant constituent of many ores, and as their name implies, quartz veins, such as the gold-bearing quartz veins, consist almost wholly of quartz.

At 573° C. low quartz transforms into high quartz. It is the modification of silica that is stable between 573° and 870°. When the temperature falls below 573° the high quartz spontaneously changes to low quartz. It is therefore of no practical importance under ordinary conditions.

Tridymite.—Tridymite is another form of silica whose crystallographic and optical properties differ markedly from those of quartz. It is not particularly abundant in nature.

Silica bricks ("Dinas bricks") that are used as refractory linings in steel furnaces and other metallurgical operations are commonly altered to tridymite and cristobalite.

Cristobalite.—Cristobalite is another modification of silica; it is isometric in crystallization. In nature it occurs in much the same way as tridymite.

As an artificial mineral it is one of the chief constituents of silica bricks, which are made by finely grinding quartz, molding the product into bricks and "burning" at 1,450° C.

Opal.—Opal (SiO_2+H_2O) is an amorphous hydrated variety of silica, containing from 1 to 12 per cent of water; and it is a hardened silica jelly of colloidal origin.

As a rock-forming constituent it occurs abundantly in diatomite, or diatomaceous earth. This substance is composed of the minute skeletons of siliceous aquatic plants of marine or fresh-water habitat. It is also known as kieselguhr and infusional earth, but these terms are obsolescent. Other forms of zoogenic opal are sponge spicules and radiolarian tests and in places these are abundant enough to make rock formations. In formations of considerable geological antiquity the opal has gone over into chalcedony and the resultant rocks are known as cherts.

Opal is soluble in a hot solution of KOH; some, indeed, is soluble at ordinary temperature in a saturated solution of Na_2CO_3. For example, diatom tests dissolve readily, whereas sponge spicules remain unattacked. This ease of attack of opal contrasts notably with the inertness of quartz.

Chalcedony.—Chalcedony is a waxy translucent form of silica composed of microscopically minute fibers of silica. It contains a variable but small amount of water. It is interpreted as consisting of fibers of quartz with a small amount of interstitial opal. Chalcedony

is much more strongly attacked by a solution of KOH than is quartz of the same grain size.

It occurs in nature most abundantly as flint and as the cement of fine-grained siliceous rocks, such as cherts. It confers the property of toughness on the material in which it occurs, and on account of its minutely fibrous nature is more readily transformed by burning into the high temperature forms. These properties determine its principal industrial uses. One of the chief uses is in the form of Danish flints, which are waterworn flint pebbles. They are widely used as pebbles in ball mills for grinding ores.

Vitreous silica.—Vitreous silica, or silica glass, is formed by melting quartz. It is also known as quartz glass and fused silica, and is now a regular commercial product. In nature, however, it is only a mineralogical curiosity, occurring in fulgurites—hollow tubes of fused silica formed by lightning striking a bank of sand—where it is known as lechateherite.

Industrial uses of silica.—Silica is used commercially (other than in its ordinary uses of sand, gravel, and structural sandstone) in the following forms:

1. Massive crystalline quartz (obtained from veins or pegmatites).
2. Quartzite.
3. Sandstone.
4. Flint, or chert (massive or as rounded pebbles).
5. Tripoli.
6. Diatomaceous earth.
7. Silica sand.

These forms of silica are used in various ways:

1. In massive form, roughly broken to size. *Example:* Massive quartz for packing acid towers.

2. In massive form cut to dimension. *Example:* Grindstone and diatomite rock.

3. In original state as pebbles. *Example:* Flint pebbles for grinding.

4. In original state as grains. *Example:* Glass sand and filter sand.

5. Crushed to coarsely granular form. *Example:* Quartz grains for sandpaper.

6. Ground to fine powder. *Example:* Ground flint for pottery manufacture and ground diatomite for polishing powder.

According to Ladoo, ground silica appears on the market under the names of silex, flint, and silica, regardless of the original form of the material, as well as under the true mineralogical names.

The following table from Ladoo illustrates the great variety of uses of silica in industry and the kinds of silica adapted to each purpose:

Uses of silica	Types of silica used
Abrasive uses:	
In scouring and polishing soaps and powders	Quartz, quartzite, flint, chert, sandstone, sand, tripoli, and diatomaceous earth; all in finely ground state.
In sandpaper	Quartz, quartzite, flint, sandstone, and sand; coarsely ground and closely sized.
In sand-blast work	Quartz, quartzite, sandstone, and sand, crushed into sharp angular grains uniform in size.
Metal buffing, burnishing, and polishing	Ground tripoli and other forms of ground silica.
For sawing and polishing marble, granite, etc.	Sharp, clean sand graded into various sizes.
As whetstones, grindstones, buhrstones, pulpstones, oilstones, etc.	Massive sandstone from very fine to moderately coarse grained.
Tube-mill lining	Chert, flint, and quartzite in dense, solid blocks.
Lithographers' graining sand	Medium to fine sand or rather coarsely ground silica and tripoli.
Tube-mill grinding pebbles	Rounded flint pebbles.
In tooth powders and pastes	Various forms of pure silica finely ground.
Wood polishing and finishing	All forms of silica ground to medium fineness.
Refractory uses: In making silica fire brick and other refractories.	Fairly pure quartzite known as gannister; not less than 97 per cent SiO_2 nor more than 0.40 per cent alkalies, tightly interlocking grains desired.
Metallurgical uses:	
In making silicon, ferrosilicon, and silicon alloys of other metals, such as copper.	Moderately pure sand, massive crystalline quartz, sandstone, quartzite, or chert.
As a flux in smelting basic ores	Massive quartz and quartzite.
Foundry-mold wash	Ground sandstone, quartz, and tripoli.
Foundry parting sand	Fine sand and ground tripoli.
Chemical industries:	
As a lining for acid towers	Massive quartz or quartzite.
As a filtering medium	Massive diatomaceous earth and tripoli, sand, finely granular quartz or quartzite, finely ground tripoli, diatomaceous earth, and other forms of silica.
In the manufacture of sodium silicate	Pure pulverized quartz sand, pure tripoli, and diatomaceous earth.
In the manufacture of carborundum	Pure quartz sand.
Paint: As an inert extender	Finely ground crystalline quartz, quartzite, and flint; also finely ground sandstone, sand, and tripoli.
Mineral fillers: As a wood filler	Finely ground crystalline quartz, quartzite, flint, tripoli, and other types of ground silica.
In fertilizers	
In insecticides	
As a filler in rubber, hard rubber pressed and molded goods, phonograph records, etc.	Finely ground silica of all types.
In road asphalt surfacing mixtures	
Ceramic uses: In the pottery industry as an ingredient of bodies and glazes.	Flint, tripoli, and chert, and other amorphous silica preferred; also all other forms of very pure silica, all finely ground.
In the manufacture of ordinary glass	Pure quartz sand.
In the manufacture of fused-quartz chemical apparatus, such as tubes, crucibles, and dishes.	Very pure massive quartz preferred.
Decorative materials: In the manufacture of gems, crystal balls, table tops, vases, statues, etc.	Rock crystal, amethyst, rose quartz, citrine quartz, smoky quartz, chrysoprase, agate, chalcedony, opal, onyx, sardonyx, jasper, etc.
Insulation:	
Heat insulation for pipes, boilers, furnaces, kilns, etc.	Massive and ground diatomaceous earth.
Sound insulation in walls, between floors, etc.	Do.
Structural materials: Sand-lime brick	Moderately pure, sharp, angular sand, preferably finer than 20-mesh, together with a small percentage of finely pulverized silica.
Optical quartz: For the manufacture of lenses and accessories for optical apparatus.	Clear, colorless, flawless rock crystal or massive crystallized quartz.

BIBLIOGRAPHY

Sosman, R. B.: The properties of silica. American Chemical Monograph Series, 865 p., 1927.

Rogers, A. F.: Natural history of the silica minerals. American Mineralogist, vol. 13, pp. 73–92, 1928.

Rosenbusch Mikroskopiche Physiographie der Mineralien und Gesteine, Band I, Zweite Halfte, by O. Mugge, 1925.

Ladoo, R. B.: Nonmetallic minerals; occurrence, preparation, utilization. McGraw-Hill Book Co., New York, 1925. (This work is particularly valuable on the industrial uses of silica.)

BARRE GRANITE

Barre granite [9] is known commercially as "dark Barre," "medium Barre," and "light Barre." It appears to be everywhere a biotite granite in which the orthoclase is considerably kaolinized and micacized, but the microcline is fresh.

Its texture ranges from fine to medium; that is, with feldspars up to 0.2 and 0.4 inch, generally, however, not exceeding 0.2 inch. Its mica particles range up to 0.1 and 0.2 inch, but in the very dark to 0.3 inch.

Its constituents, in descending order of abundance, are (*a*) clear colorless or bluish to translucent and milk-white potash feldspar; (*b*) light smoky quartz, showing optical effects of strain, rarely with rutile needles, generally with fluidal and other cavities in sheets, and with rift cracks parallel to or coinciding with them, and in some sections with another set, of fewer and shorter sheets of such cavities, at right angles to the other and with grain cracks parallel to them; (*c*) translucent to milk-white soda-lime feldspar; (*d*) biotite (black mica), some of it chloritized; (*e*) a little muscovite or bleached biotite. The accessory minerals are pyrite, magnetite, titanite, allanite, apatite, zircon, rutile. The secondary are calcite, abundant within the orthoclase, one or two white micas, epidote, and chlorite.

Finlay's analysis [10] of the darker granite is as follows:

	Per cent		Per cent
Silica	69.89	Potash	4.29
Alumnia	15.08	Water uncombined (110°)	.31
Iron sesquioxide	1.04	Water combined (ignition)	.23
Iron oxide	1.46	Phosphorus pentoxide	Trace
Magnesia	.66		99.76
Lime	2.07		
Soda	4.73		

Silica, which formed 70 per cent of the total constituents in this examination, is the total of free and combined silica. An estimate of the mineral percentages made by the Rosiwal method by the United States Geological Survey [11] on a piece of "dark Barre" granite yielded these results:

	Per cent
Feldspar	65.522
Quartz (free silica)	26.578
Mica	7.900
	100.000

[9] The following paragraphs are taken, with some omissions, from The Granites of Vermont, by T. Nelson Dale. Bulletin 404 of the U. S. Geological Survey.

[10] The Granite Area of Barre, Vt., by George I. Finlay, Report Vermont State Geologist, No. 3, 1902.

[11] Bulletin 404 (op. cit), p. 51.

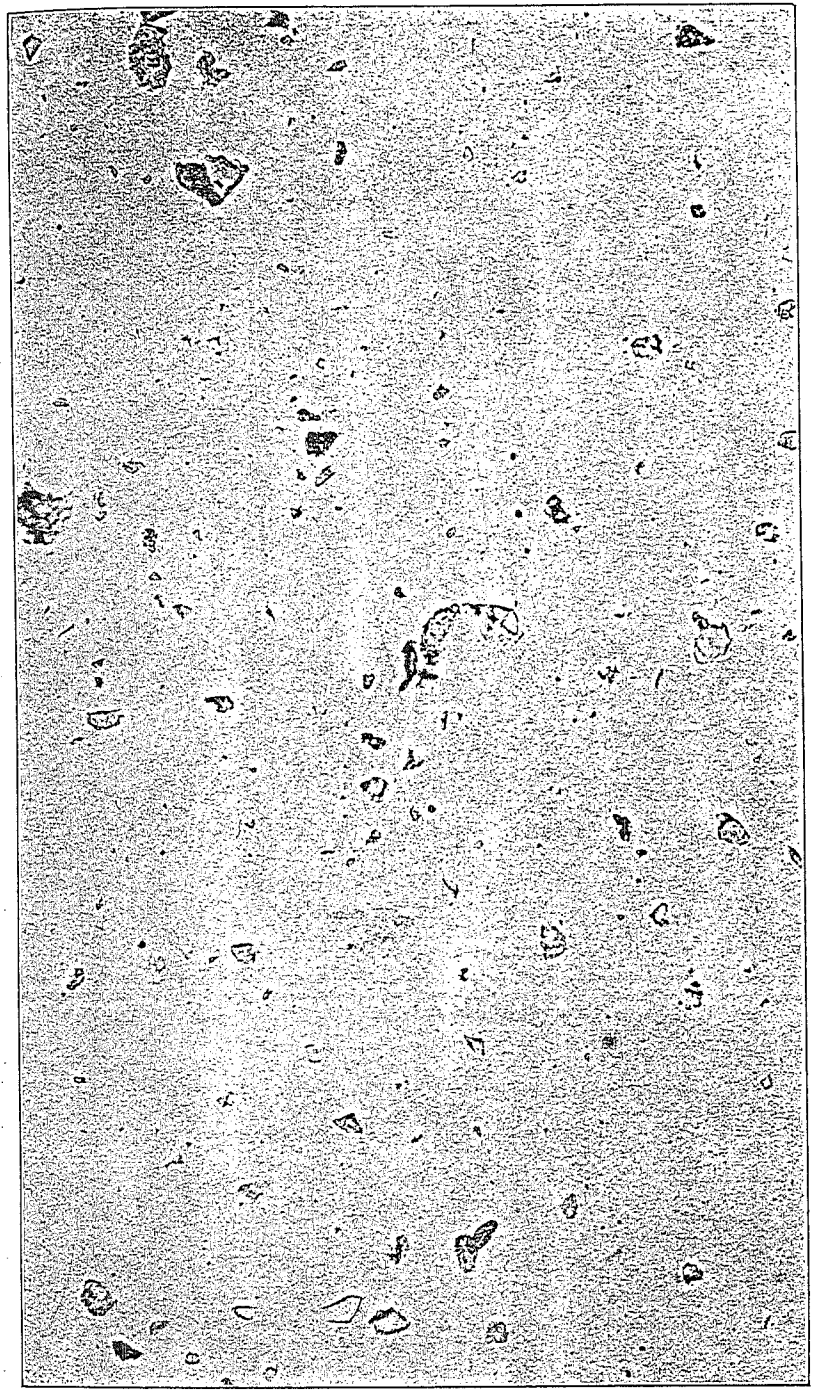


Plate 9.—Microphotograph of dust extracted from dust catcher in a granite cutting plant, first sample

Magnification of 180 diameters.



Plate 10.—Microphotograph of dust extracted from dust catcher in a granite cutting plant, second sample
Magnification of 180 diameters.

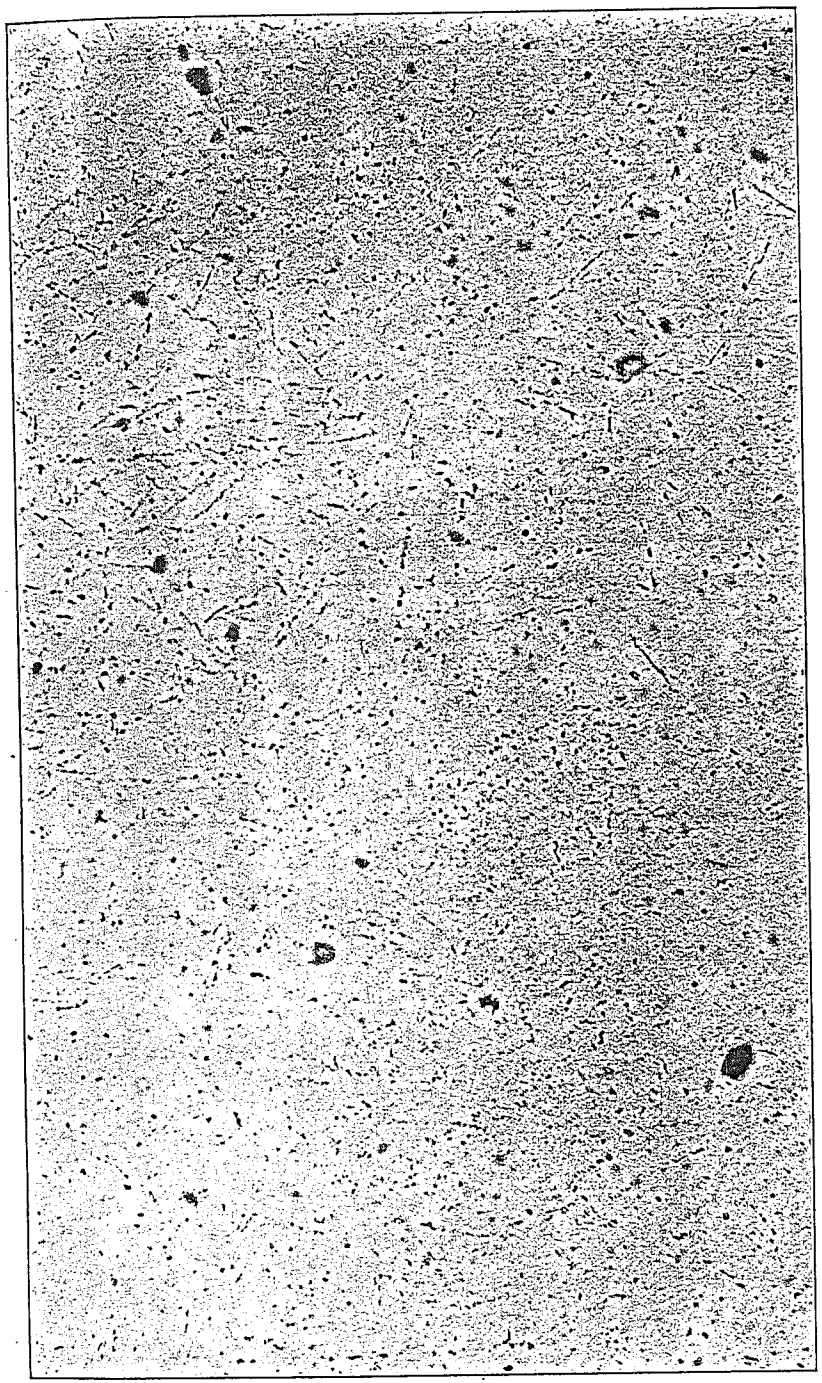


Plate 11.—Microphotograph of granite dust found settled on stones in a granite cutting shed, first sample
Magnification of 180 diameters.

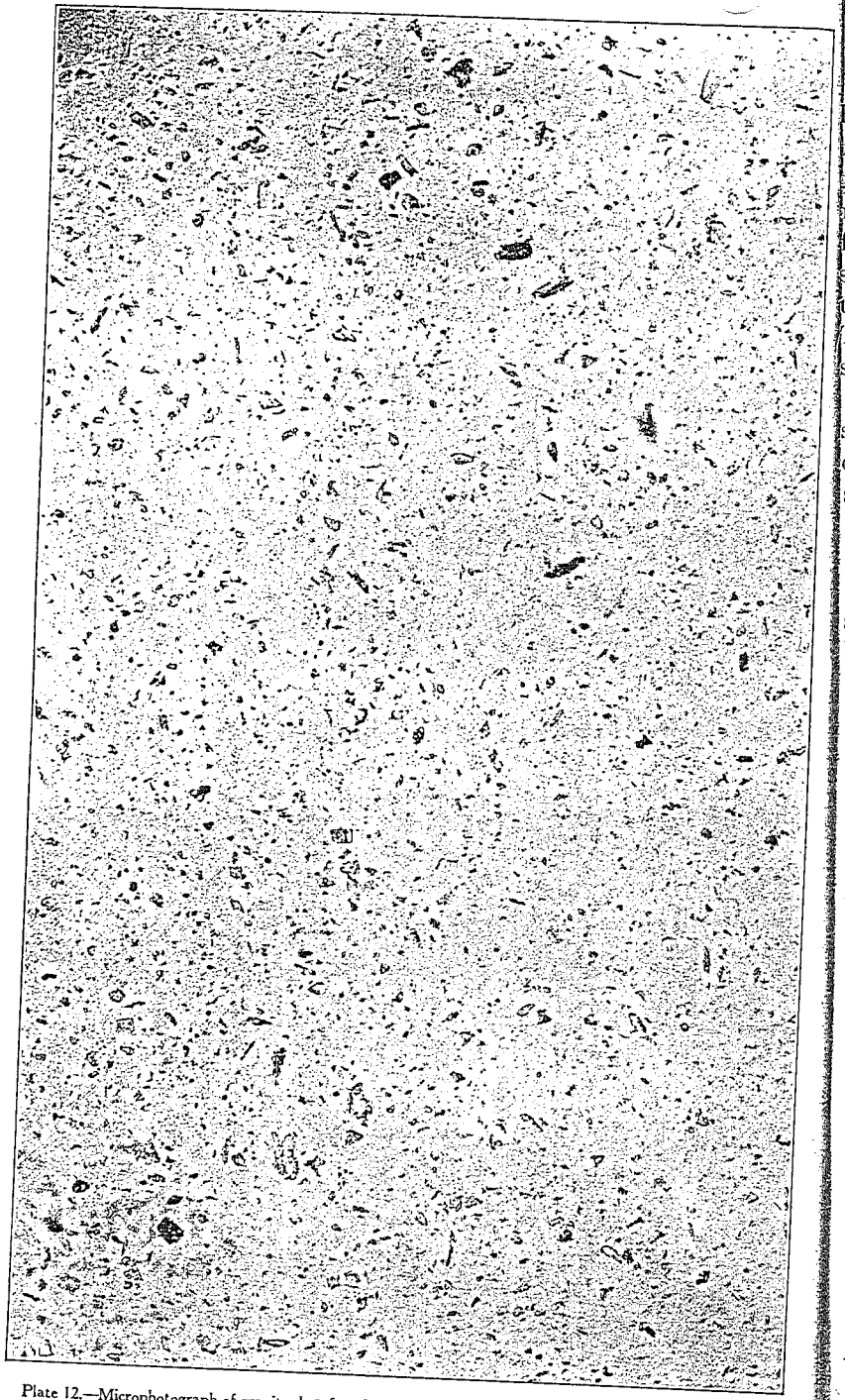


Plate 12.—Microphotograph of granite dust found settled on stones in a granite cutting shed, second sample
Magnification of 180 diameters.

While the above analyses are given as representative of "dark Barre" granite by the United States Geological Survey, in connection with the research it was necessary to collect samples for petrographic analysis of dust which was actually generated in the sheds and to which the men were exposed. One sample was obtained from dust accumulated in a dust catcher connected to the exhaust system used for removing dust from the surfacing machines, while the second sample was taken from dust accumulated on top of stones. This dust, largely generated by the hand pneumatic cutters, had settled on the stones by gravity.

The first sample showed 31.8 per cent free silica and the second sample 38.6 per cent free silica, yielding an average free silica content of 35.2 per cent. Other silicate minerals noted in these samples were biotite (abundant), muscovite (common), chlorite (rare), microlene (abundant), orthoclase (abundant), and zircon (very rare).

In view of the use of steel instruments in cutting the granite, the samples were also analyzed for steel fragments which might have been worn away from the tools. Such an examination disclosed small amounts of steel fragments, about 0.1 per cent of the samples.

The petrographic analyses were carried out by G. A. Cooper, of the department of geological sciences of Yale University.

As a matter of comparison, the results of the chemical and petrographic analysis in each of the dust studies is given in Table 2.

TABLE 2.—*Chemical and petrographic analysis of the dust in each study*

	Total silica	Quartz (free silica)
	Per cent	*Per cent*
Granite: Average	70.0	35.2
Silver polishing:		
Hollow-handle-making room	22.2	1.7
Wet pumice (2 samples averaged)	70.5	Less than 0.5
Brass foundry	73.3	19.0
Cement:		
Pack house	21.2	Less than 1.0
Crusher house, raw mill, stone house	16.8	6.5
Soft coal:		
Coal dust	(?)	1.2
Rock dust	High.	54.0
Hard coal:		
Coal dust	(?)	1.5
Rock dust	High.	31.0

On the following pages are microphotographs (Plates 9–12) of the dust examined petrographically. Plates 9 and 10 show the coarser-grained granite dust generated during the surface-cutting process, and Plates 11 and 12 show the finer-grain dust present in the air of the granite sheds.

Granite workers have frequently held the opinion that the steel particles rather than the dust itself was the cause of silicosis. Gard-

ner,[12] referring to this point, says: "The granite cutters complai that their 'trouble' is due to the steel chips from the chisels and sta that if a magnet be drawn through the dust from the floors, a larg amount of steel can be collected. On attempting this experimen some small, and a few large particles were found, but in no grea amount. Microchemical tests on the lungs of animals inhaling th dust have failed to show the presence of any iron."

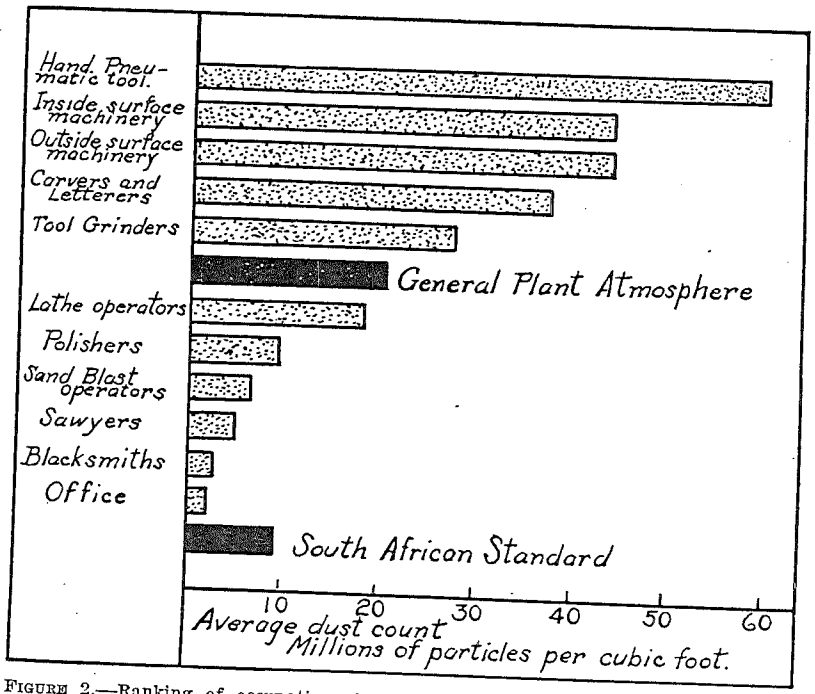


FIGURE 2.—Ranking of occupations in granite industry according to quantity of dust exposure

SURVEY OF EXTENT OF PLANT DUSTINESS

Nature of analysis.—In studying the extent of atmospheric pollution of the granite-cutting plants, the same technical procedure has been used as previously described in Public Health Bulletin No. 176. In all, 220 dust determinations were made—100 during the summer and 120 during the winter. The samples in the summer represent the air pollution in the sheds under conditions of maximum efficiency of the combined natural and artificial ventilation in use at the time. The winter samples represent the air pollution when methods of artificial ventilation alone were in use. By combining the summer and winter samples, an index of average atmospheric pollution was obtained.

[12] Gardner, L. U.: Studies on the Relation of Mineral Dusts to Tuberculosis. American Review of Tuberculosis, December, 1920.

The analyses include a microscopic count of particles above and below 10 microns in diameter, the weight of these particles, and the amount of organic and inorganic matter present in the air. The tables and charts that follow summarize the results of the 220 dust determinations. For convenience, the average readings are given in millions for total particles of dust per cubic foot of air, since the difference between total particles and particles under 10 microns was very slight and was not significant in the dust found in the granite sheds.

Due to the fact that in each plant practically the same industrial procedure is followed in cutting granite, it was not deemed necessary to obtain dust determinations of all the processes in each of the plants, but enough samples were taken to give an average condition.

General results.—Table 3 presents an analysis of the dust content of the air associated with various occupations irrespective of the plant. The occupations are listed in descending order of the average dust counts. The minimum and maximum dust counts are also given, as well as the number of men employed in each occupation and the number of samples analyzed. Figure 2 presents graphically the dust content of the air associated with various occupations. In all cases the data are given in the form of total particles rather than particles under 10 microns.

TABLE 3.—*Number of millions of dust particles per cubic foot of air, arranged in order of the dustiness of certain occupations*

	Number of men exposed	Number of observations	Minimum dust count	Maximum dust count	Average dust count
Total and average	972	215			37.2
All pneumatic hand-tool operators	565	56	2.4	201.0	59.2
Surface cutters, inside	58	34	.6	165.7	44.0
Surface cutters, outside	10	10	14.0	102.2	43.9
Carvers and letterers	24	20	11.7	99.8	37.0
Tool grinders	20	14	6.3	62.0	27.1
General plant atmosphere	121	42	2.5	64.0	20.2
Lathe operators	4	4	6.0	25.7	17.9
Polishers (all)	43	16	1.3	26.8	9.0
Sandblast operators	4	6	1.9	13.4	6.2
Sawyers	10	4	4.0	4.9	4.6
Blacksmiths	10	5	.9	8.2	2.5
Office employees	10	4	1.5	2.4	1.9
In occupations where no specific count made [1]	93				

[1] Includes workers who changed occupations during employment in granite.

The workers exposed to the general atmosphere of the plants offer a variety of occupations. This group consists of foremen, tool boys, lumpers, boxers, cranemen, bed setters, carpenters, and mechanics. The group labeled as blacksmiths also includes engineers and machinists. Draftsmen as well as clerks are considered as office employees.

was a division of the occupations on the basis of the dust count. This classification was made independently of any findings as to sickness rates or physical examinations. Four groups were used: Group A, hand pneumatic-tool cutters; Group B, surface machine operators and others exposed to more than the average dustiness of the plants; Group C, occupations in which the workers were exposed to the average dustiness of the plant (lumpers, bed setters, etc.); Group D, occupations in which the workers were exposed to less than the average dustiness of the plants. To assist the reader in keeping these groups distinct, they may be summarized as follows:

Group A: Hand pneumatic-tool cutters (614 persons).

Group B: Other occupations with more than average dustiness (104 persons).

Group C: Occupations with average dustiness (146 persons).

Group D: Occupations with less than average dustiness (108 persons).

First. Group A (hand pneumatic-tool cutters): These are kept in a separate group because of the large number of them, all under approximately the same dust exposure. Variation in dustiness from plant to plant[13] was found to be quite small in the case of this occupational group. Carvers and letterers (although generally showing a somewhat lower dust count) have been included, so as to have all hand pneumatic-tool operators in one group. Carvers and letterers by themselves would make too small a group for analysis.

Second. Group B: All other occupations showing more than the average dust content of the sheds. This group is made up primarily of surface machine operators and tool grinders and others found to have more dust exposure than the average shed atmosphere.

Third. Group C: With average general plant dustiness, made up of lumpers, bed setters, cranemen, boxers, carpenters, and mechanics.

Fourth. Group D: With less than average plant dustiness, made up of polishers (plant A), sand-blast operators, sawyers, blacksmiths, office employees, etc. The occupations in each group, the number of men, and the dust counts are shown in the following table:

[13] The excess in Shed I is noteworthy (see p. 25).

TABLE 4.—*Classification of occupations into dust-count groups*

Group	Occupation	Number of men	Dust count (million particles per cubic foot)
	More than average plant dustiness		
A	Hand pneumatic-tool operators	565	59.2
A	Carvers, letterers	24	37.0
A	Part of employment in other occupations	25	
B	Surface machine operators	68	44.0
B	Tool grinders	20	27.1
B	Others	16	
	Average plant dustiness		
C	Lumpers	146	20.2
C	Boxers		
C	Polishers (all but plant A)		
C	Cranemen		
C	Bed setters		
C	Tool carriers		
C	Mechanics		
C	Laborers		
	Less than average plant dustiness		
D	Polishers (plant A)	18	9.0
D	Sand blast operators	4	6.2
D	Sawyers	10	4.6
D	Blacksmiths	10	2.5
D	Others [1] (no specific dust count, but low)	66	

[1] Derrickmen (22), engineers (10), machinists (9), etc.

South African standard.—In presentation of the dustiness the number of particles in a cubic foot of air has been used. At this time no attempt is made to compare the dustiness of any occupation against a standard of dustiness for the granite industry, below which we might consider the condition satisfactory. The last bar of Figure 2, however, gives the standard of dustiness adopted by the South African workers for use in the Rand mines. This standard was arrived at after a consideration, first, of the use of the weight of different samples as a standard of dustiness, in which it was shown that this method of the determination of dustiness might give a misleading interpretation of the relative danger of the air sample due to the fact that a dust containing many small particles would naturally weigh less than a dust containing a small number of large ones. Yet the former might easily be considered the more dangerous, since the majority of particles found in the lungs are under 5 microns in size. Before arriving at the standard, these workers have attempted to relate their limits to the actual number of particles found in the lungs after death in proportion to the length of exposure to the dust.

Supplementing this statement, the following quotation may be made from the report of the South African workers:

> A standard based on the number of particles can, at this stage, be based only on what is readily attainable in practice. Our results have shown that to reduce the dust, as determined by the Kotze konimeter, breathed by persons below 300

particles is not difficult in any operation. Anything above this is to be classed as unsatisfactory. Between 200 and 300 may be considered as fair, between 100 and 200 as good, and below 100 as very good.[14]

Figure 2 discloses the fact that the only workers not exposed to a dust count higher than the South African standard are the sand-blast operators, sawyers, blacksmiths, and office employees, and a few other employees with no specific, but low, dust count. Table 4 shows that this group contains only a small proportion of the men employed in the granite-cutting industry in the plants studied. Those occupations creating dust exceeding the above-mentioned standard of 30 particles per c. c. (8.5 millions of particles per cubic foot) are mostly the ones making use of the pneumatic tools.

Wet grinding of tools.—The only occupation not making use of the pneumatic tool that creates a comparable amount of dust is that of wet grinding of tools. It is of interest to note in connection with wet grinding that the results obtained in this study corroborate the findings of Winslow and Greenburg [15] in their study of the dust hazard in the wet and dry grinding shops of an ax factory. These investigators have proven that protection afforded by wet grinding, as compared with dry grinding using an exhaust, is, in most instances, illusory. Their study also emphasizes the fact that the efficiency of a process of this sort must be checked by laboratory tests in order to determine its real effectiveness.

Of the 14 determinations of atmospheric dust created by the wet grinding of tools, the minimum dust content was 6.3 millions of particles per cubic foot, the maximum figure 62 millions of particles per cubic foot, with an average of 27.1 millions of particles per cubic foot. This figure is indeed enormous when one takes into consideration the fact that the grinding stones are composed of sandstone, a substance containing a high percentage of free silica, and hence of a much more injurious nature than granite dust.

Variability in readings.—Table 5 brings out the enormous variation that exists from time to time in the dust content of the air associated with the granite-cutting industry.

[14] Final Report of Miners' Phthisis Prevention Committee, Union of South Africa, 1919, p. 17.

[15] Winslow, C.-E. A., and Greenburg, Leonard: A Study of the Dust Hazard in the Wet and Dry Grinding Shops of an Ax Factory. Public Health Reports, Oct. 8, 1920.

TABLE 5.—*Distribution of dust counts, classified by occupations, granite-cutting industry*

Number of millions of dust particles per cubic foot of air	All hand pneumatic-tool workers	Surface cutters		Carvers and letterers	Tool grinders	Lathe operators	Polishers	Sand blast operators	Sawyers	Blacksmiths	Office employees	General plant atmosphere
		Inside	Outside									
Under 2		1					1	1		4	2	
2 to 3.9	1	1					2	1			2	1
4 to 5.9	3						3	2	4			6
6 to 7.9					2	1	3					2
8 to 9.9					2		1			1		4
Under 10	4	2			4	1	10	4	4	5	4	13
10 to 19.9	6	2	2	4	3	1	1	2				12
20 to 29.9	6	6	1	4	1	2	3					9
30 to 39.9	3	7	3	8	2							4
40 to 49.9	7	4	1	1	2							1
50 to 59.9	4	7	1	1	1							
60 to 69.9	6	4		2	1							3
70 to 79.9	6											
80 to 89.9	3		1									
90 to 99.9	3	1										
100 to 109.9	2		1									
110 to 119.9	1											
120 to 129.9	2											
130 to 139.9												
140 to 149.9	1											
150 to 159.9												
160 to 169.9	1	1										
170 to 179.9												
180 to 189.9												
190 to 199.9												
200 to 209.9	1											
Any number of particles	56	34	10	20	14	4	[1] 14	[2] 6	4	5	4	42

[1] Exclusive of 2 readings in plant A.
[2] Exclusive of following readings of general air in sand blast: 270.4, 155.2, 114.8, 98.4; average, 160.

This variation is especially evident in those processes where pneumatic tools are in use. Part of the variation is due to the wetting of the stone while cutting, since some workers do this and others do not.[16] Part is due to the variation in different plants. As a matter of reference, an additional table is given showing the average dustiness by dust-count groups in each of the large plants. It will be found that in general the averages are about the same in each dust-count group, whatever the plant.

TABLE 6.—*Average of readings in each plant, by dust-count group*

Group	Shed									
	N	K	M	C	E	A	B	I	J	L
A	45.0	43.2	56.1	55.6	51.6	49.6	62.1	121.1	54.8	63.5
B		38.6	41.1	[a] 23.2	46.4	48.2	24.4	40.0	52.6	32.4
C	11.8	36.0	7.0	15.3	19.8	28.1	13.8	8.6	13.0	18.5
D			4.8	8.2	1.5	8.5	14.1	6.7	2.3	
	Number of readings									
A	16	18	2	4	6	8	4	4	8	6
B		2	2	7	10	6	10	8	6	6
C	4	4	4	6	2	8	14	2	4	8
D			2	1	4	8	2	4	2	

[a] One reading of 165 million particles omitted because surface-cutting bush-hammer dust removal nozzle was off the stone.

[16] In one instance an operator using a diamond point pneumatic tool worked the stone wet. The resulting dust amounted to 21.8 millions of particles per cubic foot. The same operator was then instructed to work the stone dry; as a result, the amount of dust reached the high figure of 45.2 millions of particles per cubic foot.

Comparison of results in winter with those in summer.—As mentioned in an earlier portion of this report, all the granite-cutting sheds are provided with numerous windows and doors which are kept open during the summer months. For this reason the dust determinations made in connection with this inquiry were divided into two parts—winter and summer observations. Table 7 presents a summary of these findings comparing the conditions under extreme differences of natural ventilation.

TABLE 7.—*Difference in atmospheric dust conditions during winter and summer*

Occupation	Average dust count in millions of particles per cubic foot of air		Remarks
	Winter	Summer	
All pneumatic hand-tool operators	55.2	64.6	
Surface cutters:			
Inside	45.0	36.0	
Outside	(1)	43.9	
Carvers	37.5	36.5	
Tool grinders	30.0	23.3	
General plant atmosphere	22.6	16.3	
Lathe operators	17.9		
Polishers	11.0	5.7	
Sand-blast operators	6.9		Dust conditions same in winter as in summer.
Sawyers	4.8	4.4	
Blacksmiths	1.4	3.3	
Office employees	1.6	2.3	Windows in office open.

[1] Not operated in winter.

One is surprised to find that the winter conditions seem to be better than the summer for the hand pneumatic cutters, the largest occupational group. Only four occupations showed a distinct improvement in summer conditions over winter conditions—indoor surface cutting, tool grinding, polishing, and those occupations which create no dust but whose workers are exposed to the general plant atmosphere. Five of the processes show practically the same dust exposure during both seasons of the year, while three of the occupations show a slight increase. The three occupations showing an increase in dust content during the summer months are pneumatic-tool workers, blacksmiths, and office employees.

It is quite simple to explain why blacksmiths and office employees are exposed to more dust in summer than in winter. During the warmer months the windows and doors of the rooms housing these workers are open, thus allowing dust in the outdoor atmosphere to blow in. That there is much dust outside the various sheds is quite obvious. One sample showed a count of 2 million particles per cubic foot in the air just outside the blacksmith shop of one of the sheds. Much of this dust comes from the open shed windows and doors, but the majority of the dust finds its origin in the various dust catchers

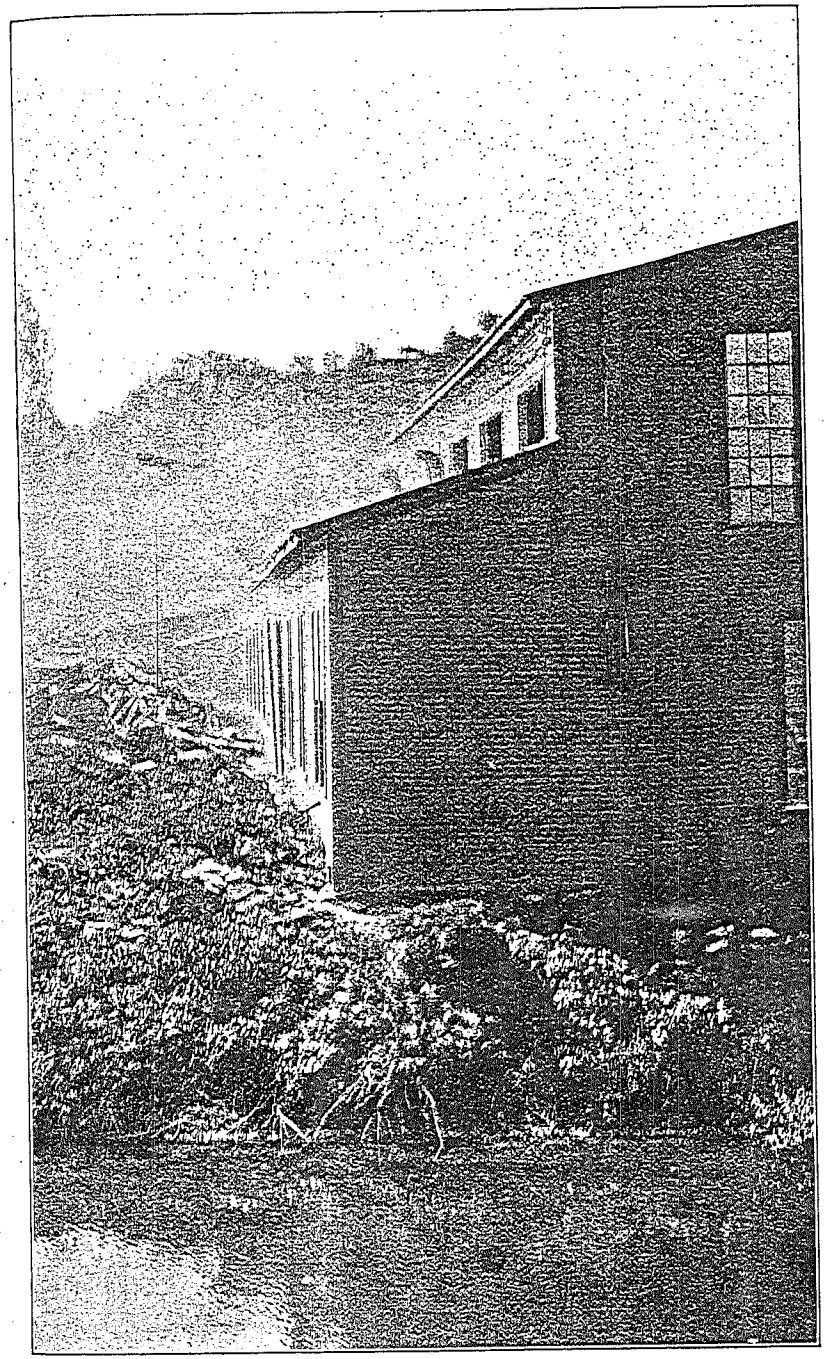


Plate 13.—Two exhausts pouring dust into the air outside of the plant

The dust is seen above the roof of the lean-to.

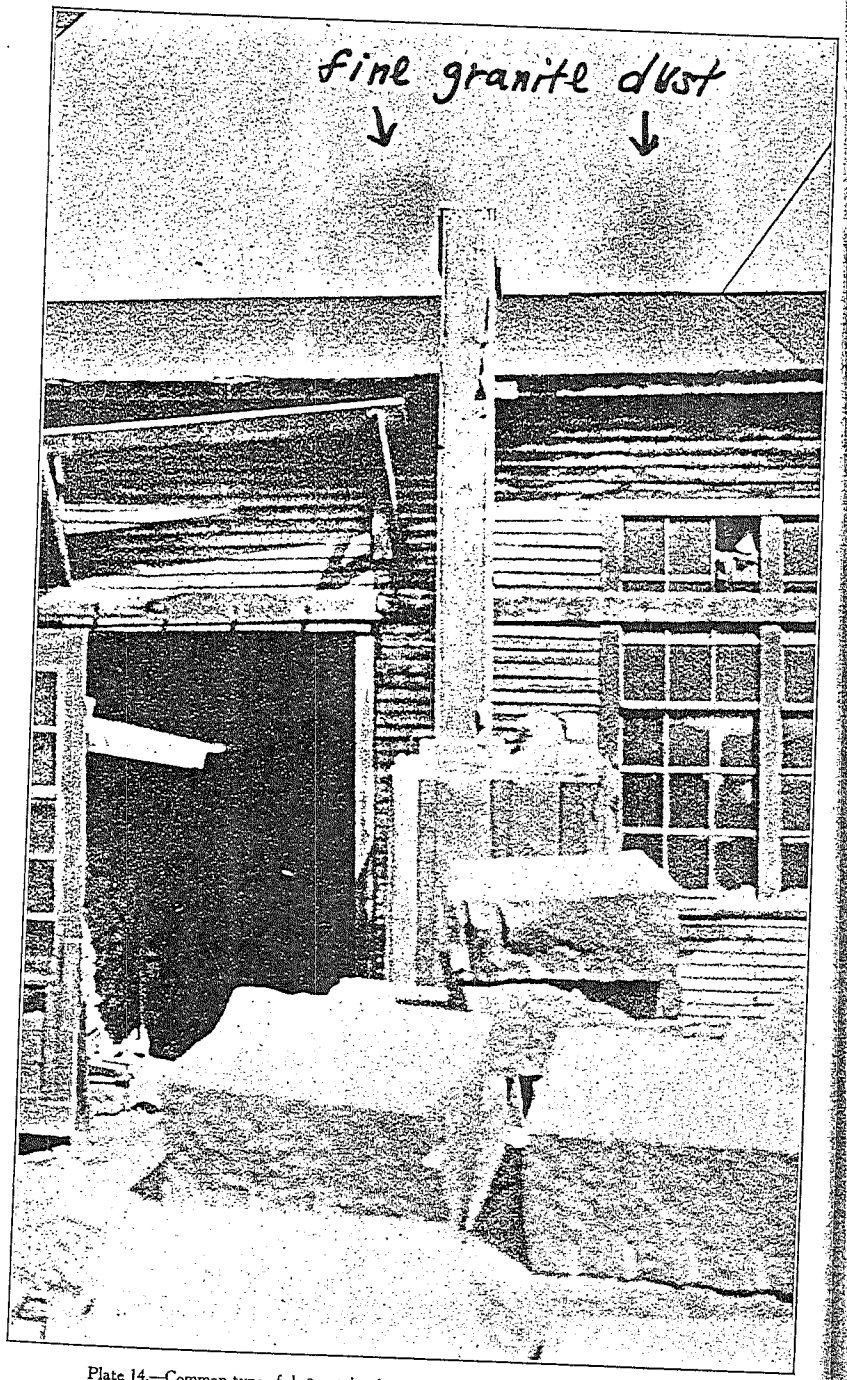


Plate 14.—Common type of dust catcher in use in many granite cutting sheds of Vermont

used in connection with the surfacing machines. The dust removed by the suction device used with these machines is blown into some sort of a storage bin, such as depicted in Plates 13 and 14. These plates illustrate clearly how the dust blows right back into the shed or into some neighboring plant. Most of these dust catchers are constructed of loosely nailed boards with a rectangular wooden stack, the top of which is not much higher than the roof of the shed.

The increase in the dust count among pneumatic hand-tool workers during the summer season is not so easily explained. This operation is more arduous than the others, the worker creating a steady stream of dust. Some of this dust may be blown back into the operator's face by a current of outdoor air, a phenomenon quite possible in the summer but not in the winter, when the sheds are well inclosed.

Comparison of helmets with and without positive air pressure.—The advantage of using helmets supplied with positive air pressure in sand-blasting operations is brought out in Table 8.

TABLE 8.—*Dust content of air of sand-blast room, showing the protection afforded by the use of helmets with and without positive air pressure*

	Number of observations	Average dust content	
		Millions of particles per cubic foot	Total dust, mgs. per cubic foot
Air of sand-blast room	4	157.1	20.63
Air under helmet using positive pressure	2	1.9	.40
Air under helmet not using positive pressure	2	11.7	1.04

The amount of dust breathed by the operator using a helmet supplied with positive air pressure was approximately one-sixth that of the operator using a helmet without positive air pressure. These results are similar to those found by Winslow, Greenburg, and Reeves [17] in their study of the efficiency of certain devices used for the protection of sand blasters against the dust hazard.

Types of exhaust systems for surface-cutting machines.—There are two types of exhaust systems for the removal of dust in use with surface-cutting machines, those in which an individual blower is supplied to each machine and those where a large blower is used to remove the dust from two to as many as eight surfacers. It was felt that in the latter system of which there are more in use than the individual type, the machines farthest away from the blower had less available suction than the machines nearest the blower, owing to improper design.

[17] Winslow, C. E. A., et al.: The Efficiency of Certain Devices Used for the Protection

A number of determinations were made for each system in use and the results show that the amount of dust in the air near a surfacing machine was 12 millions of particles per cubic foot less where an individual blower was used.

At present only 28 per cent of the surfacing machines in use are equipped with an individual exhaust fan. Even in the latter instance the exhaust system is none too efficient, as shown by the average count for the 14 determinations made at these surfacing machines, namely, 32.9 million particles per cubic foot of air. With a properly designed system of exhaust ventilation, it is possible to remove a large proportion of the dust, even without the use of an individual fan for each machine. This is borne out by surveys made elsewhere.

Count in various dusty trades.—Table 9 is appended to give an indication of the dustiness in the various trades in which studies have been conducted.

TABLE 9.—*Average dust count in certain dusty trades*

Industry	Count in millions of particles per cubic foot of air [1]	Industry	Count in millions of particles per cubic foot of air [1]
Cement plant	26.0	Silverware manufacturing:	
Granite cutting:		Rooms where dust is created—	
Cutters—		Dusty processes	5.2
Hand pneumatic tool operatives [2]	59.2	Nondusty processes	1.7
Others [3]	35.9	Other rooms	.8
Attendant labor	17.0	Municipal dust (street cleaners):	
Anthracite coal mining:		Congested district	4.1
Miners and miners' helpers	231.5	Residential district	1.8
Attendant labor	31.1	Cotton industry:	
Bituminous coal mining:		Carding room	8.6
Coal cutters and coal loaders	112.3	Weaving and spinning rooms	4.5
Attendant labor	3.9		

[1] Total particles.
[2] Including 58 per cent of all workers.
[3] Carvers and letterers included with other cutters (surface machine operatives, lathe operatives and sand-blast operatives).

The highest count is among miners, but this is mostly coal dust with a low silica content; the next highest is in the granite industry.

II. FACTORS INFLUENCING SICKNESS RATES

GENERAL CONSIDERATIONS

The methods employed in collecting the morbidity data have been outlined in the introduction, but some consideration is necessary of the various factors which may be expected to have an influence on the sickness of the industrial population, such as physical characteristics of the men, occupation, dust count, years of exposure to granite dust, age distribution, and racial composition.

The number of workers in the morbidity study and the number given physical examinations are indicated in the following table:

TABLE 10.—*Number of workers in morbidity study and number given physical examinations*

Number of persons on whom morbidity records were made	972
Years of observation	1,346
Number of granite workers with physical examinations	503
Number of persons with physical examinations in plants where morbidity records were kept	296
Number of persons with physical examinations in other plants	207
Number of persons with physical examinations who were formerly employed in granite, but now in other industries [1]	24
Number of persons with physical examinations in the families of cutters [1]	12

A year of observation in this study is the equivalent of stating that the record was kept for a period of one year on one person, or that one person was observed for nine months, another for three, or any such combination. The total years of observation would be the sum of the period of observation for all individuals in the group referred to.

It may be seen from the table that the years of observation are half again as great as the number of persons. This means that, on the average, each individual was under observation for about a year and a half. Included would be some individuals who might be observed for only a week or two. The short period of observation would not be due to the fact that they had just entered the granite industry but that, except for this short period, they were employed in plants on which morbidity records were not taken. Their actual length of exposure to granite dust might be anywhere from a very short period to 40 or 50 years; but during the short period of

[1] These 2 groups are additional to the 503 mentioned above.

observation they would have little chance to be sick, compared with persons whose record was continuous throughout the study. Thus it is quite necessary, when considering the sickness records, to deal, not with the individuals but with the period during which they were observed, i. e., during which the record of their sickness was maintained. Rates of sickness in this report are thus calculated on the number of illnesses per 1,000 years of observation or (in case of severity rates) on the number of days lost per year of observation. In the former case this would be the equivalent of the number of cases which 1,000 persons would have over a period of one year; in the latter case the number of days one person would be sick in one year.

In calculating the amount of time observed for individuals who developed tuberculosis and were finally dropped from the company pay rolls it was necessary to regard them as still in the study until its close, or until their death.

Outside of a small number of examinations made among persons formerly employed in granite but now working in other industries, and among persons in the families of granite cutters, it may be noted that 503 physical examinations were made in all. Part of these were made among employees in plants where the morbidity study was carried on and part among employees in some of the outside plants. For certain purposes it will be possible to use all of the examinations of employees (i. e., in cases where it is not of moment to have exact information about the population among whom the physical examinations were made). For other purposes it will be necessary to limit the analysis to the examinations made in plants where the morbidity study was carried out.

It may be noted from the table that 296 such examinations were made. All the workers in these plants (with one or two exceptions) were carried on the morbidity records, so that there is 100 per cent representation so far as sickness is concerned; but this was not possible in the case of physical examinations. The very important question arises immediately as to how far the group given physical examinations in these plants was representative of all the workers in the plants.

An attempt was made to examine all the workers in these plants, but as this examination was on a voluntary basis, only such workers were examined as applied. In addition every effort was made to give examinations to persons known or suspected to have tuberculosis. It is believed, for instance, that, with two exceptions, every active case of tuberculosis occurring in the plants carrying morbidity records throughout the period of the study was given a physical examination. Although the question of the representativeness of the physical examinations will be taken up in more detail in the section devoted to them, it can be seen at once that selection has been an important factor. What is of particular moment for the immediate purpose is a fairly warranted assumption that this factor of selection did not affect materially the workers who had been in the industry a relatively short time. It was not until tuberculosis began to develop among them that a tendency appeared for relatively more examinations among those most affected by dust. Since morbidity records were carried on all, this assumption can be checked by comparing the frequency of absences from sickness among those given physical examinations and among those not given physical examinations for various length of service groups. The rates are given in Table 11.

TABLE 11.—*Frequency of absences (eight days and more) due to sickness among workers given and not given physical examinations, by length of service*

	Years in granite						
	Up to 5	5 to 9	10 to 14	15 to 19	20 to 24	25 to 34	35 and over
	Rate per 1,000						
With physical examination	171	187	459	335	247	408	526
Without	84	111	52	92	103	105	79
	Cases						
With physical examination	8	6	26	14	21	43	36
Without	12	10	6	12	18	19	6
	Years observed						
With physical examination	46.8	32.0	56.6	41.8	85.1	105.3	68.5
Without	143.3	89.8	115.3	130.0	174.4	181.1	76.4

So far as the advanced length of service groups are concerned, the incomparability of the groups with and without physical examinations is too obvious for comment, but it is noted that if workers are taken who have been in the granite industry less than 10 years the excess is much less. This is of importance both in permitting some analysis of the physical condition of the average worker before the dust hazard has had a chance to exert an effect, and in watching the progress of the earlier stages of silicosis as noted in the course of physical examinations. The latter will be taken up in the section devoted to them (p. 89); the former may be discussed immediately, since the average physical condition of this group of workers may be thought of as one of the factors influencing the sickness rates.

PHYSICAL CHARACTERISTICS OF GRANITE WORKERS

Granite workers have an average height of 66.9 inches. This fact is of interest because of the large proportion of north Italians in the group (33 per cent of all the workers). Hrdlicka gives the average height of a group of north Italians as 66.8.[18] The height of the granite worker appears to be about average in comparison with the general industrial worker, as the study of 10,000 industrial workers (Public Health Bulletin No. 162) indicates.[19] In that study, five races (American white, colored; Irish, German, English) had average heights above 66.9; and four races (Russian-Austrian, Polish, Italian, and foreign-born Jewish) had average heights below 66.9. The average for the whole group of 10,000 was 66.9.

The weight of granite workers is, on the other hand, distinctly above the average for industrial workers, showing that the granite worker has a tendency to be heavier for his height than the average worker. The average weight of granite workers who had been in the industry for less than 10 years was 154.3 pounds, while the average for industrial workers under 30 years of age (i. e., of about the same ages) was 146.7.[20] For granite workers in the industry from 10 to 20 years, the average weight was 159.8, while the average for industrial workers, 30 to 40 years (i. e., of about the same ages) was 151.4.[19] In fact, the only race showing average weights as great as those of granite workers was the colored.

With respect to weight, therefore, the group of granite workers might be expected to have a minimum amount of tuberculosis. They are, upon entering the industry, a sturdy group.[21]

In the section on physical examination, the chest expansion and vital capacity of granite workers is taken up in detail. There it will be found that in the early years of employment in granite, their chest expansion is about equal to that of industrial workers generally. The vital capacity appears to be somewhat lower. Systolic blood pressure is either the same as in the general industrial population, or possibly a little higher.

In Table 12 a comparison is given between the diseases and defects found on physical examination in this study and those found among general industrial workers. In order to have a group who could not as yet have been greatly affected by the possible hazards of the granite industry, the comparison is limited to workers (without active or suspected tuberculosis) who have been in the industry less than 10 years. Examinations made both among those in the plants carrying morbidity records and among those in the outside plants are included. Even so, the records of only 96 persons are available. For industrial workers generally the comparison is limited to a comparable age group (25 to 29), of which there were 1,845 persons. These rates are taken from Table 16, page 161, of Public Health Bulletin No. 162, and since quite a large population is included, the number of cases is omitted. The numbers are given, however, for the granite workers.

[18] Hrdlicka, Alex.: Anthropology of the Old Americans II Stature. American Journal of Physical Anthropology, July–September, 1922.

[19] Britten, Rollo H., and Thompson, L. R.: A Health Study of Ten Thousand Male Industrial Workers. Public Health Bulletin No. 162, p. 60.

[20] Mean of averages for each race, taken from Table 56, p. 76, of Public Health Bulletin No. 162. In obtaining averages for granite workers, those with tuberculosis were omitted.

[21] The bearing which home conditions or economic status may have on this fact is discussed in another section (p. 43).

TABLE 12.—*Physical condition of granite workers with less than 10 years' length of service (without active or suspected tuberculosis) compared with general industrial workers, ages 25 to 29*

	Percentage		Number of diseases or defects, granite workers
	Granite workers	Industrial workers [1]	
Digestive:			
Constipation	2.1	13.3	2
Other digestive	3.1	6.9	3
Eye	10.4	10.6	10
Ear	18.8	19.3	18
Heart:			
Enlarged	3.1	3.0	3
Organic lesions	2.1	3.2	2
Irregular	5.2	1.8	5
Other circulatory: Arteriosclerosis	4.2	6.2	4
Hernia, varicose veins, etc.:			
Flat feet	5.2	20.2	5
Hernia	6.3	8.9	6
Enlarged rings		3.4	
Varicose veins	2.1	2.7	2
Hemorrhoids	3.1	7.5	3
Varicocele	17.7	5.0	17
Nose and throat:			
Chronic naso-pharynx (including rhinitis)	[2]100.0	49.3	96
Enlarged tonsils	7.3	21.9	7
Diseased tonsils	1.1	11.4	1
Respiratory:			
Bronchitis		3.9	
Tuberculosis	Excluded.	2.3	Excluded.
Emphysema	1.1	.5	1
Silicosis	78.1		75
Skin	5.2	9.5	5
Venereal	2.1	1.4	2

[1] Public Health Bulletin No. 162, p. 161.
[2] Universally recorded on examinations made in the winter time.

In general, it may be said that the group of granite workers compares favorably with the general industrial group. Although considerable allowance must be made for differences in method and interpretation by different examiners, there does not seem to be any marked excess among granite cutters in the more serious diseases and defects. In fact, the percentages follow each other very closely. The two manifest differences appear to be associated with the dust hazard in the granite industry, namely, the percentage with silicosis (for which there is no counterpart among the general industrial group), and the high percentage with chronic rhinitis or pharyngitis (a dis-

cussion of which is given on p. 70). Irregular heart and variocele, both subject to the personal equation in a large degree, are the only other conditions showing any particular excess.

Since the four dust-count groups form an important aspect of the study, it is well to consider more or less the physical characteristics of workers in these four groups. The difference which is most manifest is an economic one. The hand pneumatic and other cutters (Groups A and B being largely made up of these) are the highest-paid workers. They live under somewhat better sanitary conditions. Accordingly, there is no reason to expect these two groups to show a higher incidence of tuberculosis, or indeed of other diseases, unless a relation exists between their exposure to dust and these diseases. A point to be kept in mind, however, is that Groups A and B are possibly better able financially to be absent on account of sickness. For instance, it was found on analysis that surgical operations were confined mostly to the A and B groups. Vacations and absences from miscellaneous causes except sickness (see p. 66) are also higher in the A and B groups. So far as the physical make-up of the workers goes, very little difference was found. If anything, those in A and B groups are rather heavier for their height than those in C and D. This fact is shown in Table 13, giving the height and weight in the four groups, for all workers given physical examinations (in outside plants as well as in those carrying morbidity records), except persons diagnosed as having tuberculosis or suspected tuberculosis.

TABLE 13.—*Average height and weight of workers (without active or suspected tuberculosis) in each dust-count group*

Group	Average height	Average weight	Persons
	Inches	*Pounds*	
A (hand pneumatic cutters)	66.8	159.5	224
B (others with more than average dust)	66.9	161.7	46
C (average dust)	67.3	158.1	30
D (less than average dust)	67.4	152.0	12

YEARS IN GRANITE INDUSTRY (LENGTH OF SERVICE)

It was found practicable to classify the workers on the basis of the number of years' exposure to granite dust—i. e., the length of their service in the granite industry—without invalidating the record of the length of their service in a particular occupation. In most cases the occupational history and the industrial history were identical. Thus persons in Group A were employed in that group for the full period shown by "years in granite." It is not possible, of course, to know exactly what the dust exposure of each of these groups was in previous years. One important change which is known was the

adoption, some 30 years ago, of the hand pneumatic tool. Prior to that Group A were presumably exposed to much less dust than is shown by the present dust counts; and it is quite possible that their exposure prior to that time was less than that of Group B. Other changes may also have occurred. Yet, in general, the dust count of Group A may be thought of as applying throughout the industrial history of the individual from the time he entered the granite industry. This makes possible a very specific comparison.

An additional factor may be the exposure to dust in other employments prior to entering the granite industry. As a matter of fact, these workers had on the average been employed so long in silica dust that the influence of prior employment must be almost negligible. Some analysis was made with respect to the prior history of individuals employed only for a short time in granite, but only negative results were obtained. A large number of granite cutters were formerly employed in cutting marble and other soft stone.

In any comparison between the dust-count groups allowance must be made for a marked difference in length of service. Hand pneumatic and other cutters form a skilled trade with an exceptionally long service in the industry. Table 14 makes a comparison of the percentage of workers who have been employed in the industry for less than 5, 5 to 9, and 10 years and more, with Groups A, B, C, and D of the granite industry on one side, and the 10 industries covered in Public Health Bulletin No. 162 on the other. (Table 4, p. 13, Public Health Bulletin No. 162.)

TABLE 14.—*Industry and length of service, granite workers in each dust-count group,[1] compared with industrial workers generally*

	Length of service (years)		
	Up to 5	5 to 9	10 and over
	Percentage		
A	14	6	80
B	13	8	79
C	27	13	60
D	19	19	62
	Number		
A	85	40	489
B	14	8	82
C	39	19	88
D	21	20	67

	Length of service (years)		
	Up to 5	5 to 9	10 and over
	Percentage—Continued		
Cigar	26	13	61
Pottery	27	16	57
Glass	25	19	56
Post Office	27	18	55
Foundry	27	18	55
Government	24	34	42
Steel	36	25	38
Gas	54	24	22
Cement	64	18	18
Chemical	82	10	8

[1] Workers in plants carrying morbidity records.

The percentage who have been employed for 10 years and more among hand pneumatic-tool cutters is 80, whereas in other industries it varies from 61 to 8 per cent. A more precise comparison between

the four dust-count groups on the present study is provided by Figure 3, giving the percentage by length of service. Groups A and B have a much smaller percentage of workers in the shorter length of service groups [22] and a much larger percentage of workers

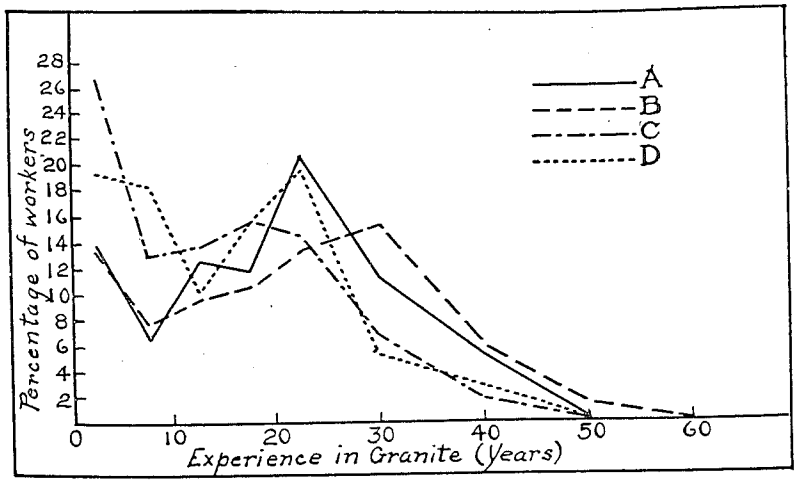


FIGURE 3.—Length of service of workers in each dust count group

in the advanced length of service groups. If we take 20 years and over, Group A has 55 per cent; Group B, 59; Group C, 31; and Group D, 36. The data are given in Table 15.

TABLE 15.—*Length of service of workers in each dust group*

Group	Years in granite								
	Up to 5	5 to 9	10 to 14	15 to 19	20 to 24	25 to 34	35 to 44	45 and over	Total
	Percentage								
A	13.8	6.5	12.7	11.9	20.8	22.6	10.4	1.1	100
B	13.5	7.7	9.6	10.6	13.5	30.8	11.5	2.9	100
C	26.7	13.0	13.7	15.8	14.4	13.0	3.4	------	100
D	19.4	18.5	10.2	15.7	19.4	10.2	5.6	.9	100
	Number								
A	85	40	78	73	128	139	64	7	614
B	14	8	10	11	14	32	12	3	104
C	39	19	20	23	21	19	5	------	146
D	21	20	11	17	21	11	6	1	108

Workers in Groups A and B who were given physical examinations have relatively longer lengths of service than those who were not given physical examinations. The reverse is true of Groups C and D.

[22] The curves lie under those for Groups C and D at the left of the graph.

The group of workers in outside plants who were given physical examinations agrees rather closely as to length of service with the group in the plants carrying morbidity records.

For reference a table is included giving the number of years in granite for certain specific occupations.

TABLE 16.—*Length of service in relation to occupation*

Occupation	Years in granite							
	Under 5	5 to 9	10 to 14	15 to 19	20 to 24	25 to 34	35 and over	Total
Group A:								
Pneumatic hand-tool operators	29	35	76	67	119	119	64	509
Carvers	3	1	1	4	3	9	3	24
Pneumatic hand-tool apprentices	52	3	1	------	------	------	------	56
Other workers classed in A	1	1	------	2	6	11	4	25
Group B:								
Surface cutters	------	1	7	6	13	30	11	68
Tool grinders	13	5	1	3	------	1	3	26
Other workers classed in B	1	2	2	2	1	1	1	10
Group C:								
Lumpers	20	9	10	9	12	6	------	66
Polishers (except in Plant A)	1	2	3	3	3	9	4	25
Boxers	3	2	2	4	1	2	------	14
Bed setters	1	1	------	2	1	------	------	5
Tool carriers	6	------	------	------	------	------	------	6
Other workers classed in C	8	5	5	5	4	2	1	30
Group D:								
Derrick men	4	3	3	7	5	------	------	22
Engineers	------	3	------	1	3	3	------	10
Machinists	3	------	1	3	1	1	------	9
Foremen and manufacturers	------	2	1	1	2	2	1	9
Blacksmiths	------	------	1	1	2	2	4	10
Sawyers	1	3	1	1	3	------	1	10
Polishers (Plant A)	1	5	3	2	4	2	1	18
Other workers classed in D	12	4	1	1	1	1	------	20

AGE DISTRIBUTION OF WORKERS

It is natural that the extended length of service among granite workers would reflect itself in a higher average age than is found in industry generally. This is brought out in Figure 4 and the accompanying Table 17. There is a difference of more than 10 years in the average age, and the shape of the curve for granite workers, with more or less tendency to skew toward the younger ages, is unlike that exemplified in industry generally.

TABLE 17.—*Age distribution of granite workers and industrial workers generally*

	Age					
	Up to 20	20 to 29	30 to 39	40 to 49	50 to 59	60 and over
	Percentage					
Granite workers	4	19	26	33	16	3
Industry generally [1]	5	32	33	19	8	3
	Number					
Granite workers	37	180	248	1,319	153	33
Industry generally	498	3,270	3,320	959	829	267

[1] Page 11, Table No. 2, Public Health Bulletin No. 162: Ten Thousand Male Industrial Workers.

RELATION BETWEEN AGE AND YEARS IN GRANITE INDUSTRY

The extended length of service of granite workers, especially cutters, simplifies the analysis of the data to an extent that will hardly be realized by the reader unless he has dealt with problems involved in the rapid turnover found in most industries. Indeed, so large a proportion of the workers had no industrial experience prior to that in granite and also remained in a single occupation throughout their industrial life that it becomes possible to state the

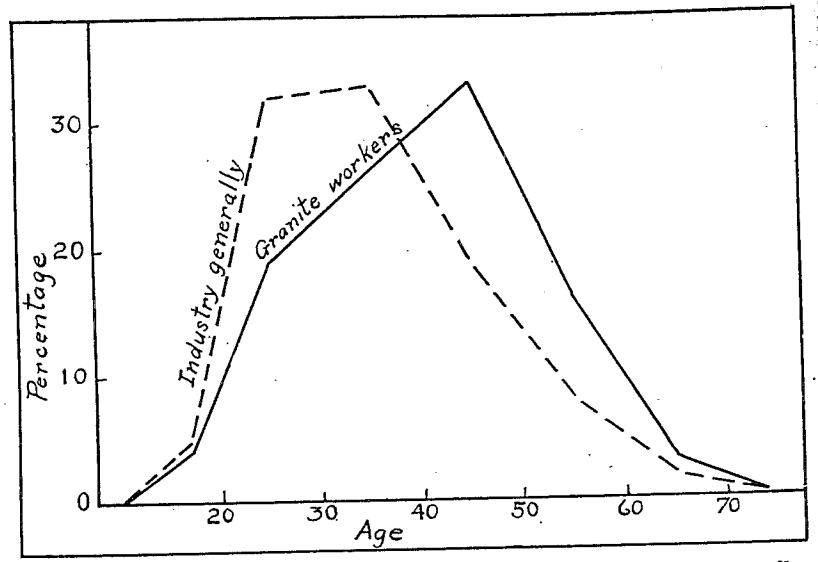


FIGURE 4.—Age distribution of granite workers and industrial workers generally

age of these workers in terms of their years in the granite industry. What that means, in brief, is that the factor of age, so troublesome in studies of sickness and mortality, is converted into a factor of length of service—a phase that would have to be kept under constant observation, whether age was considered or not. It becomes possible to state the number of years a group has been in the industry and to include in the statement the age of the group.

First, consider a table giving the distribution of all of the workers in the study (i. e., in plants carrying morbidity records) by age and by years in the granite industry.

TABLE 18.—*Age distribution of granite workers in various length of service periods*

Years in granite	Age											
	Total	Under 20	20 to 24	25 to 29	30 to 34	35 to 39	40 to 44	45 to 49	50 to 54	55 to 59	60 to 64	65 and over
Up to 5	159	36	57	29	8	12	2	6	-------	4	1	4
5 to 9	87	1	23	35	17	4	2	3	-------	2	-------	-------
10 to 14	118	-------	2	31	39	20	17	5	4	-------	-------	-------
15 to 19	124	-------	-------	3	33	44	22	12	7	3	-------	-------
20 to 24	184	-------	-------	-------	8	58	69	28	15	3	2	1
25 to 34	201	-------	-------	-------	-------	5	60	82	32	11	8	3
35 to 44	86	-------	-------	-------	-------	-------	1	10	34	35	6	-------
45 and over	11	-------	-------	-------	-------	-------	-------	-------	-------	3	6	2
Total[1]	970	37	82	98	105	143	173	146	92	61	23	10

[1] 2 unknown age.

To make it possible to visualize this table, a dot chart has been prepared, one dot to a person (fig. 5). It will be observed that a rather definite relation between age and length of service exists. From this is derived the extremely useful formula of adding 20 years to the average length of service of a group of granite workers to obtain the average age of the group.[23]

The use of the formula will become plainer in the section on physical examinations, where it is frequently found desirable to compare averages for granite workers by length of service with averages for general industrial workers by age.

NUMBER OF WORKERS IN EACH PLANT

In the main, the dust conditions are quite parallel in the various plants for corresponding occupations. Especially is this true of the most important occupational group, hand pneumatic granite cutters. Therefore, it has been possible to group the plants together in the succeeding study, putting the emphasis rather on dust count and length of service.[24] Later a special consideration of the sickness rates in each plant will be possible.

For reference, two tables are added, giving the number of workers in each plant according to dust-count groups and to broad groups of length of service.

[23] One phase needs mention—the relation is truer for cutters than for Groups C and D, as the latter have much shorter lengths of service. In fact, it might be illegitimate to apply the method at all to these latter groups by themselves. However, it has not been found necessary to do that.

[24] Differences in dust count due to the fact that the polishers in Plant A did not work in the general shed has been allowed for by putting this occupation in dust-count Group D so far as this particular plant was concerned.

TABLE 19.—*Percentage of workers who are in each dust-count group, by plants*

	Percentage					Number				
	Total	Group A	Group B	Group C	Group D	Total	Group A	Group B	Group C	Group D
All plants	100	63.2	10.7	15.0	11.1	972	614	104	146	108
A	100	52.4	8.9	14.1	24.6	191	100	17	27	47
B	100	56.2	10.4	22.4	10.9	192	108	20	43	21
C	100	52.2	4.3	21.7	21.7	23	12	1	5	5
D	100	84.8	6.1	3.0	6.1	33	28	2	1	2
E	100	63.4	14.6	12.2	9.8	41	26	6	5	4
F	100	76.5	17.6	5.9		17	13	3	1	
G	100	65.0	20.0	5.0	10.0	20	13	4	1	2
H	100	78.4	13.5	5.4	2.7	37	29	5	2	1
I	100	71.6	12.2	12.2	4.0	74	53	9	9	3
J	100	51.5	12.1	15.2	21.2	33	17	4	5	7
K	100	65.8	13.7	17.8	2.7	73	48	10	13	2
L	100	54.8	14.3	21.4	9.5	42	23	6	9	4
M	100	50.0	4.3	30.4	15.2	46	23	2	14	7
N	100	66.7	11.1	11.1	11.1	18	12	2	2	2
In 2 or more plants	100	82.6	9.8	6.8	.8	132	109	13	9	1

TABLE 20.—*Distribution of workers by plant, length of service, and dust-count groups*

Plants	Dust Group A, by length of service (years)			Dust Group B, by length of service (years)			Dust Group C, by length of service (years)			Dust Group D, by length of service (years)		
	Up to 10	10 to 24	25 and over	Up to 10	10 to 24	25 and over	Up to 10	10 to 24	25 and over	Up to 10	10 to 24	25 and over
	Percentage											
All plants	20.4	45.4	34.2	21.1	33.7	45.2	39.7	43.8	16.4	38.0	45.4	16.7
A	27.0	41.0	32.0	17.7	35.3	47.0	48.1	44.5	7.4	36.2	38.9	14.9
B	16.7	45.4	38.0	20.0	30.0	50.0	41.9	41.9	16.3	33.3	42.9	23.8
I	15.1	56.6	28.3	11.1	44.5	44.5	22.2	55.6	22.2	33.3	33.3	33.3
K	20.8	35.4	43.8	30.0	30.0	40.0	30.7	38.5	30.7	50.0	50.0	
Others	18.9	44.9	36.2	28.6	37.2	34.3	42.2	37.8	20.0	44.1	41.1	14.7
2 or more	22.9	49.6	27.5	7.7	23.1	69.2	22.2	77.8			100.0	
	Number											
All plants	125	279	210	22	35	47	58	64	24	41	49	18
A	27	41	32	3	6	8	13	12	2	17	23	7
B	18	49	41	4	6	10	18	18	7	7	9	5
C	1	5	6	1			1	2	2	3	1	1
D	1	21	6	1	1		1				2	
E	6	4	16	1	3	2	3	2		2	1	1
F	2	8	3		1	2	1					
G	1	5	7	1	2	1	1				2	
H	5	15	9	2	3			2		1		
I	8	30	15	1	4	4	2	5	2	1	1	1
J	3	12	2	2	1	1	1	4		3	2	2
K	10	17	21	3	3	4	4	5	4	1	1	
L	2	12	9	2	1	3	4	3	2	4		
M	13	3	7			2	6	3	5	2	4	1
N	3	3	6		1	1	1	1			2	
2 or more	25	54	30	1	3	9	2	7			1	

These tables indicate that the various plants are quite comparable for occupation and length of service.

RACE AND SOCIAL CONDITIONS

In a study based on such a relatively small group, it becomes impossible to eliminate the effect of certain factors which it would be desirable to consider. One of these is race. The method followed has been to make a separate study of the incidence of tuberculosis and other sickness among the different races (p. 112), both as a check upon the elimination of this factor in the general study and because of the interest in the relation between race and sickness.

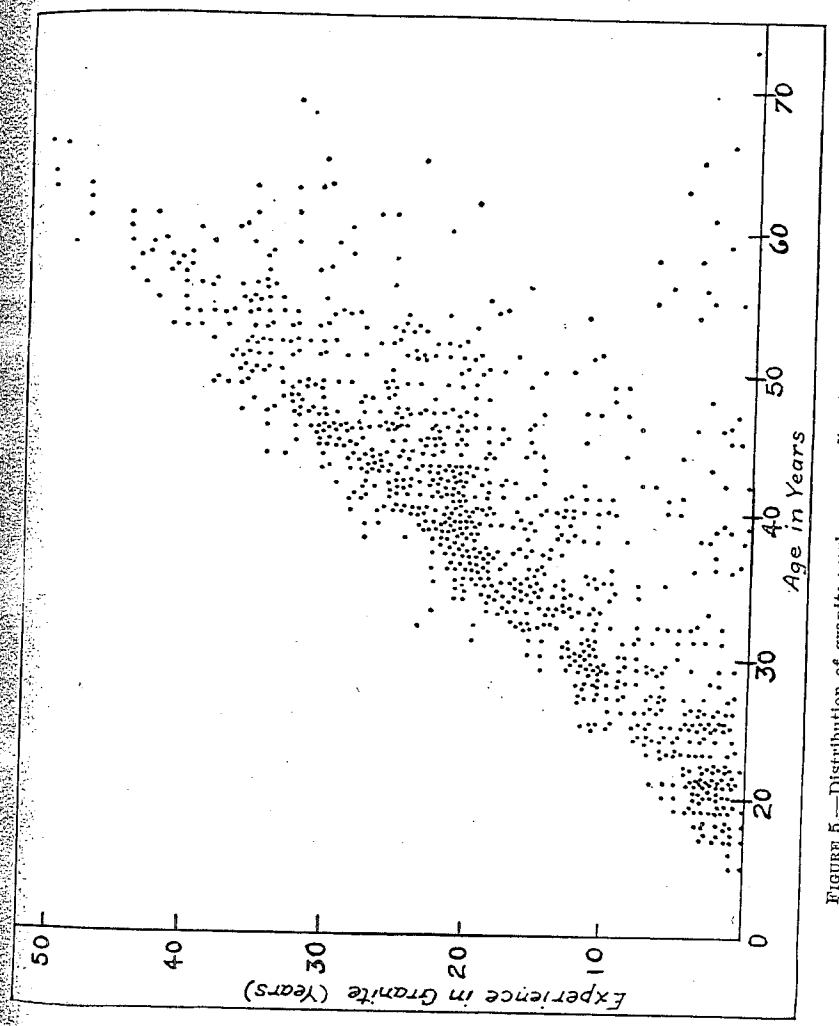


FIGURE 5.—Distribution of granite workers according to age and length of service

The distribution of workers according to race is given in a series of tables, as follows:

Table 21. Percentage and number in each race.

Table 22. Percentage and number of each race in each dust-count group.

Table 23. Number of each race in each dust-count group and each length-of-service group.

TABLE 21.—*Race of granite workers*

	Percentage	Number		Percentage	Number
Total	100.0	972	Swedish	3.6	35
Italian and Swiss	33.0	321	Irish	3.1	30
Scotch	20.6	200	Finnish	1.9	18
American	13.4	130	Canadian	1.6	16
Spanish	8.1	79	Mixed	1.6	16
French Canadian	7.6	74	Others	1.1	11
English	4.3	42			

TABLE 22.—*Race of granite workers by dust-count groups*

	Percentage				Number			
	Group A	Group B	Group C	Group D	Group A	Group B	Group C	Group D
Total	100.0	100.0	100.0	100.0	614	104	146	108
Italian and Swiss	41.5	28.8	15.8	12.0	255	30	23	13
Scotch	19.5	36.5	15.8	17.6	120	38	23	19
American	8.5	2.9	24.7	36.1	52	3	36	39
Spanish	11.9	2.9	2.0	-----	73	3	3	-----
French Canadian	3.4	9.6	19.9	13.0	21	10	29	14
English	3.7	5.8	6.8	2.8	23	6	10	3
Swedish	3.9	3.8	3.4	1.8	24	4	5	2
Irish	2.0	3.8	4.8	6.5	12	4	7	7
Finnish	2.6	1.0	-----	.9	16	1	-----	1
Canadian	.8	1.9	3.4	3.7	5	2	5	4
Mixed	1.6	1.9	.7	2.8	10	2	1	3
Others	.5	1.0	2.7	2.8	3	1	4	3

TABLE 23.—*Race of granite workers, by dust-count groups and length of service*

Race	Length of service (years)													
	Up to 5	5 to 9	10 to 14	15 to 19	20 to 24	25 to 34	35 and over	Up to 5	5 to 9	10 to 14	15 to 19	20 to 24	25 to 34	35 and over
	Group A							Group B						
Italian and Swiss	16	14	43	34	48	71	29	8	3	5	5	6	2	7
Scotch	19	6	7	10	24	28	26	3	-----	-----	3	7	18	1
American	16	2	1	6	11	12	4	1	1	-----	-----	-----	1	-----
Spanish	15	12	16	9	18	3	-----	-----	-----	2	-----	-----	1	-----
French Canadian	4	-----	5	3	4	4	1	1	3	-----	1	-----	2	3
English	4	1	2	1	4	4	7	-----	-----	1	-----	-----	2	3
Swedish	5	-----	-----	6	6	7	-----	-----	-----	2	1	-----	1	-----
Irish	3	2	-----	-----	3	2	2	-----	1	-----	-----	1	2	-----
Finnish	1	1	3	3	5	3	-----	-----	-----	-----	-----	-----	1	-----
Canadian	-----	-----	-----	-----	2	3	-----	-----	-----	-----	1	-----	1	-----
Mixed	2	2	-----	-----	2	2	2	1	-----	-----	-----	-----	-----	1
Others	-----	-----	1	1	1	-----	-----	-----	-----	-----	-----	-----	1	-----
	Group C							Group D						
Italian and Swiss	5	7	2	3	5	1	-----	2	5	3	1	2	-----	-----
Scotch	5	2	4	4	-----	6	2	2	8	1	2	1	3	2
American	12	3	6	6	4	4	1	12	2	4	6	11	2	2
Spanish	-----	-----	2	1	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
French Canadian	6	4	1	5	10	3	-----	2	2	2	2	3	2	1
English	4	1	2	1	-----	1	1	1	-----	-----	1	-----	1	-----
Swedish	2	2	-----	-----	-----	1	-----	-----	-----	1	-----	1	-----	-----
Irish	2	-----	1	-----	2	1	1	-----	2	-----	1	1	2	1
Finnish	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	1	-----	-----
Canadian	-----	-----	1	2	-----	2	-----	2	-----	-----	1	1	-----	-----
Mixed	1	-----	-----	-----	-----	-----	-----	-----	1	-----	-----	-----	1	1
Others	2	-----	1	1	-----	-----	-----	-----	-----	-----	3	-----	-----	-----

Eighty-three per cent of the workers in the industry fell into five racial groups—Italian, Scotch, American, Spanish, and French-Canadian—and a brief discussion of the habits and social conditions of these groups is needed to understand the effect of race on the various aspects of this study.

The Italians represented in the study are principally from northern Italy and the Swiss border. They are partly of Teutonic blood and are quite different in physical make-up as well as in temperament from the southern Italians. The majority learned to cut stone in their native country when very young. Most of the stone in that region is limestone or marble and they seldom worked on granite. These Italians are the most highly skilled of the granite workers in Barre and do practically all of the carving and the statuary work. They do not, as a rule, have large families, and they make persistent efforts to educate their children. Their homes are clean and very comfortably furnished and they have an abundance of excellent food. Such conditions are not conducive to a high incidence of tuberculosis.

The Scotch people in the industry are principally from Aberdeenshire. They are a sturdy, thrifty lot, and are of good racial stock. Coming from a granite center, many of them learned their trades before immigrating to this country. They were the first to come from a foreign country to work in the granite in Vermont. They have very comfortable homes, and their living conditions are also above the average.

The Americans in the industry are for the most part local people and represent the strong, sturdy New England stock. Many of them came from the farms and apprenticed for the trade. They are usually of almost pure English ancestry.

The Spaniards observed in this study emigrated from the Provinces of northeastern Spain, principally from the Province of Santander. Their physical characteristics are decidedly Basque, and inasmuch as they are from the country adjacent to the Basque Provinces of Spain, it is easy to account for their physical make-up. With the exception of some of the French-Canadians, the Spaniards are the most recent of the immigrants in the industry and have had a shorter period of exposure to granite dust. Their homes are not so good, and in many instances there is considerable overcrowding. Many of them have not brought their families with them and so live with other Spanish families or in groups in small tenement buildings. It is in such instances that overcrowding is worst. They have not mixed with the other people as have the other foreigners, and consequently have not learned the language and customs of their adopted country.

The Spaniards are principally cutters, making $8 a day and above. Frequently one would operate a small plant and employ, in most

instances, all Spaniards. They also worked in groups in other sheds. They rarely worked alone.

The Canadians in the industry are of two distinct types—those of the English-Scotch stock and the French. The first group is quite familiar to us, as it is parallel to our own American people of that extraction. The French-Canadians are decidedly in the majority. A few of them are cutters, but as a rule they fill the less technical positions such as bed setting, polishing, tool grinding, and similar positions. The French-Canadians have remained a practically pure stock and retained many French customs. These workers emigrated from the rural parts of Canada. Their home conditions are not as good as those of the Italians and Scotch, and in many instances there is overcrowding among them. The average French-Canadian family is very large and much of the wage-earner's salary is required to support them. The positions largely filled by these workers do not pay as much as cutting and this lower wage, combined with a large family, makes their living conditions inferior to that of other families in the industry.

The presence of three golf courses in this small city, used frequently by granite cutters, is evidence of the amount of time devoted to sports.

ALCOHOLISM

Alcoholism, in its effect on the total amount of sickness and rather specific effect on tuberculosis and pneumonia, is in many industries a factor requiring serious consideration. Among granite workers in Barre, however, it was a factor of nominal importance. Since there was a feeling in certain quarters that the high rate of tuberculosis sickness and mortality among granite workers should be ascribed to alcoholism, it becomes necessary to deal with this factor in some detail.

Only seven cases of sickness from alcoholism (two days or longer) were noted, a rate of 3.7 per 1,000. There were also two 1-day cases. In the next table a comparison is made as to the amount of sickness ascribed to alcoholism in this study compared with that in the other dust studies. It is clear that there is no necessity of correcting the sickness records in this instance to allow for the effect of alcoholism.

TABLE 24.—*Frequency of absences[1] from alcoholism in various dust studies*

	Annual rate per 1,000	Cases[2]	Years observed		Annual rate per 1,000	Cases[2]	Years observed
Granite study	4	7	1,346	Silver-polishing study	20	14	715
Anthracite-coal study	403	450	1,116	Cotton study	2	2	801
Cement study	128	98	763	Soft-coal study	43	21	494

[1] Duration of 2 consecutive working days or longer.
[2] 1 person frequently had more than 1 case of alcoholism.

Consumption of alcohol among Italians is mostly in the form of wine, used constantly at mealtime. Among the Scotch, consumption is mostly in the form of stronger drinks. In both instances the use is fairly constant, but excesses are rather infrequent.

PRESENCE OF EPIDEMICS

Sickness records obtained during an epidemic period will naturally be inflated, not only from the particular cause of the epidemic but from related causes. It becomes necessary therefore to examine the chronology of the sickness record kept in this study to ascertain whether any serious epidemic occurred. In Table 25 is given the number of cases occurring in each month of the year from the beginning of the study to its close. A few specific causes have been selected in addition to the cases from all causes. Small numbers make impossible any smoothness in the material, even when (as here) all two working-day and longer cases are included.

TABLE 25.—*Month and year of incidence of sickness—All causes and certain specified causes—Two days and longer*

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
All causes:												
1924				11	17	1	4	14	7	17	9	20
1925	20	25	33	18	10	16	6	16	11	8	25	9
1926	4	10	11	12	12	3						
All respiratory:												
1924				7	10	1	2	5	6	11	6	14
1925	10	17	32	10	4	12	2	5	6	6	16	8
1926	3	9	9	10	8	1						
Nasal fossae:												
1924				4	3			1	2	4	1	7
1925	3	7	10	2	2	1		1		2	6	4
1926		5	2	2	1							
Influenza and grippe:												
1924				2	4					1	1	1
1925	1	4	17	4					1		5	4
1926	1	2	5	8	2	1						
Tuberculosis and suspected tuberculosis:												
1924					1			2	2	2	2	4
1925	3	3	3	3	2	7	2	3	4	4		1
1926	2	2			3	1						

What stands out is a peak in February and March of 1925. Examination of the specific causes shows an excess in the cases of influenza or grippe during these months—21 out of 64 cases occurring in these two months. Diseases of the nasal fossae reflect the same epidemic tendency. It was felt, however, that this epidemic was not of severe enough proportions to affect the sickness rates in any marked degree.

III. GENERAL SICKNESS RECORD

INCIDENCE

Manner in which sickness record was obtained.—Reference has been made in the introduction (p. 4) to the general manner in which the sickness records were obtained. In this particular study an intimate contact was made with the physicians of the city, and in a considerable majority of the more severe illnesses the doctor's diagnosis was obtainable. In addition to the help given by the doctors in this particular study the assistant of the medical officer was a local girl of Italian parentage, whose father was a stonecutter in Barre, so that she was well known to the people she visited. The records of both the general and tuberculosis hospitals in the city were made available in ascertaining the diagnoses of illness of cases treated in them.

In the case of prolonged sickness it was customary for the plants to drop the workers from the pay roll after a certain interval, but for the purpose of this study sick workers were necessarily kept on the records until recovery and return to work or until death.

The morbidity records were commenced in Plant A on April 1, 1924, and by April 15 were under way in all but a few plants (with a relatively small number of workers). By July 1 the study had been extended to all but one of the plants finally included, and this plant had only 18 employees at the time it was taken in. Since the study closed on June 30, 1926, it may be stated that two full years of observation were possible, with certain additional data obtained from April 1 to July 1, 1924.[25]

What minimum duration should be employed?—As indicated previously, all absences from the plants due to sickness were recorded, whether of one working day or longer. Absences of short duration, however, are subject very much to the habits and psychology of a particular group of workers. The question arose, therefore, in dealing with sickness among granite cutters as to what minimum number of days should be adopted as a basis for the incidence rate. For the days lost it appeared logical to use all the time workers were sick, whether from long or short absences. Accordingly, the only

[25] The study commenced in the different plants on the following dates: Apr. 1, 1924, A (187 employees); Apr. 15, B (106), C (25), D (30), E (39), F (13), G (18), H (25); May 1, I (65), J (14); June 1, M (29), K (51); June 15, L (24); Jan. 1, 1925, N (18).

cases omitted from the calculations were those lasting less than two consecutive working days.[26]

With incidence, however, the minimum period used becomes of great importance. A preliminary analysis of the sickness records showed an unusual situation, in which very little short sickness occurred—68 per cent of the cases were eight days and longer, whereas in ordinary experience the percentage is from 35 to 40. It was immediately evident that factors were at work producing an abnormally low sickness rate for very short cases. Chief among these may be the facts that the granite workers had a 5-day week in the summer and a 5½-day week in the winter, worked only eight hours a day, and were, for the most part, economically able to take extended vacations (many went to Europe for vacations). It is felt that they were able to recuperate over the week-end from minor illnesses without taking any time off from work, as would be impossible for a group (like those in the cement plant) working seven days a week.

Whatever causes were at work, it appeared evident that incidence rates must be based on a minimum that would leave out this dubitable record of short illness. The limit set was eight calendar days or longer, except for a few special purposes in the course of the bulletin where it seemed necessary to consider the shorter cases. Using a minimum of eight[27] days limits the study to sickness of real severity, and has the special advantage of being comparable with many of the records of sick-benefit associations, which usually have a waiting period of seven days, i. e., do not pay for illness unless the worker is sick for eight days or longer.

[26] It might have been preferable to have used no minimum at all with respect to severity rates; but the material had been worked up on the basis of two working days or longer, and the exclusion of one working-day cases could have no appreciable effect on the severity rates.

[27] In the original records absences were counted from the date when absence from work started, not when the illness started. This proved to be an important point in an industry where only five or five and one-half days a week were worked. In fact, it was found that 48 per cent of the cases of illness (two working days or longer) were recorded as dating from Monday—i. e., the absence from work beginning on that day. The sickness frequently began earlier; much on Sunday, some on Saturday. It was therefore necessary to estimate in some way the length of these cases of sickness, as other studies are based on the calendar days lost, not on calendar days from the date when absence from work began. So far as severity rates were concerned, it seemed practicable to disregard the difference, as its effect would be negligible in relation to long cases; but in the case of incidence it seemed most logical to include with the 8-day cases those which numbered seven days from the time when absence from work started. This exaggerates very slightly the 8-day and longer cases, because some few of the included cases really originated on the day specified, but the resulting rates can be assumed to be closer to the true incidence of 8-day and longer cases than if this change had not been made. In this connection it might be mentioned that sick-benefit association records show relatively few cases starting on Monday, because the worker is inclined to date the case back to Sunday in order to secure an additional day's benefit. A sample showed 63 cases starting on Sunday and 34 cases starting on Monday. This is quite different from the record among granite workers, where a sample showed that 7 started on Friday, 1 on Saturday, none on Sunday, and 70 on Monday.

In limiting the sickness study to 8-day and longer cases, however, the authors do not mean to convey the idea that there may be no significance in the different rates of short illnesses in the various dust studies. Whatever factors can be identified as more or less responsible, the point remains that there was a much lower incidence of short cases of sickness in the granite-dust study than in the other studies, and this difference may have some bearing on the health hazard of the industry itself, especially with reference to the kind of sickness occurring. Respiratory illness of short duration is primarily that of the upper respiratory system not of the lungs, and the inhalation of a silica dust of minute size may not have the same effect on these organs as vegetable, cement, or other dust. This point will be discussed further in connection with a comparison as to the incidence of sickness in each of the dust studies (p. 51).

The necessity of dealing with the period of observation of the men has previously been taken up (p. 29). It is only necessary to re-emphasize here that in only a very few cases had the men been employed in granite for a short time. In a great proportion of cases where a worker was in the sickness study for a short period, he had come in from another plant in which morbidity records were not kept or changed during the study to such a plant. Six months' observation on two such men may be fairly taken as equivalent to one year's observation on one man.

General incidence by cause.—In the study as a whole there were 237 absences due to sickness lasting eight days or longer,[28] giving a rate of 176.1 per 1,000 years of observation. It has already been pointed out that an observation year is equivalent to observing one person for one year, or several persons for fractions of a year, totaling to one year.

As the cases of tuberculosis will be dealt with in a later section, the incidence of sickness for this cause (containing in some cases two absences for a single person) receives no consideration in the following section.

Throughout the bulletin, sickness rates are exclusive of all accidents. Since accidents have no bearing on the dust hazard, it has been felt less confusing to omit all consideration of them.

In most records of sickness among industrial workers, there will be found repeated absences from the same cause within a few days. These are in most cases relapses. As an arbitrary rule a second absence from the same cause within a week has been classified as a relapse, not as a new case, the total time disabled being accredited to the original case.

In order to ascertain the significance of the rates, it is necessary to make a comparison with other data. This is done in Table 26 for the following groups:

(*a*) A group of gold miners in the West, working in hard rock with a high silica content.

(*b*) A group of cement workers, the results of the study of which are given in Public Health Bulletin No. 176.

(*c*) A group of workers in the iron and steel industry.

(*d*) The general sick benefit experience of many industrial concerns, as reported to the Public Health Service.

[28] Among the 237 absences due to sickness there were 17 which were recorded as due to two causes (in no case was more than two causes found for a single absence). Although this percentage of joint causes (7.2 per cent) is small and not in general of importance, it does affect some minor causes of absences to a notable degree. For instance, only two cases of bronchitis were recorded as occurring by themselves, but three additional cases were associated with some other cause. It has been found advisable to treat the sickness records from two aspects: First, on the basis of the frequency of absences. Such rates, in general, have to do with all causes, but it has sometimes been necessary for the purpose of comparison with other data to assign joint-cause absences to an arbitrary primary cause, and thus derive rates of frequency of absences according to cause. However, for the purpose of analysis within the study it has been found preferable to treat the sickness from a second aspect—namely, the incidence of sickness from specified causes. In this case an absence due to two causes would be assigned to both of the causes, providing these appeared in the particular table under consideration. The unit is not the absence, but the disease causing disability. The purpose is to obtain not the rate of absence but the incidence of sickness of specific cause. In a comparison between respiratory and nonrespiratory causes an absence due to two different respiratory diseases would of course count once; but an absence due to a respiratory and a nonrespiratory disease would count with each. Thus, the incidence of sickness from all causes (each absence counting once) would be less than the sum of the incidence of sickness from respiratory and nonrespiratory causes. A parallel situation arises with respect to specific causes.

Another point to be mentioned is in regard to operations. They are classed under the particular cause responsible for the operation, on the assumption that operations are primarily due to sickness.

TABLE 26.—*Comparison of frequency of absences due to specified cause among granite workers with that in certain other industrial groups—8-day and more*

	Rate per 1,000 years observed				
	Granite workers	Hard rock gold mining	Cement workers	Iron and steel industry	General sick benefit
Sickness, exclusive of accidents	176.1	207.9	155.9	70.1	86.0
Respiratory diseases	120.4	107.4	89.1	33.2	40.1
Influenza and grippe	34.2	65.6	59.0	16.7	18.4
Tuberculosis	37.1	10.0	1.3	1.4	1.5
Bronchitis, acute, chronic	3.0	5.0	7.8	2.9	5.3
Pneumonia	4.5	3.1	1.3	4.9	3.3
Pharynx and tonsils	8.9	18.1	11.8	3.5	5.9
Other respiratory	[1] 32.7	5.6	7.9	3.8	5.7
Digestive system	14.1	28.1	13.1	9.3	12.7
Diseases of stomach, diarrhea, enteritis	3.7	11.2	3.9	4.6	6.1
Appendicitis	3.7	12.5	3.9	2.3	3.1
Other diseases of digestive system	6.7	4.4	5.3	2.4	3.5
Diseases of nervous system	8.2	12.5	5.2	3.9	5.7
Diseases of circulatory and genito-urinary systems	6.7	8.1	10.5	5.4	6.1
Diseases of the skin	.7	6.2	9.2	2.5	3.5
Rheumatism, acute and chronic	4.5	15.6	13.1	5.1	5.5
Ill-defined	9.7	1.9	1.3	.6	2.3
All other	11.9	28.1	14.4	10.1	10.1
Number of years under observation	1,346	1,602	763	89,305	336,525

[1] Nasal fossæ, 18.9; pleurisy, 11.6; asthma, 2.2.

Aside from the obviously high rate from tuberculosis in the granite industry (a subject which will be studied exhaustively in a later section), what stands out among granite workers are the high rates for diseases of the nasal fossae (which may be considered as a result of mechanical irritation), and pleurisy. The pleurisy, which was invariably dry, must be taken as being associated with the tuberculosis. The pneumonia rate is interesting, although based on small numbers.

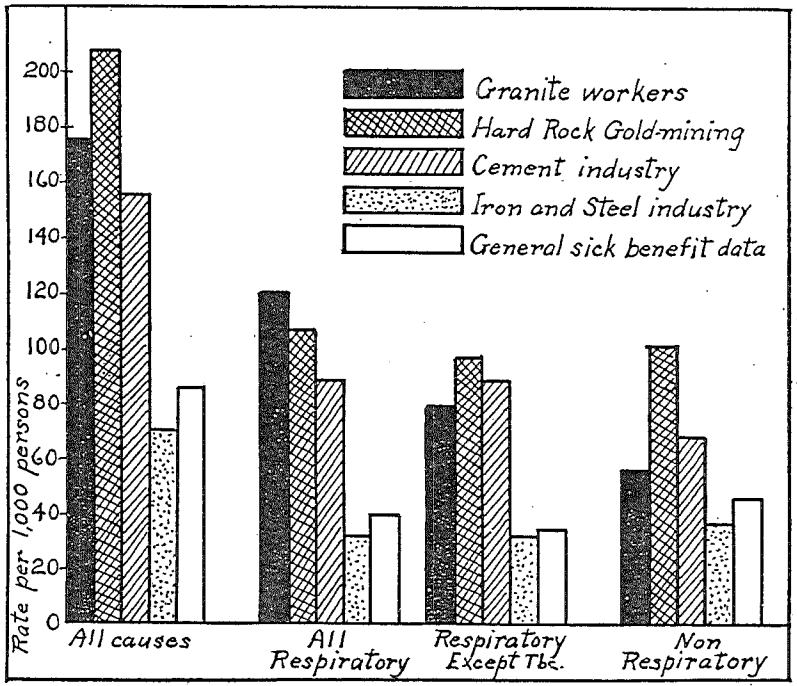


FIGURE 6.—Comparison of frequency of absence due to sickness among granite workers with that in certain other industrial groups. Eight days or longer

It may be stated that no sickness of a nervous character could be ascribed to the effect of the hand pneumatic-cutting instruments.

To make the comparison graphic a figure has been prepared to show the comparison in the case of broad groups: All causes, all respiratory, all respiratory except tuberculosis and suspected tuberculosis, all nonrespiratory. The rate for all causes (eight days and longer) is much higher than in the general experience represented by the sick benefit data, but it is not unique. For respiratory conditions, however, the rate for the granite industry is higher than any of the other groups compared. When allowance is made for the incidence of sickness due to tuberculosis, the gold-mining experience

(where dust of a similar nature is involved) and the cement experience are somewhat higher—all three being marked above the usual experience. For nonrespiratory illness, except ill-defined, the granite industry shows nothing significant.

In view of the fact that this study forms one of a group of investigations of the effect of specific dusts on the health of the worker, it is desirable to present a picture of the sickness rates in all of the studies, which is done in the following table. For the purpose of a satisfactory comparison all cases lasting two consecutive working days or longer are included.

TABLE 27.—*Sickness*[1] *from respiratory conditions in 6 dusty trades*

	Annual rate per 100 years of observation						Cases					
	Granite	Cement	Hard coal	Soft coal	Cotton	Silver polishing[2]	Granite	Cement	Hard coal	Soft coal	Cotton	Silver polishing[2]
Asthma	0.2	------	0.4	------	0.9	0.4	3	------	4	------	7	3
Bronchitis	.3	5.0	9.0	14.4	2.0	2.1	4	38	100	71	16	15
Pneumonia	.5	.4	.2	1.0	.2	.1	7	3	2	5	2	1
Tuberculosis	3.7	.1	.7	------	------	.1	50	1	8	------	------	1
Suspected tuberculosis	.8	------	------	------	------		11	------	------	------	------	
Nasal fossae	4.9	8.7	8.4	------	26.0	7.4	66	66	94	------	208	53
Grippe, influenza	4.3	20.6	18.1	1.2	18.6	6.6	58	157	202	6	149	47
Pharyngitis and tonsillitis	.7	7.5	5.7	4.7	2.9	.7	9	57	64	23	23	5
Pleurisy	1.1	.3	.9	.2	.2	.4	15	2	10	1	2	3
Other respiratory	------	.1	1.7	1.4	.4	------	------	1	19	7	3	------
Total respiratory	16.5	42.7	45.1	22.9	51.2	17.9	223	325	503	113	410	128
Years under observation	------	------	------	------	------	------	1,346	763	1,116	494	801	715

[1] Duration of 2 consecutive working days or longer.
[2] Males only, to agree with the other studies.

After making allowance for the irregularities involved in obtaining sickness records, some striking facts are brought out by the table. There is evidently a difference in the nature of the respiratory diseases occurring among persons exposed to different kinds of dust. The hard-coal industry and the cement plant have high rates for grippe and certain other minor respiratory infections. In the soft-coal industry, bronchial diseases and penumonia are excessive; in the cotton industry, grippe and nasal fossae conditions; in the granite industry, tuberculosis. Pleurisy is excessive in the granite and hard-coal industries. The silver-polishing group shows no excess from any cause.

Incidence in the various dust-count groups.—What is of particular significance in the present study, however, is the relation between the general sickness record and the dustiness of the occupations. Again, it is most feasible to use the broad dust-count groups referred to previously. Group A, it will be recalled, is made up of hand pneumatic-

tool cutters, including letterers and carvers; Group B of other cutters and workers subject to a dust hazard greater than that of the general plant atmosphere; Group C of workers subject to the general plant atmosphere; and Group D of workers with less than the dust of the general plant atmosphere.

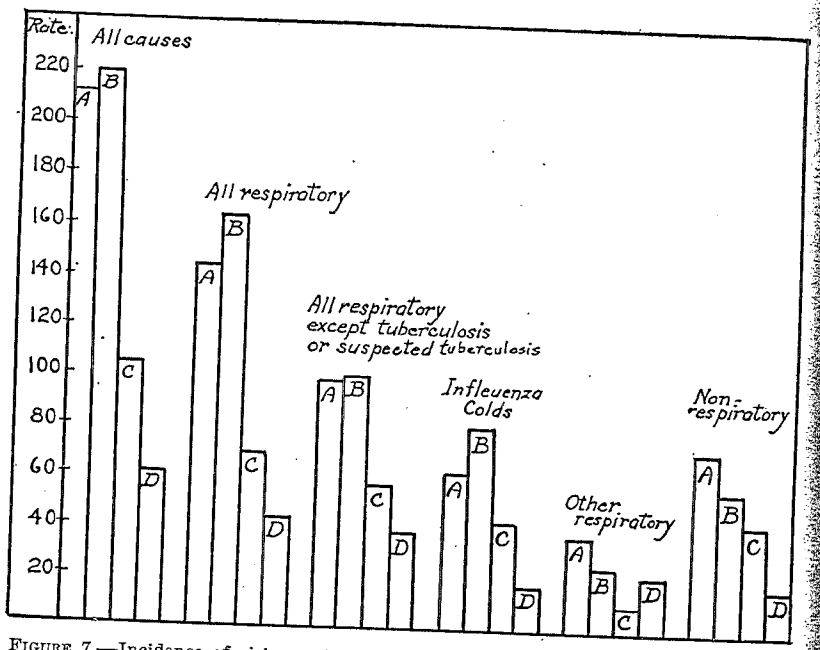


FIGURE 7.—Incidence of sickness from certain causes in the four dust count groups. Eight days or longer (rate per 1,000)

In Table 28 the rates (cases per 1,000 years of observation) are given for all causes and certain specific causes. A clearer picture of the relations is given in Figure 7.

TABLE 28.—*Incidence of sickness from certain causes in the four dust-count groups, eight days and more*

	Rate					Cases				
	Total	A	B	C	D	Total	A	B	C	D
All causes	176.1	212.0	219.2	105.2	61.0	237	169	35	22	11
All respiratory	121.1	144.3	162.8	66.9	44.3	163	115	26	14	8
All respiratory except tuberculosis and suspected tuberculosis	84.7	99.1	100.2	57.4	38.9	114	79	16	12	7
Influenza	36.4	37.6	68.9	33.5	5.5	49	30	11	7	1
Colds	19.3	25.1	12.5	9.6	11.1	26	20	2	2	2
Tuberculosis	37.1	45.2	68.9	14.3		50	36	11	3	
Suspected tuberculosis	4.4	6.3			5.5	6	5			1
Other respiratory	29.7	37.6	25.0	9.6	22.2	40	30	4	2	4
Nonrespiratory	58.7	72.8	56.4	43.0	16.6	79	58	9	9	3
Years of observation	1,346	797.1	159.7	209.2	180.4					

In Group A and Group B the incidence rate for all causes is about 215 per 1,000 years; in Group C it is 105; in Group D, 61. All respiratory shows a striking difference. When sickness from tuber-

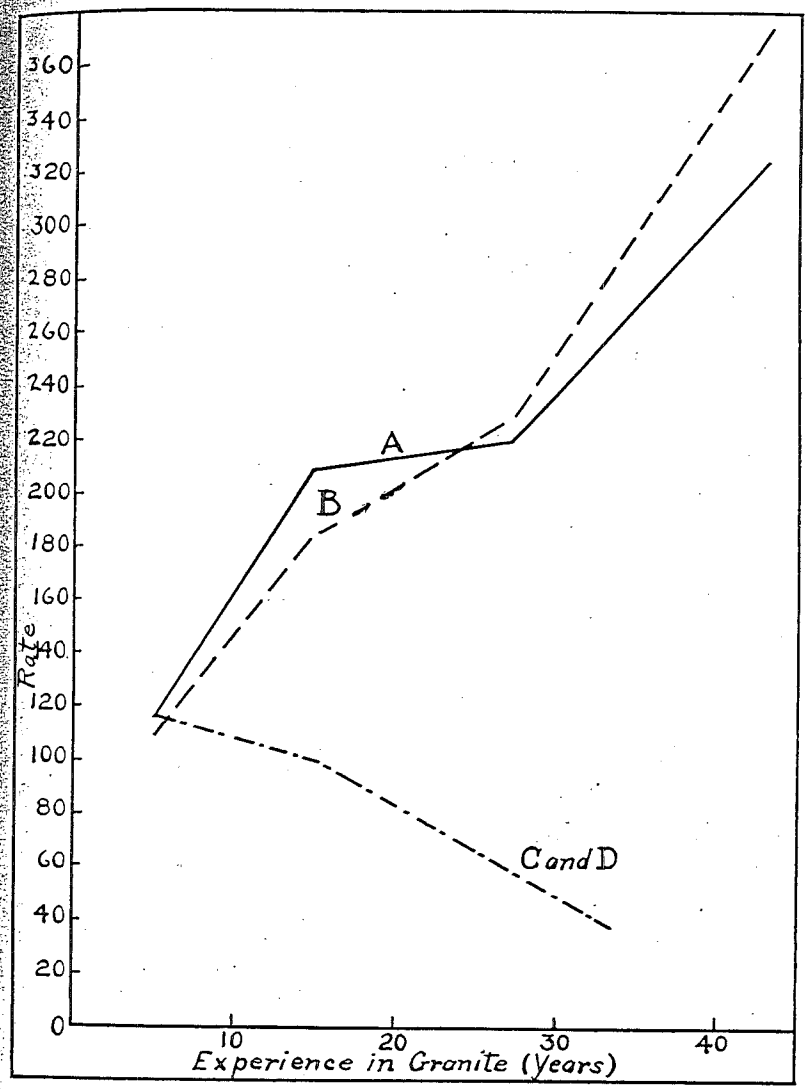


FIGURE 8.—Incidence of sickness from all causes in the four dust count groups by length of service. Eight days and more (rate per 1,000)

culosis and suspected tuberculosis is eliminated, the respiratory rates are still higher in Groups A and B than in C and D, due primarily to influenza and colds. Even the nonrespiratory shows a similar contrast. There is a positive suggestion in this material that

the general sickness rates among granite cutters, as well as the tuberculosis prevalence, reflects the excessive dust hazard. Groups C and D appear to have moderate rates.

An analysis was also made of the specific occupations falling into each dust-count group, and in general the differences just brought out persist for the specific occupations in any one dust-count group.

The relationship is strengthened when attention is given to the changes in these rates with length of service. First, the comparison is made for all forms of illness in Figure 8 and Table 29.

TABLE 29.—*Incidence of sickness from all causes in the four dust-count groups by length of service, eight days and more*

Dust groups	Total	Length of service (years)						
		Up to 5	5 to 9	10 to 14	15 to 19	20 to 24	25 to 34	35 and over
		Rate per 1,000						
A	212.0	115.9		210.2		220.1	325.4	
B	219.2	108.3		183.7		228.9	375.0	
C	105.2	116.3		100.0		37.9		
D	61.0							
		Cases						
A	169	5	12	21	18	29	51	33
B	35	3		5	2	6	10	9
C	22	11	1	6	3	1		
D	11	1	3		3	3	1	
		Years of observation						
A	797.1	95.6	51.1	103.4	82.1	171.0	192.5	101.4
B	159.7	18.4	9.3	17.2	20.9	21.0	48.9	24.0
C	209.2	49.8	26.6	31.9	36.1	31.2	28.8	4.8
D	180.4	26.3	34.9	19.3	32.6	36.3	16.3	14.7

The rates for the C and D groups decline with increasing length of service; in other words, with age. The story is very different with the A and B groups, which show a rapid increase in the rates from 116 per thousand to 325 per thousand for A, and from 108 per thousand to 375 per thousand for B.

As an additional indication of the relation between dust exposure and sickness rates among granite cutters, Table 30 has been prepared to show the changes in a broad way for certain types of illness. Since no marked difference was found between Groups C and D, they were combined in order to give sufficient numbers in the advanced length of service groups.

TABLE 30.—*Incidence of sickness from all causes and certain causes, by length of service, dust-count Groups A and B contrasted with dust-count Groups C and D, eight days and longer*

	Rate			Cases		
	Up to 10	10 to 24	25 and over	0 to 10	10 to 24	25 and over
All causes:						
A and B	114.7	195.0	280.9	20	81	103
C and D	116.3	85.4	15.5	16	16	1
All respiratory:						
A and B	51.6	134.8	207.2	9	56	76
C and D	65.4	64.0	15.5	9	12	1
All respiratory except tuberculosis and suspected tuberculosis:						
A and B	45.9	105.9	117.3	8	44	43
C and D	50.9	58.7	15.5	7	11	1
All nonrespiratory:						
A and B	63.1	62.6	81.8	11	26	30
C and D	50.9	26.7	----	7	5	----
Years observed:						
A and B	174.4	415.6	366.8	----	----	----
C and D	137.6	187.4	64.6	----	----	----

A good deal of the increase in Groups A and B is evidently to be ascribed to tuberculosis, but by no means all of it. Respiratory conditions still show an increase, even after sickness from tuberculosis and suspected tuberculosis has been subtracted. There is a definite increase in nonrespiratory sickness as well. Throughout the comparison it is found that Groups A and B start at the beginning of industrial life with rates corresponding to those in C and D, and then rise rapidly. Rates in C and D in advanced length of service groups are difficult to determine because of the small number of workers in these groups who remained for a long time in the industry; but in general there seems to be a tendency for the rates to decrease in conformity with normal morbidity experience. The rates in Groups A and B rise with length of service and thus appear to reflect an industrial hazard.

Sickness rates according to dust-count groups among persons without tuberculosis.—Although it has been shown that the sickness rates are greater in the A and B groups, with the greatest dust exposure, even apart from sickness from tuberculosis, this point can perhaps be brought out a little better by eliminating entirely all persons diagnosed on the physical examination as having tuberculosis or even "suspected" tuberculosis. This is done in the following table. The comparison is difficult because we are limited to the group of workers who were given physical examinations in plants carrying morbidity records, and must then subtract all cases that were diagnosed as having tuberculosis or suspected tuberculosis.

TABLE 31.—*Incidence of sickness from all causes, respiratory and nonrespiratory causes among persons not diagnosed on physical examiations as having either tuberculosis or suspected tuberculosis, eight days and more*

	Rate per thousand		Cases [1]		Years exposed	
All causes:						
Group A	239.6	257.5	49	63	204.5	244.7
B	348.2		14		40.2	
C	114.5	96.2	3	4	26.2	41.5
D	64.9		1		15.4	
Respiratory:						
Group A	132.0	143.0	27	35		
B	199.0		8			
C	76.3	48.1	2	2		
D						
Nonrespiratory:						
Group A	112.5	118.5	23	29		
B	149.3		6			
C	76.3	72.1	2	3		
D	64.9		1			

[1] Only 4 operations, all in Group A.

In spite of the small numbers which remain (only about 286 years of observation, on less than 200 persons), it is still possible to show very definitely a contrast between the sickness rates in Groups A, B, C, and D. The rate for all causes (which now, of course, does not include any absence due to tuberculosis) is 257 per 1,000 in Groups A and B combined and 96 per 1,000 in Groups C and D. A rate of 257 is extremely high for illness lasting eight days or longer; and this rate is based on 245 years of exposure. For respiratory diseases (again exclusive of any tuberculosis or sickness from "suspected" tuberculosis) the rates are 143 and 48, respectively. Although the latter rate, based only on two cases of illness, is subject to a wide fluctuation, the probable error of the rate being 22, it is still significantly below the rate for Groups A and B. It is found that the rates for nonrespiratory sickness are 118 and 72 for the A–B and C–D groups, respectively—again a clear excess for the groups more exposed to dust.

Sickness among persons with and without silicosis.—A number of workers were diagnosed on physical examination as not having silicosis. It becomes possible, therefore, to contrast this group with those having silicosis. In doing so, in order to make the two groups fairly comparable as to age and length of service, it appears best to limit the comparison to workers who have been in granite less than 15 years. Even with this limitation, twice as many persons are found with silicosis as without. The records can apply only to workers given physical examinations in plants where morbidity records were carried. The data are given in Table 32. As usual, sickness lasting eight calendar days and longer has been used; but in the case of colds and influenza an exception was made, because of the short duration of the average cold, and cases lasting two working days or longer have been included. No separation was deemed practicable between influenza and colds, since the cases classified as influenza were of no longer duration than those classified as colds.

TABLE 32.—*Incidence of sickness from all and from respiratory causes (8 days and more) among persons with and without silicosis; also from colds and influenza (2 days and more), less than 15 years' service in granite*

	Rate per 1,000	Cases	Years observed
All causes (8 days and over):			
Silicosis	263.5	20	75.9
No silicosis	220.4	8	36.3
All respiratory (8 days and over):			
Silicosis	158.1	12	
No silicosis	137.7	5	
Colds and influenza (2 days and over):			
Silicosis	158.1	12	
No silicosis	55.1	2	

In view of frequent statements in the literature as to the relatively high incidence of colds and other sickness among persons suffering from silicosis, this table is of special interest. Although the contrast is not great, and the numbers are small, there is suggested a slightly higher rate from all causes, all respiratory causes, and colds and influenza among persons with silicosis. In the case of colds and influenza the rate is more than twice as high.

Length of employment.—Study of sickness among the floating population in any industry is of interest; but it was not possible to make such a study in the present instance for two reasons. First, because there were very few persons of this character, the length of service being abnormally long. Second, because it was not possible to ascertain whether a worker who left the employ of one of the companies carrying morbidity records went into another industry, or simply transferred to one of the outside granite-manufacturing companies in Barre.

DURATION OF SICKNESS

Days lost from specific causes.—Severity rates in this study are based on calendar days lost per person per year (strictly per year of observation), using absences lasting two working days or longer. The rates are therefore slightly less than if based on all absences, but the difference is not material. It should also be mentioned that the duration was calculated from the date when disability began, not the date when the sickness began, since the latter information was not available. In comparison with the records of sick benefit associations, which are calculated from the date when sickness began,

this is a point which must be kept in mind. However, it is obvious that no material difference is occasioned.

In the case of severity rates absences due to more than one cause can not be treated as they were in the case of incidence. It is not legitimate to ascribe to one cause all of the duration of an absence due to two different causes. In order that the treatment may be as conservative as possible, days lost for joint causes have been included only when both causes fall in the group under consideration.

The severity rates among granite workers are excessive—more than 16 days per person per year. However, in view of the fact that most of this excess severity is due to tuberculosis and will be taken up in a later section, only a brief summary of the severity rates is necessary at this point. Table 33 gives very briefly the data as to days lost.

TABLE 33.—*Days lost from all causes of sickness and from broad classes*

	Days lost per person per year	Total days lost
All causes	16.6	22,408
All respiratory	14.4	19,325
All respiratory except tuberculosis and suspected tuberculosis	1.8	2,425
Nonrespiratory	2.1	2,805
Total years of observation		1,346

Comparison with other data.—More meaning will attach to these results if a comparison be made with representative data from other sources. Reference has already been made to data obtained from a rubber company, for which extensive experience is available. In both cases the figures are for the duration of illness lasting two days or longer. Since the employees of the rubber company are carried on the pay roll for 52 weeks of disability, it is necessary to make a correction by limiting the duration of long cases in the present study to one year. The rates are also given for the full duration and show that the difference made by this subtraction is not very great. Table 34 gives the days lost per person per year for each respiratory condition. Although the subject of tuberculosis will be taken up separately, as a matter of comparison the figures for tuberculosis are included in the present table. The data for the rubber company are based on working days lost instead of calendar days lost, so that possibly a seventh should be added to these rates for comparison with the rates for granite.

TABLE 34.—*Days lost from specific respiratory causes among granite workers and in a rubber company (males), joint causes classified according to primary cause*

	Days lost per person per year			Total days lost		
	Granite	365 days[1] maximum	Rubber company	Granite	365 days[1] maximum	Rubber company
All respiratory	14.53	12.22	1.61	19,561	16,456	17,699
Tuberculosis (active and suspected)	12.56	10.25	.08	16,904	13,799	903
Tuberculosis (active)	12.30	9.99	.08	16,551	13,446	903
Respiratory (except tuberculosis and suspected tuberculosis)	1.97		1.53	2,657		16,796
Influenza	.83		.55	1,112		6,057
Nasal fossæ	.28		.33	376		3,625
Pleurisy	.28		.10	374		1,108
Pneumonia	.35		.12	467		1,327
Tonsillitis	.13		.22	177		2,385
Pharyngitis	.02			33		
Bronchitis	.06		.16	76		1,778
Asthma	.03			42		
Other respiratory			.05			516
Years of exposure	1,346		10,984			

[1] For comparison with the rubber company, which keeps employees on the pay roll only for 52 weeks, the days were also calculated by regarding 365 days as the maximum for any one case.

As in the case of incidence, it was necessary to classify absence as to primary cause in order to make a satisfactory comparison with other data. In tables limited to this study alone the classification suggested previously has been followed.

It is clear that most of the sickness occurring among granite cutters, if taken from the point of view of days lost, is due to tuberculosis; in fact, where the rate for other respiratory conditions is 1.97 days per person per year, for tuberculosis it is 12.56.

Figure 9 gives the comparison for each respiratory condition aside from tuberculosis. The diseases showing a difference are influenza and grippe, pneumonia, pleurisy, and asthma.

For nonrespiratory diseases very little difference between the granite workers and the rubber company workers is found. Nervous-system disorders and diseases of special senses and epidemic and infectious diseases alone show higher rates in the granite group. The rate for all nonrespiratory diseases is appreciably lower in the granite group (2.12 to 2.55). The data are given in Table 35.

TABLE 35.—*Days lost from each class of disease among granite workers and in a rubber company (males). Joint causes classified as to primary cause.*

	Days lost per person per year		Total days lost	
	Granite	Rubber company	Granite	Rubber company
All causes	16.65	4.17	[1] 22,408	45,757
Respiratory	14.53	1.61	[2] 19,561	17,699
Nonrespiratory	2.12	2.55	2,847	28,058
Digestive	.57	.85	[3] 769	9,301
Nervous system and spinal cord	.45	.20	[4] 605	2,179
Circulatory system	.36	.11	[5] 478	1,210
Genito-urinary and annexa	.06	.10	79	1,056
Skin	.05	.11	62	1,187
Bones and joints	.06	.08	82	866
Epidemic and infectious	.18	.05	[6] 250	491
All others	.22	.54	296	5,914
Ill-defined and unknown	.17	.53	226	5,854
Years of life exposed	1,346	10,984		

[1] If limited to 52 weeks, rate is 14.34 and days lost 19,303.
[2] If limited to 52 weeks, rate is 12.22 and days lost 16,456.
[3] Of the 769 days, 501 are operations.
[4] Apoplexy 238 days, insane 122.
[5] Two cases of endocarditis 213 and 187 days.
[6] Syphilis 132 days.

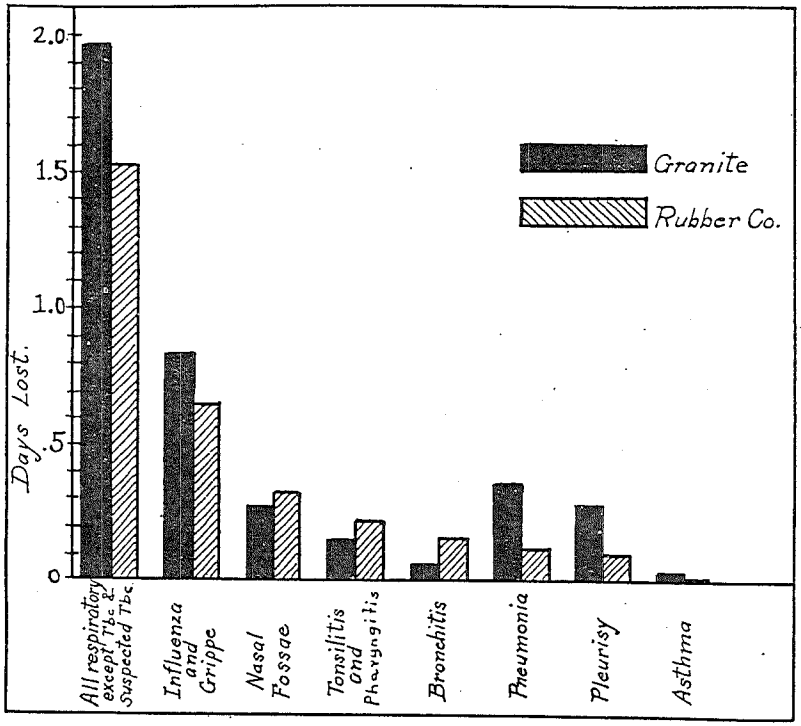


FIGURE 9.—Days lost from specific respiratory causes (exclusive of tuberculosis) among workers in granite and in a rubber company. Joint causes classified as to primary cause

Days lost in the different dust-count groups.—The relation in the various dust-count groups was found to be very significant in the case of tuberculosis. The following table gives the days lost per person per year for all causes, respiratory, tuberculosis, all respiratory except tuberculosis, and nonrespiratory. Days lost from absences due to two causes are excluded except where both causes fall in the specified group.

TABLE 36.—*Days lost from all and from respiratory causes in the four dust-count groups*

Group	Days lost per person per year					Years of observation
	All causes	All respiratory	Tuberculosis	All respiratory except tuberculosis	Nonrespiratory	
A	22.0	19.3	16.6	2.0	2.5	797.1
B	15.7	13.8	12.0	1.7	1.9	159.7
C	8.7	7.2	3.7	1.6	.9	209.2
D	3.1	1.5	.1	1.3	1.6	180.4

The great contrast between the four groups for days lost from all causes (22 for Group A to 3.1 for Group D) is clearly due mostly to tuberculosis, which will be discussed in detail in a later section. Therefore, in the accompanying table the effect of tuberculosis has been eliminated by considering days lost from respiratory conditions except tuberculosis and suspected tuberculosis, and also days lost from nonrespiratory conditions. The relation is not definite, but is slightly suggestive of higher rates in the groups most exposed to dust.

TABLE 37.—*Days lost from nontuberculous[1] causes of sickness in the four dust-count groups, by broad length of service periods in years*

Dust-count group	Days lost per person per year			Total days lost			Years of observation		
	Up to 10	10 to 24	25 and over	Up to 10	10 to 24	25 and over	Up to 10	10 to 24	25 and over
A	2.2	4.9	5.1	318	1,698	1,685	146.7	356.5	293.9
B				58	321	191	27.7	59.1	72.9
C	4.2	3.1	.5	241	405	9	76.4	99.2	33.6
D				337	174	25	61.3	88.2	31.0

[1] Active and suspected tuberculosis excluded.

Days lost in dust-count groups and years in granite.—In spite of the risk of repetition, it appears rather necessary to show the severity rates from all causes as affected by the occupation and the length of service. Again the broad dust-count groups are used. Table 38 gives the days lost per person per year.

TABLE 38.—*Days lost from all causes of sickness in the four dust-count groups, by broad length of service periods, in years*

Dust-count groups	Days lost per person per year			Years of observation		
	Up to 10	10 to 24	25 and over	Up to 10	10 to 24	25 and over
A	2.5	17.0	37.8	146.7	356.5	293.0
B	2.1	13.5	22.6	27.7	59.1	72.0
C	3.7	11.6		76.4	99.2	33.4
D	5.9	1.7		61.2	88.2	31.0

The association of sickness with the dust hazard could hardly be shown more concretely. Among hand pneumatic-tool cutters with

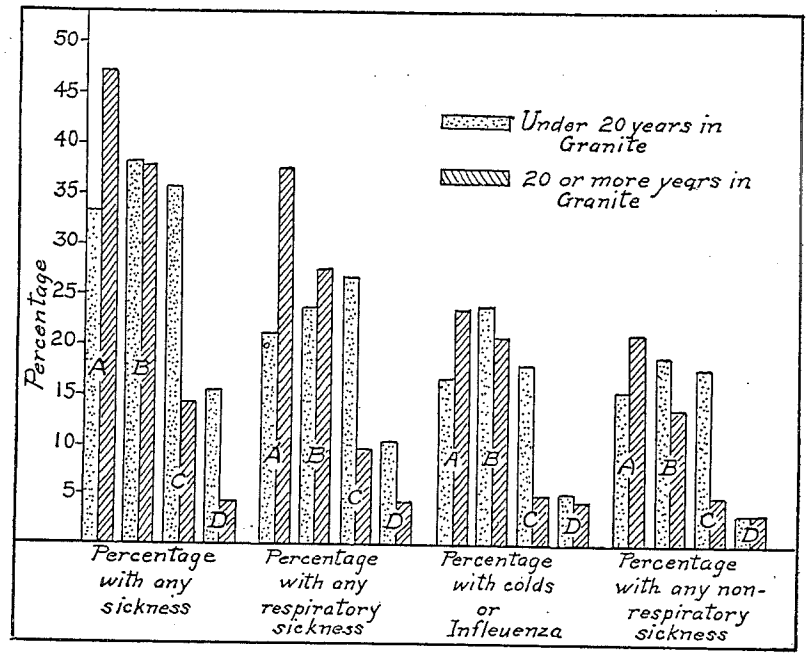


FIGURE 10.—Percentage of workers with sickness from certain causes by length of service and dust count groups

advanced length of service an average of 38 days was lost per person per year from all causes lasting two working days or longer. Group B rises to a point nearly as high. It is questionable as to whether any relation between dust hazard and the severity of sickness is suggested in the case of Groups C and D.

PERCENTAGE WITH CASES OF SPECIFIC SICKNESS

In sickness rates as used elsewhere in this bulletin no account is taken of the number of illnesses from which a given person might

suffer. In using 8-day and longer sickness this is not an important factor, but it does seem of interest to show that, if we consider the percentage of persons having a specific group of diseases, the relations found elsewhere in this report still hold. In dealing with such percentages, it becomes necessary to limit the study to individuals with approximately the same period of observation, since the chance that a worker would have an illness would increase as his record of observation increased. Accordingly, the comparison is limited to workers who were in the study for two years or longer, and is based on the number of workers, not on the years of observation. If an individual has two cases of illness, one respiratory and one nonrespiratory, he would count both as a person sick from respiratory illness and as a person sick from nonrespiratory illness. For this reason, the sum of the percentage of persons sick from these two groups will be in excess of the percentage of persons sick from any cause. Table 39 and Figure 10 present the percentages for the four dust-count groups. To make a rough allowance for the factor of length of service, which is so different in the A and B groups from what it is in the C and D groups, those with less than 20 years in granite and those with 20 years or more in granite have been treated separately.

TABLE 39.—*Percentage of workers (in study for two years or longer) with sickness from certain causes, by length of service and dust-count groups*

	Percentage			Number		
	All	Less than 20 years	20 years and over	All	Less than 20 years	20 years and over
With any sickness:						
A	42.3	33.3	47.2	80	22	58
B	38.0	38.1	37.9	19	8	11
C	28.8	35.6	14.3	19	16	3
D	11.3	15.4	4.3	7	6	1
With any respiratory sickness:						
A	31.7	21.2	37.4	60	14	46
B	26.0	23.8	27.6	13	5	8
C	21.2	26.7	9.5	14	12	2
D	8.1	10.3	4.3	5	4	1
With cold or influenza:						
A	21.2	16.7	23.6	40	11	29
B	22.0	23.8	20.7	11	5	6
C	13.6	17.8	4.8	9	8	1
D	4.8	5.1	4.3	3	2	1
With any respiratory except cold, influenza, and tuberculosis, all forms:						
A	6.3	6.1	6.5	12	4	8
B	2.0		3.4	1		1
C	4.5	4.4	4.8	3	2	1
D	3.2	5.1		2	2	
With any nonrespiratory:						
A	19.0	15.2	21.1	36	10	26
B	16.0	19.0	13.8	8	4	4
C	13.6	17.8	4.8	9	8	1
D	3.2	5.1		2	2	
Persons:						
A				189	66	123
B				50	21	29
C				66	45	21
D				62	39	23

The results are quite consistent with what has been shown elsewhere. The dust-count groups with the greatest exposure show the largest percentages with illness, whether the criterion is all illness, respiratory, colds, influenza, or a nonrespiratory illness. Also, the percentage of persons affected in the A group generally shows a tendency to be higher among those with 20 years or more length of service in granite.

RELATIVE SICKNESS IN THE VARIOUS PLANTS STUDIED

In an earlier section of the report were given the dust counts as found in specific occupations in the various plants under observation. More or less difference was found. However, the following tables indicate that the sickness rates were not radically different in the various plants. Table 40 presents the material for several of the large plants, for all diagnoses, for respiratory, and for nonrespiratory. Considering the small numbers, the rates are remarkably uniform.

TABLE 40.—*Incidence of sickness in the larger plants, all diagnoses and respiratory and nonrespiratory diagnoses, 8-day and longer*

Plants	Rate per 1,000 years observed			Cases			Years of observation
	All diagnoses	Respiratory	Nonrespiratory	All diagnoses	Respiratory	Nonrespiratory	
All plants	176.1	121.1	58.7	237	163	79	1,346.0
Plant K	150.9	137.2	27.4	11	10	2	72.9
Plant A	149.9	105.6	44.3	44	31	13	293.5
Plant I	204.8	149.0	55.9	22	16	6	107.4
Plant B	170.6	108.2	66.6	41	26	16	240.3
All other	188.2	126.5	66.4	119	80	42	632.3

Table 41 gives similar data as to severity:

TABLE 41.—*Days lost from respiratory and nonrespiratory illness, by plant*

Plants	Days lost per person per year			Total days lost			Years of observation
	Any sickness	Respiratory	Nonrespiratory	Any sickness	Respiratory	Nonrespiratory	
All plants	16.6	14.4	2.1	22,408	19,329	2,805	1,346.0
Plant K	17.2	16.7	.3	1,253	1,221	19	72.9
Plant A	12.6	9.9	2.7	3,703	2,915	788	293.5
Plant I	29.6	26.5	3.1	3,176	2,845	331	107.4
Plant B	12.2	9.8	2.2	2,937	2,364	524	240.3
All others	17.9	15.8	1.8	11,339	9,984	1,143	632.3

Two plants were large enough to permit a broad comparison by dust-count groups and length of service. (Table 42.) The [illegible]

encies previously pointed out are found in these two plants and also in the group of "other" plants.

TABLE 42.—*Days lost from all causes, by plant, dust-count groups, and length of service*

Plant	Dust-count groups	Days lost per person per year		Total days lost		Years of observation	
		Under 20 years	20 years and more	Under 20 years	20 years and more	Under 20 years	20 years and more
All	A and B	7.1	30.8	2,836	17,181	398.1	558.7
	C and D	8.8	1.0	2,261	130	257.5	132.1
"A"	A and B	16.6	23.2	1,245	2,113	74.8	91.2
	C and D	3.8	.7	315	30	82.1	45.4
"B"	A and B	7.2	24.3	404	2,362	56.1	97.4
	C and D	2.9	.2	164	7	55.6	31.2
All other	A and B	4.4	34.3	1,187	12,706	267.1	370.1
	C and D	14.9	1.7	1,782	93	119.8	55.5

ABSENCE FROM CAUSES OTHER THAN SICKNESS

From the nature of obtaining the sickness record and the other conditions previously outlined, the authors feel that a reasonably complete record of absence due to sickness was obtained. It does seem advisable, however, to indicate that the higher rates found in the groups with the high dust counts could not be due to failure to classify absence as due to sickness in these groups. In fact, a much greater proportion of absence from other causes also occurred in these groups. In Tables 43 and 44 are given the rates of absence due to vacations and "other reasons (not sickness)" in the four dust-count groups, and also the days absent from these two sets of conditions. Absences of two working-days or longer are considered. It is necessary to state that practically no absences occurred from closing down of plants except in the fall and winter of 1924. During this period, when a good deal of slackness occurred, even vacations were closely associated with the closing of plants, and it was found advisable to omit from the following tables (*a*) all absences classed as "no work" (these were the result of closing of plants and therefore could not be ascribed as connected with sickness); (*b*) vacations during Christmas, 1924 (a large proportion took vacations at this time because of slackness in the work); (*c*) vacations abroad (these may have been associated in some cases with sickness, but their duration was so great that it did not seem practicable to include them in the tables); (*d*) absences due to "other reasons" from January 20 to February 1, 1925 (special closing of the plants occurred at this time, and the absences evidently were not connected with sickness).

TABLE 43.—*Incidence of absences from causes other than sickness in the four dust-count groups, by length of service, two days and longer*

	Rate				Cases				Years of observation			
	Total	Up to 10	10 to 24	25 and over	Total	Up to 10	10 to 24	25 and over	Total	Up to 10	10 to 24	25 and over
Total:												
A	411	341	418	439	328	50	149	129	797.1	146.7	356.5	293.9
B	338	325	491	219	54	9	29	16	159.7	27.7	59.1	72.9
C	210	183	242	179	44	14	24	6	209.2	76.4	99.2	33.6
D	116	163	91	97	21	10	8	3	180.4	61.2	88.2	31.0
Vacations:												
A	236	225	233	245	188	33	83	72				
B	194	181	271	137	31	5	16	10				
C	124	131	131	89	26	10	13	3				
D	55	49	57	65	10	3	5	2				
Other reasons:												
A	176	116	185	194	140	17	66	57				
B	144	144	220	82	23	4	13	6				
C	86	52	111	89	18	4	11	3				
D	61	114	34	32	11	7	3	1				

TABLE 44.—*Days absent from causes other than sickness in the four dust-count groups*

Dust count group	Rates per 1,000 years of observation			Days absent				Years of observation
	All causes other than sickness	Vacation	Other reasons	All causes other than sickness	Vacation	Other reasons		
						Total	No work	
A	2.98	1.81	1.17	2,374	1,439	935	95	797.1
B	2.27	1.20	1.06	362	192	170	33	159.7
C	1.29	.79	.50	270	166	104	8	209.2
D	.62	.28	.34	112	51	61		180.4

Both "vacations" and "other reasons" are closely associated with the dust-count groups, whether we deal with the incidence of such absences or their duration. It has already been observed that the groups most exposed to dust were also those in the best economic circumstances. It appears that they therefore felt freer to take vacations or to be absent from miscellaneous causes. At the same time, it is possible that the dust hazard itself resulted in some absences, the men feeling the necessity of laying off in order to recuperate. It is not necessary to stress such a hypothetical point. The discussion has been brought in particularly to show that there could hardly have been a tendency for absence which was in reality due to sickness to be ascribed to other causes more frequently in the C and D dust-count groups than in the A and B dust-count groups.

SICKNESS PRIOR TO DEVELOPMENT OF TUBERCULOSIS

Sickness from other causes among persons who have tuberculosis requires special treatment, because while a person is disabled from

tuberculosis no record is possible of sickness from other diseases which he might have, or which he would have if he were at work. In calculating rates of this character, accordingly, it has been found advisable to subtract from the exposure the weeks during which each person was disabled from tuberculosis. What is of special interest is that such rates give, for the tuberculous population, the rate of sickness during the period prior to the break from tuberculosis.

This record was usually obtained before physical examination or the classification of the case as to the presence of tuberculosis.

TABLE 45.—*Incidence of sickness, eight days and longer, except tuberculosis and suspected tuberculosis, of different classes among workers with and without tuberculosis on physical examination*

	Rate per 1,000		Cases	
	Group with tuberculosis actual or suspected on physicals	Others	Group with tuberculosis actual or suspected on physicals	Others
All cases (except tuberculosis or suspected tuberculosis)	320.8	118.0	35	146
All respiratory (except tuberculosis or suspected tuberculosis)	183.3	70.3	20	87
Digestive and genito-urinary	55.0	14.6	6	18
Epidemic and general	27.5	21.8	3	27
Ill-defined	73.3	4.0	8	5
Influenza	82.5	29.9	9	37
Colds	27.5	17.8	3	22
Other respiratory	82.5	25.1	9	31
Years of observation			109.1	1,236.9

The table is based not on the frequency of absences, but on the incidence of sickness from the various classes of disease; in other words, an absence due to two causes would be assigned to both, and the sum of the incidence rates will be greater than that of the frequency of absences from all causes. This is discussed on page 48.

The rate for all causes among persons who subsequently developed tuberculosis was nearly three times as high as among the others. The excess is found in the case of nearly all diagnoses, but special note should be given to the large number of ill-defined conditions from which this group suffered.

Considerable sickness was classified by the worker as "fatigue," and in some instances this diagnosis was made in persons who later developed tuberculosis. Figure 11 indicates the sickness record for each case of "fatigue," with the result of the case, with respect to the development of tuberculosis.

MORTALITY DURING PERIOD OF STUDY

During and subsequent to the period of the study a large number of deaths occurred among the workers, both in plants where morbidity records were kept and in other plants. A record of these deaths was obtained and the number dying from each cause is shown in Table 46. The age at death for each individual is added in parentheses, except in the case of tuberculosis.

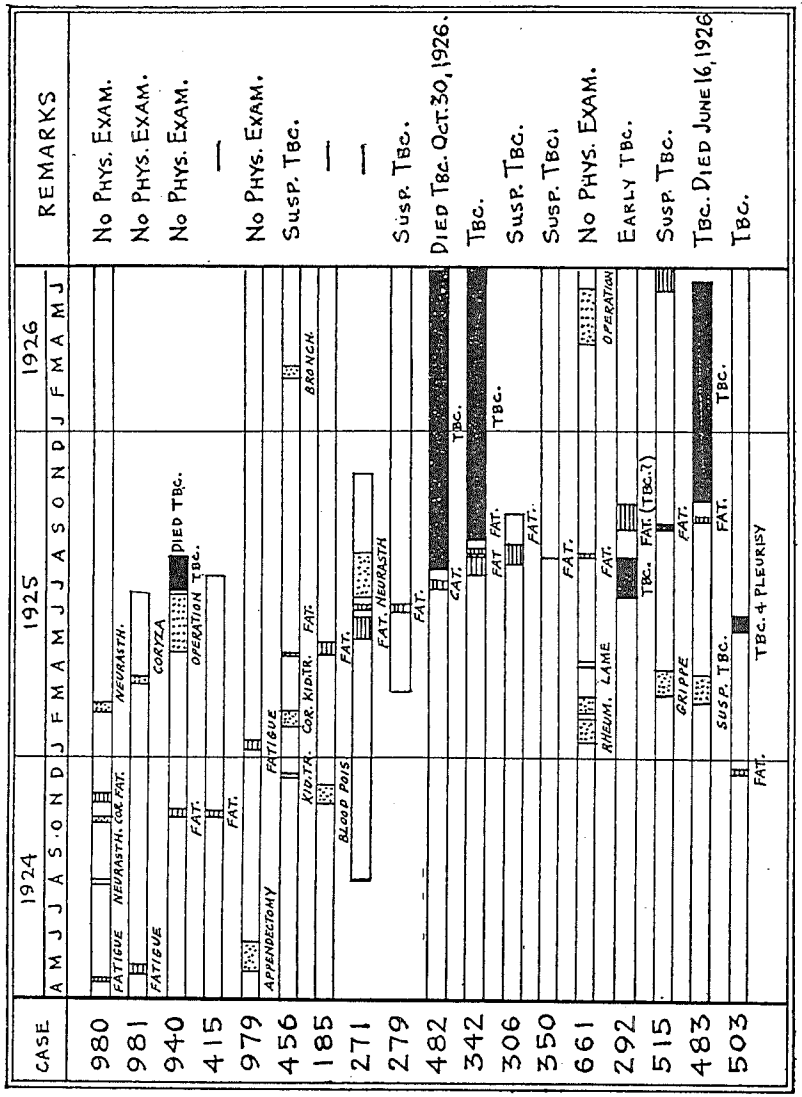


FIGURE 11.—Sickness diagnosed as "fatigue." Two days and more

TABLE 46.—*Mortality by cause for granite workers in plants carrying morbidity records and in outside plants*

Cause of death	In plants carrying morbidity records	In outside plants
Tuberculosis	41	32
Pneumonia	4 (46,[1] 40, 27, 64)	
Endocarditis	2 (55, 52)	
Cancer	2 (54, 48)	2 (58, 22)
Valvular heart disease and nephritis		1 (60)
Apoplexy	1 (59)	
Cerebral embolism and chronic gastric enteritis		1 (51)
Prostatectomy		1 (44)
Ill-defined	2 (46, 51)	
Nonindustrial accident	4 (53, 45, 38, 65)	
Total	56	37

[1] Age at death.

The main cause of death was evidently tuberculosis (78 per cent) and these deaths are considered separately in a later section. It is rather interesting to note that there was but one death from nephritis or other kidney condition, which is consistent with the analysis of the death certificates, where no excess was found (p. 181).

IV. PHYSICAL EXAMINATION FINDINGS APART FROM SILICOSIS AND TUBERCULOSIS

GENERAL CONSIDERATIONS

The physical characteristics of granite workers during the early part of their employment in this industry have been taken up in the section devoted to factors influencing sickness. The purpose of the present discussion is to bring to bear upon the problem of the dust hazard in this industry what further information is available from the physical examinations, the points of particular interest being silicosis, other symptoms and physical signs depending on exposure to dust, rhinitis and pharyngitis, hearing, chest expansion and vital capacity, blood pressure, and miscellaneous factors. In addition, some effort is made to tie up the physical examinations with the sickness record. Before these points are taken up, certain preliminary considerations require mention.

Percentage of workers examined.—As previously noted, 296 physical examinations were made of workers in the plants carrying morbidity records, and 207 additional physical examinations were made of workers in outside plants. These are the two groups of examinations which will be analyzed in this section. Later, some attention will be given to two additional groups; those among workers formerly employed in granite but at the time of the study working in some nondusty industry, and those in the families of granite workers.

Of special interest are the group of 296 physical examinations made in plants carrying morbidity records, because these are based on a population (the total number with morbidity records) of known characteristics as to age, length of service, race, plant, etc. Of the 972 persons having morbidity records, 30 per cent were given a physical examination. In general, these examinations were made of workers who volunteered, but, in addition, every effort was made to secure examinations on cases suspected of being tuberculous.

The percentage of workers who were examined in each plant was determined, and while this varied from 20 to 50 per cent, in general it tended to be the same in most of the plants.

Representativeness of physical examinations.—In view of the fact that not all the workers in the plants under special study were given physical examinations, a point of fundamental significance is

the extent to which the group given physical examinations was representative of all of the workers in the plants. The fact that every effort was made to secure examination of persons suspected of having tuberculosis (a procedure of great importance in ascertaining the exact prevalence of this disease) suggests immediately that a selection has taken place. Reference to this factor was made on page 31, where the sickness rates in the groups with and without physical examinations were compared for varying lengths of service. It was found that the sickness rates were fairly comparable among workers who had been in the industry a relatively short time, but not in the least comparable among workers who had been exposed for a considerable period. This comparison gives the clue to a possible interpretation of the examinations in terms of the total group of workers—the group with short lengths of service (under 15 years) may be taken as fairly representative, while on the other hand, the group with long lengths of service (15 years or over) must be taken, in general, as including all workers most severely affected by the dust hazard. Briefly, then, for workers with less than 15 years of service, the percentage with silicosis or related conditions which appear early in the period of dust exposure can be determined from the physical examinations themselves, disregarding entirely the group not given examination. Thus, among hand pneumatic-tool cutters with less than 15 years' exposure to granite dust, 87 out of 107 were classed as having silicosis (see p. 89) or 81 per cent. Since this percentage increases very rapidly with length of service, it is not in itself of much importance, but it shows the process followed of relating the number with silicosis to the total number given physical examinations, rather than to the total number of workers in the plants carrying morbidity records. Since only those given physical examinations are considered, it is possible to include the outside plants, among whom 207 physical examinations were made. This has been done in the above calculation. When consideration is given to workers with advanced lengths of service, however, the opposite procedure is employed. For instance, the number found to have active tuberculosis is related not to the total number given physical examinations, but to the total number of workers in the plants carrying morbidity records. For this purpose, it is necessary to disregard the examinations made in plants where no morbidity records were maintained. This distinction is fundamental.

The physical examinations were not confined to one period of the study or to any one season of the year, but were distributed fairly equally over the whole time.

CHEST EXPANSION AND VITAL CAPACITY

A cardinal physical sign accompanying silicosis as recognized in all studies of this subject is a diminished chest expansion. It has already been noted that at the beginning of industrial life granite workers without tuberculosis had a chest expansion not below that of other industrial workers. On the other hand, their vital capacity seemed somewhat lower than might be expected. It is of considerable interest to trace the effect of exposure to granite dust upon both of these factors. To do so it seemed necessary to separate those who had tuberculosis, or were suspected of having it, from the others, since the chest expansions and vital capacities would be lowered by this condition. In the following tables, accordingly, the data are given separately for those with and those without tuberculosis. This is especially necessary in view of the fact that the group given physical examinations are, as has been emphasized, overweighted by these cases of tuberculosis. If actual and suspected cases of tuberculosis are omitted, the group may be taken as much more representative of the granite worker generally than would otherwise be the case, at least of the granite worker who has not yet developed tuberculosis. All workers given physical examinations, whether in the plants carrying morbidity records or not, are included.

TABLE 47.—*Chest expansion of workers with and without tuberculosis (actual and suspected), by length of service*

Years in granite	Average	Distribution as to chest expansion (in centimeters)												
		0	1	2	3	4	5	6	7	8	9	10	11	12
Without tuberculosis (actual or suspected)														
Up to 5	7.7				1	4	2	4	5	4	2	4	3	3
5 to 9	7.1					2	3	2	4		1	1		2
10 to 14	7.4				1	3	6	2	5	2	1	3	3	2
15 to 19	6.7				1	3	4	4	1	3		5		
20 to 24	6.4		1	1	3	9	5	2	4		4	4	1	2
25 to 34	5.5		2	1	6	6	1	5	8	4	2	2		
35 and over	3.6		2	2	4	1	3	1		3				
With tuberculosis (actual or suspected)														
Up to 5	5.7			2				1			1			
5 to 9									1			1		
10 to 14					1	2	3	4	2		1			
15 to 19						1	1						1	
20 to 24	6.5			1		2	1		2	1				1
25 to 34	4.4		1	3	5	7	6	3	2	1	1			
35 and over	3.3		2	3	3	3	1	2						

TABLE 48.—*Vital capacity of workers with and without tuberculosis (active and suspected), by length of service*

Years in granite	Average	Distribution as to vital capacity (in liters)																
		1.8 to 1.9	2.0 to 2.1	2.2 to 2.3	2.4 to 2.5	2.6 to 2.7	2.8 to 2.9	3.0 to 3.1	3.2 to 3.3	3.4 to 3.5	3.6 to 3.7	3.8 to 3.9	4.0 to 4.1	4.2 to 4.3	4.4 to 4.5	4.6 to 4.7	4.8 to 4.9	5.0 and over
Without tuberculosis (active or suspected)																		
Up to 5	4.0							1	1	6	5	1	6	1	4		2	4
5 to 9	4.0							1	2	1	2	1	3	1		5		1
10 to 14	4.0							3	2	1	2	6	3	6	3	1		3
15 to 19	3.9							2	2	2	1	2	3	1	2	1	1	1
20 to 24	3.8				2	1	2	2	3	4	1	2	9		4	2	3	1
25 to 34	3.4		4		1	3	2	5	2	2		6	6			3		
35 and over	3.0		1	1			3	8		1			1					
With tuberculosis (active or suspected)																		
Up to 5			2						2				1					
5 to 9	3.3										1			1				
10 to 14			2				1	1	2		2	1	1		1	1		
15 to 19	3.3			1														2
20 to 24				2		1		1	1	1				1				
25 to 34	3.0		2	1	4	4	1	5	2			1		1		2		
35 and over	3.0	1	1	1		1		5	1		2			1			1	

Average chest expansion starts at 7.7 centimeters; by 20 years in granite (about 40 years of age) it is 6.4; after 35 years in granite (age about 55 and over) it is 3.6. The corresponding figures for vital capacity are 4 liters, 3.8, and 3.

The meaning of these figures can be made clear by a comparison with general industrial data. Figures 12 and 13 give the curves for 10,000 male industrial workers from Public Health Bulletin No. 162, together with the curves for the present study, both for persons without tuberculosis or suspected tuberculosis and for those with this condition. As in previous cases 20 years may be added to the length of service in estimating age.

Starting at about the same height the granite workers show a more rapid decline than do the industrial workers, even in the group without tuberculosis or suspected tuberculosis. There is every presumption that this decreasing chest expansion reflects the developing fibrosis. The group with tuberculosis lies below the other group. The curve for vital capacity is more difficult of interpretation, as the granite workers show a definitely lower vital capacity throughout than do the industrial workers. Here, as would be expected, the group with tuberculosis is consistently less than the other granite workers.

BRONCHITIS

It was expected that a number of cases of bronchitis would be found among the granite workers. Collis [29] speaks of it as a common

complication of silicosis among the miners in South Africa. It has been previously stated that the diagnoses used in the morbidity records were obtained from the physicians in private practice in Barre, Vt., and this removed the personal factor in diagnosis. Doctor McFarland,[30] who has spent a number of years in private practice in Barre, Vt., states that "Chronic bronchitis is not a frequent complication (of silicosis), although it does occur."

Râles in cases of silicosis uncomplicated were not frequently found. The incidence of basal râles, unaffected by cough (indicative of bronchitis), was very low, apparently much less than what would be found in other persons who are as robust as the granite workers in the group studied. The pathology of chronic bronchitis, briefly, is a chronic infection of the bronchial mucosa and an ultimate thinning of the walls and dilatation of the bronchioles. The extensive fibrosis incident to silicosis is quite opposite to this condition.

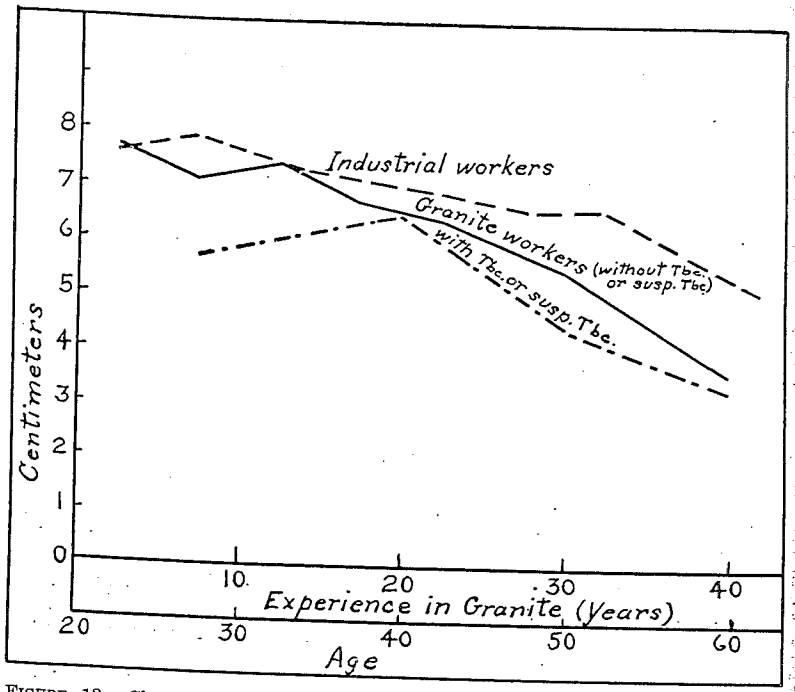


FIGURE 12.—Chest expansion of granite workers with and without tuberculosis (active and suspected) by length of service and of general industrial workers of corresponding ages

Working and living conditions of persons exposed to dust are probable factors in the prevalence of bronchitis. The chemical content of

[30] McFarland, William: Silicosis and Tuberculosis as Seen in Granite Workers at Barre, Vt. Jour. Ind. Hyg., August, 1927.



X ray 1.—Case 424. P. L., Austrian, aged 38 years

Granite cutter with hand pneumatic tool for 23 years.
Examination: Height, 66 inches; weight, 152 pounds; chronic rhino-pharyngitis; systolic blood pressure, 120; vital capacity, 3,600 cubic centimeters; chronic bronchitis and silicosis.

the dust, however, seems to be the main causative factor. Landis[31] makes no report of bronchitis as occurring among the cases of silicosis in potters he observed; however, he found that it was very common among workers exposed to organic dust.

Lanza[32] does not mention bronchitis as occurring frequently in cases of silicosis among the zinc miners in southwestern Missouri.

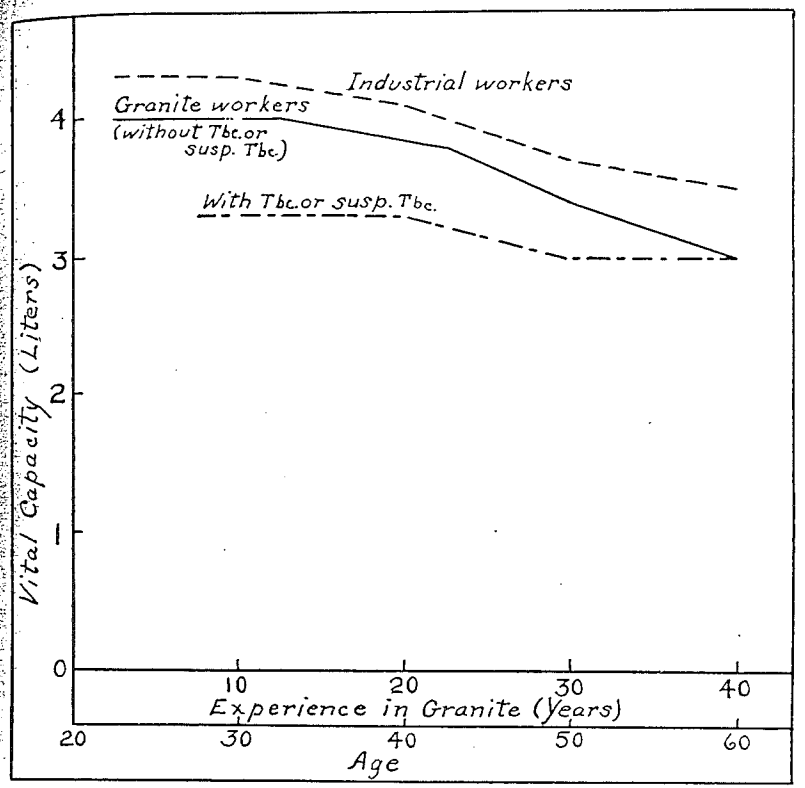


FIGURE 13.—Vital capacity of granite workers with and without tuberculosis (active and suspected) by length of service; and of general industrial workers of corresponding ages

An X ray of one person having chronic bronchitis and silicosis is included in this section.

HEARING

A probable effect of the granite working on hearing is suggested in the material collected in this study. In Table 49 is given the percentage and number of workers with normal hearing in both ears

[31] Landis, H. R. M.: The Relation of Organic Dust to Pneumonokoniosis.
[32] Lanza, A. J.: Miners' Consumption. A Study of 433 Cases of the Disease Among Zinc Miners in Southwestern Missouri. Public Health Bulletin No. 85, 1917.

according to years in granite, also the amount of the defect.[33] The ability to hear whispered voice sounds at 20 feet was classed as normal.

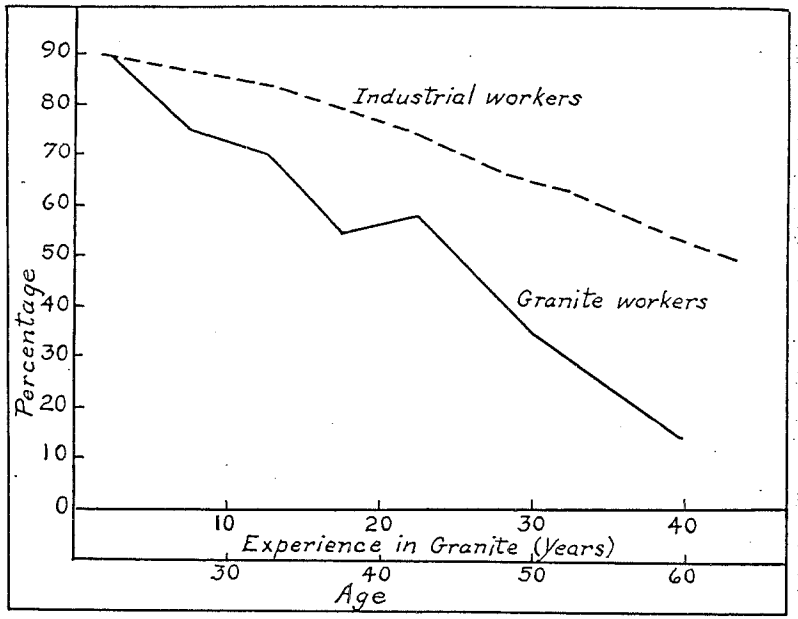


FIGURE 14.—Percentage of granite workers with normal hearing in both ears by length of service compared with general industrial workers of corresponding ages

TABLE 49.—*Percentage, with specified degrees of hearing, by length of service*

Years in granite	Percentage						Number					
	Total	Normal both ears	Poorer ear: 15 feet	Poorer ear: 10 feet	Poorer ear: 5 feet	Entirely deaf	Total	Normal both ears	Poorer ear: 15 feet	Poorer ear: 10 feet	Poorer ear: 5 feet	Entirely deaf
0 to 4	100	89	11	------	------	------	28	25	3	------	------	------
5 to 9	100	75	25	------	------	------	16	12	4	------	------	------
10 to 14	100	70	17	13	------	------	40	28	7	5	------	------
15 to 19	100	54	25	21	------	------	24	13	6	5	------	------
20 to 24	100	58	35	4	2	2	52	30	18	2	1	1
25 to 34	100	35	49	14	------	1	77	27	38	11	------	1
35 and over	100	14	64	22	------	------	36	5	23	8	------	------

Comparison is next made with the general industrial population in Table 50 and Figure 14.

[33] Those with active or suspected tuberculosis, who showed no significant differences from the others, are included.

TABLE 50.—*Percentage of granite workers with normal hearing in both ears, by length of service, compared with that of general industrial workers of corresponding ages*

Years in granite	Granite workers	Age	Industrial workers generally [1]	Years in granite	Granite workers	Age	Industrial workers generally [1]
Up to 5	89	Up to 25	90	25 to 29	35	45 to 49	67
5 to 9	75	25 to 29	87			50 to 54	63
10 to 14	70	30 to 34	84	30 and over	14	55 to 59	56
15 to 19	54	35 to 39	79			60 and over	50
20 to 24	58	40 to 44	74				

[1] Public Health Bulletin 162, p. 161.

Both curves start at approximately the same point, indicating a fair agreement in the method of conducting the test; but the curve

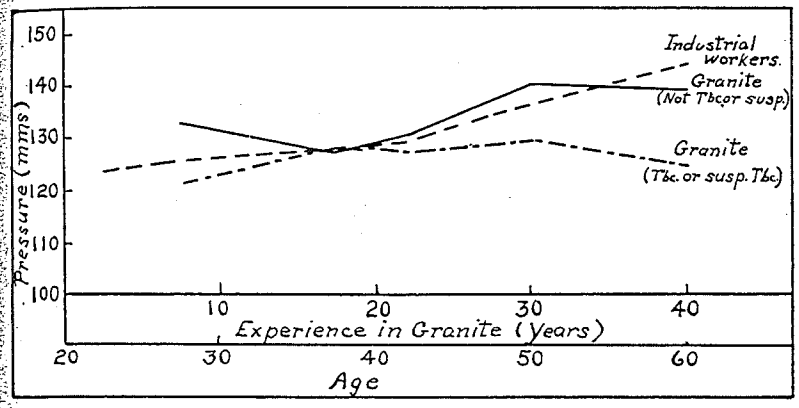


FIGURE 15.—Systolic blood pressure of granite workers with and without tuberculosis, active and suspected, by length of service and of general industrial workers of corresponding ages

for granite workers falls with much greater rapidity than the curve for industrial workers. In fact, the contrast in later industrial life is so great that there seems no reasonable doubt of the relation between hearing and granite working.

BLOOD PRESSURE IN COMPARISON WITH OTHER STUDIES

Systolic and diastolic blood pressures were taken as a part of the routine of the physical examination. From Public Health Bulletin No. 162 is taken the curve found among 10,000 male industrial workers, and this is placed (in fig. 15) beside a curve for granite workers without tuberculosis (actual or suspected), and a third curve for granite workers with this condition. The averages and distribution for granite workers are given in Table 51.

TABLE 51.—*Systolic blood pressure of granite workers with and without tuberculosis, active and suspected, by length of service*

Years in granite	Average	95 to 104	105 to 114	115 to 124	125 to 134	135 to 144	145 to 154	155 to 164	165 and over
Up to 15 years:									
Without tuberculosis	133	1	3	22	28	22	4	5	
With tuberculosis [1]	122	1	4	5	5	2			
15 to 19:									
Without tuberculosis	127		3	4	11	2	1		
With tuberculosis [1]	129	1	1	2		3		1	
20 to 24:									
Without tuberculosis	131		3	19	8	11	3	3	1
With tuberculosis [1]	128	1	2	5	5	1	2	1	
25 to 34:									
Without tuberculosis	140	1	2	5	9	13	15	4	3
With tuberculosis [1]	130		5	9	6	9	4	1	
35 and over:									
Without tuberculosis	139	1	1	4	2	2	4	3	2
With tuberculosis [1]	125	2	3	5	2	3	1	1	

[1] Actual or suspected.

As would be expected, the blood pressure of workers with tuberculosis is markedly below that of the other workers. The granite worker generally shows a close correspondence in systolic blood pressure with that of the general industrial population.

CHANGES IN WEIGHT WITH LENGTH OF SERVICE

It is interesting to see whether the granite worker shows the same gradual increase in weight with increased length of service which is typical of the industrial worker. All workers who had been diagnosed as tuberculous or as suspicious cases have again been eliminated. In view of the fact that granite workers are heavier on the average at the beginning of industrial life than workers in general (see p. 32) it has been necessary, in order to make this comparison, to reduce the average weights to an index basis, using as the base for granite workers the weight at the beginning of industrial life (less than 10 years' length of service), and for industrial workers at large the weight for corresponding ages (20 to 29 years). In Table 52 the averages and the indices are given together. As in previous comparisons of this character, 20 years is added to the length of service to give the corresponding age (see p. 39). It should be noted from the table that the granite workers were above the average of industrial workers generally throughout the period of life and that it is only the percentage change in weight which is portrayed in the figure.

TABLE 52—*Average weight of granite workers without tuberculosis (active and suspected), by length of service, and of general industrial workers of corresponding ages, with indices*

Granite workers			Industrial workers		
Years in granite	Average	Index	Age	Average	Index
Up to 10	154.3	100.0	20 to 29	146.7	100.0
10 to 19	159.8	103.6	30 to 39	151.4	103.1
20 to 24	161.0	104.3	40 to 44	155.0	105.6
25 to 34	160.6	104.1	45 to 54	156.8	106.9
35 and over	158.1	102.4	55 and over	154.7	105.5

The indices are graphed in Figure 16. After about 15 years the granite workers (even though they have not been diagnosed as having tuberculosis or suspected tuberculosis) fail to gain in weight as rapidly as the general industrial workers. By 30 years in the granite industry (corresponding to 50 years of age) the granite workers have gained only half as much in weight over the initial figure as have the industrial workers generally.

RELATION BETWEEN SICKNESS AND CERTAIN PHYSICAL FACTORS

Sickness among those with and without silicosis.—A discussion of sickness among persons with and without silicosis will be found on page 57.

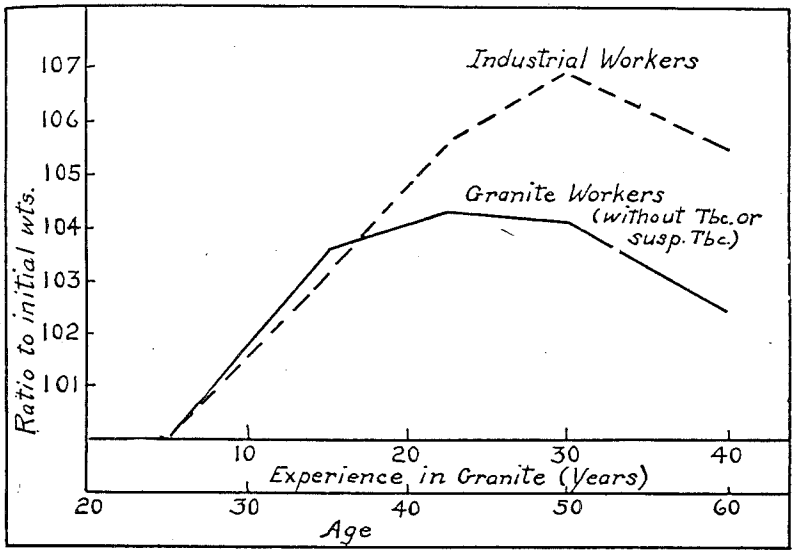


FIGURE 16.—Relative weight of granite workers without tuberculosis (active or suspected) by length of service; and of general industrial workers of corresponding ages

Sickness according to physical defect or disease.—An attempt was made to see whether the sickness rates were greater among workers with certain types of physical defects or diseases (as noted on the physical examination). Three groups of defects and diseases were made: (*a*) Constitutional (diabetes, neurasthenia, constipation, rheumatism, etc.); (*b*) circulatory (heart, arteriosclerosis, etc.); and (*c*) anatomical (hernia, varicocele, congenital defects, hemorrhoids, etc.). All persons diagnosed as having tuberculosis or suspected tuberculosis were omitted, since this group would obviously have higher sickness rates. Table 53 gives the case rates for sickness of all causes and for respiratory causes among persons with and without any constitutional defect, with and without any circulatory

defect, and with and without any anatomical defect. Persons with a constitutional defect may or may not have a defect in one of the other groups. The severity rates are included in the table.

TABLE 53.—*Incidence of sickness*[1] *(all causes and respiratory) among workers with and without certain groups of diseases and defects*

Defects	Incidence				Days lost				Years of observation
	Rate per 1,000		Number of cases		Per person per year		Total		
	All causes	All respiratory	All causes	All respiratory	All causes	All respiratory	All causes	All respiratory	
Constitutional:									
With	603	356	22	13	19.2	9.9	701	363	36.5
Without	203	107	53	28	5.7	4.2	1,491	1,091	260.7
Circulatory:									
With	226	194	7	6	17.7	9.9	548	307	30.9
Without	278	143	68	35	6.7	4.3	1,633	1,057	244.9
Anatomical:									
With	278	109	23	9	8.1	3.1	666	253	82.7
Without	269	166	52	32	8.4	5.7	1,626	1,111	193.3

[1] 8 days and longer.

The relationship is very consistent for one type of defect—constitutional. The incidence rates for respiratory causes is 356 per 1,000 for persons with constitutional defects and 107 for persons without them; for nonrespiratory causes the rates are 247 and 96, respectively. The comparison on the basis of number of days lost per person per year is equally clear-cut. Circulatory and anatomical defects do not show these tendencies, although in the case of circulatory defects the figures for days lost are suggestive.

The consistency of these differences is especially evident when length of service is considered. This is done in Table 54 for the constitutional group of impairments.

TABLE 54.—*Incidence of sickness*[1] *and days lost (all causes and respiratory) among workers with and without constitutional diseases or defects, by broad length of service groups*

	All causes			All respiratory		
	Under 15 years	15 to 24 years	25 years and over	Under 15 years	15 to 24 years	25 years and over
	Case rate per 1,000					
With	578	698	570	331	349	380
Without	241	168	202	121	116	92
	Days lost per person per year					
With	15.5	24.4	19.2	8.3	8.7	11.8
Without	4.6	5.5	6.7	4.4	5.3	3.2

[1] 8 days or over.

TABLE 54.—*Incidence of sickness and days lost, etc.*—Continued

	All causes			All respiratory		
	Under 15 years	15 to 24 years	25 years and over	Under 15 years	15 to 24 years	25 years and over
	Number of cases					
With	7	6	9	4	3	6
Without	18	13	22	9	9	10
	Total number of days lost					
With	188	210	303	101	75	187
Without	341	425	725	328	411	352
	Years of observation					
With	12.1	8.6	15.8			
Without	74.6	77.4	108.7			

No doubt one reason why the sickness rates are higher among persons with constitutional defects is that some absences are due to the specific disease on the basis of which the person was classified in the group "with constitutional defect." For instance, a worker with rheumatism (diagnosed on physical examination) may have had some sickness lasting eight days or longer from rheumatism. The correlation between sickness and constitutional defects is perfectly real, but it will be of more interest to ascertain whether workers with constitutional defects have an excess of sickness from causes not directly associated with the disease or defect which was the basis of their classification in the group. It seemed desirable, therefore, to subtract from the comparison all sickness which was the basis of classifying a person in the defect group. The subtractions are made only in the case of the constitutional defects, since no differences of any particular consequence were found in the case of other impairments. The modified rates are given in Table 55, where the comparison by length of service has been retained.

TABLE 55.—*Incidence of sickness*[1] *and days lost (all causes and respiratory) among workers with and without constitutional diseases and defects, omitting sickness due to these conditions*

	All causes			All respiratory		
	Up to 15 years	15 to 24 years	25 years and over	Up to 15 years	15 to 24 years	25 years and over
	Case rate per 1,000					
With	331	232	317	331	232	253
Without	201	168	166	121	116	92

TABLE 55.—*Incidence of sickness and days lost, etc.*—Continued

	All causes			All respiratory		
	Up to 15 years	15 to 24 years	25 years and over	Up to 15 years	15 to 24 years	25 years and over
	Days lost per person per year					
With	7.8	2.4	11.3	7.8	2.4	10.3
Without	3.5	5.5	3.8	2.2	4.6	2.3
	Number of cases					
With	4	2	5	4	2	4
Without	15	13	18	9	9	10
	Total number of days lost					
With	94	21	179	94	21	166
Without	263	425	417	167	353	249
	Years observed					
With	12.1	8.6	15.8	----------	----------	----------
Without	74.6	77.4	108.7	----------	----------	----------

[1] 8 days or over.

It is still found that the rate for all causes and for respiratory causes is higher among persons with constitutional defects; but this is not true for nonrespiratory causes. Persons with constitutional defects appear more liable to illness from causes other than the particular cause on the basis of which the classification was made. The effect of eliminating sickness which was the basis of the classification can be seen by comparing Tables 54 and 55.

OTHER RELATIONS

In concluding this section, it should be pointed out that a number of other relations were tested out, but with only negative results. For instance, it was felt that vital capacity and chest expansion might easily show a definite correlation with sickness. No significant differences were found, even when the individual's deviation from a supposed normal was calculated. An effort was made to show a difference as to sickness in the case of blood pressure, but the results were also negative. Small numbers made any very definite study impossible, and it is felt that these phases of the relation between sickness and the physical examination, which, after all, have no direct bearing upon the study of the dust hazard among granite workers, must be left until data from all of the dust studies can be assembled.

V. SILICOSIS

BASIS OF DIAGNOSIS

In the course of the physical examinations of granite workers both the diagnosis of silicosis and the symptoms considered in making the diagnosis were set down on the examination form. After the physical examination and history of the case were completed the diagnosis was recorded as to the nature and extent of the silicosis. In addition to the physical examinations X rays were taken in a large proportion of the cases and were used to substantiate the physical findings.

Physical examinations of granite cutters were made at an office located outside the plants after working hours, except in case of workers who were having time off for vacation or minor illnesses and who came for examination. In some of the cases of tuberculosis examinations were given in the patients' homes or in hospitals. All the X rays were taken after the physical examination.

An effort was made to examine all the employees in the granite plants where the study was being carried on, but it was impossible to do so because of the morbid fear of tuberculosis which many cutters have. The attitude of the cutters toward the study was friendly and they expressed a desire to cooperate, but as a rule they were unwilling to come for examination. They were not apparently adverse in any instance to the collection of information as to sickness among them, but in cases of chest affections they were inclined to be very uncommunicative. However, inasmuch as most of these affections were of a chronic nature, time afforded opportunity to study them with the family physician, from whom also an accurate record of them could be obtained.

Apart from the X rays, the main points upon which diagnosis of silicosis was made in the cases observed in this study were, first, history, and, second, physical findings. The history included the history of exposure to dust, record of the development of a nonproductive cough which, in these instances, was due to irritation of the upper respiratory tract, and a history of occasional pains in the chest which is incident to the development of pleurisy in relation to silicosis. In the early cases there is generally a beginning of impairment in resonance and a diminished tactile and vocal fremitus, with diminished breath sounds. Later, there is limita-

tion of chest expansion, bilateral in nature. As the condition progresses this restriction becomes greater and there is a hyperplasia of the muscles of the chest, due to the increased respiratory effort. In these more advanced cases there is still greater evidence of impaired resonance, and in the most advanced cases evidences of consolidation. Tactile and vocal fremitus has also diminished in proportion to the length of exposure. The breath sounds do not change to any particular type, but there is in general a softening of all respiratory sounds. There are two additional signs which are of the greatest importance in the differentiation of silicosis from other pathological conditions, and these are absence of râles and absence of any toxemia.

MEDICAL FINDINGS

Both the medical and the occupational history of a patient are important in making a diagnosis of an occupational disease. In silicosis there is always a history of exposure to siliceous dust. The nature of the respiratory diseases which a patient may have had previously may also be a factor indirectly related to the development of silicosis.

General appearance.—In general, patients with silicosis were well nourished and apparently healthy, and except in advanced cases there was usually no evidence on casual examination of any impaired physical ability.

Very early in silicosis a limitation is developed in the expansibility of the chest. This finding was quite consistent. The expansion of the chest continued to decrease as the condition progressed. In advanced cases the chest walls are apparently fixed and the patient moves only the abdomen and perhaps the lower part of the ribs in breathing. In some of these cases it was found that the maximum chest expansion was 2 centimeters.

Symptoms.—Dyspnoea was the principal complaint of the cases of silicosis. In the earlier stages of the disease it was noticeable only on exertion. It increased in direct proportion to the period of exposure to dust. The fibrosis progresses gradually, until it completely fills the alveoli, and by the continuous displacement of normal functioning tissue produces a progressive dyspnoea.

From the following description of symptoms written by a patient seeking advice it is apparent that he was most seriously concerned about dyspnoea. The history which he relates closely resembles the histories of many of the more advanced cases which were observed in this study.

The patient was 46 years old and had been exposed to granite dust for more than 25 years. He gave a rather lengthy history of his health, stating that he had not lost weight, and had had no fever nor any other symptoms of tuberculosis, but said: "I noticed that if I lifted anything heavy, I was out of wind. I could walk without any inconvenience, but any weight to lift, just a few seconds of fast work, or a run of a few steps, and I was 'all in.' My wind kept getting shorter all the time. After two months' vacation my wind seems worse than ever. I have been back at work two weeks and feel worse than before—at least, much shorter-winded."

Doctor Lanza [34] observed an excessive amount of dyspnœa among the miners with silicosis in the Joplin district, Missouri. Doctor McFarland,[35] also, reports a similar condition among granite cutters. "Silicotic patients are loath to give an accurate history of anything referable to their chest conditions, as they have a profound fear of tuberculosis. For example, many times they state they are not dyspnœic when it is evident they are."

Doctor Sayers [36] also refers to dyspnœa as the cardinal symptom among many miners whom he has observed. "The cardinal symptom, it will be noted, is shortness of breath, especially on exertion. The cardinal sign is diminished expansion of chest. These symptoms are slight in the early stages. The cough is that of irritation and may be brought on by having the man take a deep breath. It can not, however, be considered a cardinal symptom. Recurrent colds and pains in the chest are important symptoms."

Pains in the chest seem to be a common complaint among the granite cutters. There were instances of illness from pleurisy; but when this was severe enough to cause a patient to lose time from work, it was usually a sign of incipient tuberculosis. The pains in the chest were of a more transient nature, and the cutters usually attributed them to rheumatism, lumbago, or other remote causes. During the course of the study no case of pleurisy with effusion was found either on physical examination or in the sickness reports. The existence of plastic pleurisy, which is a part of silicosis even from the beginning, perhaps accounts for the fact that pleurisy with effusion is found so infrequently among these people.

Another symptom was a slight cough, usually without expectoration, and probably not of pulmonary origin, but resulting apparently from mechanical irritation in the upper respiratory tract.

Examination of the chest.—The restricted chest expansion has already been mentioned. The restriction is symmetrical. There were no other evidences of external changes in the chest. The emphysematous type of chest was rather rare.

---

[34] Public Health Bulletin No. 85.
[35] McFarland, William: Silicosis and Tuberculosis as Seen in the Granite Cutters in Barre, Vt. Jr. Ind. Hygiene, August, 1927.
[36] Some Observations on Industrial Silicosis. R. R. Sayers, A. M., M. D., The Industrial Doctor, November, 1927.

In the early cases there was slight impairment of resonance, and as the disease progressed this finding became more pronounced. The area of greatest impaired resonance was generally found over the hilus of each lung posteriorly, the impairment being evidently due to enlargement of the lymph glands of the hilus. In advanced silicosis there was indication of consolidation, and because of the great amount of fibrosis the note obtained on percussion was quite dull. Impaired resonance was, then, a very constant finding.

In some of the early cases of silicosis tactile and vocal fremitus were about normal, but as the disease progressed they diminished because of poor resonating quality of the lung tissues. This tendency is in contrast to the findings in regard to the localized fibrosis of tuberculosis, which gives an increase in these phenomena. These results agree with those of Doctor Lanza's [37] cases in the Joplin, Mo., zinc mines.

In the early cases of the disease there were changes in breath sounds, without a particular type predominating as in the case of tuberculosis; but there was a general softening of the respiratory sounds throughout the chest, evidently attributable to the generalized fibrosis in the alveoli, while it is a localized fibrosis which alters the sounds in cases of tuberculosis. In the bases of the lungs, where vesicular breathing is normally found, the breath sounds were in some cases almost inaudible. Similar changes have been noted by Tattersall,[38] McFarland,[39] and others. Changes in breath sounds, together with impaired resonance, limited chest expansion, and changes in fremitus were the most constant findings in these cases of silicosis.

Tuberculosis or bronchitis as complications of silicosis produced râles, but in the uncomplicated cases, râles were absent.

The absence of toxemia in silicosis is accounted for by the absence of infection.

FINDINGS BASED ON EXAMINATION OF X RAYS

The diagnosis of silicosis by means of the X ray alone is comparatively easy when the condition is fully established, while the physical examination is of more importance when the disease is in its incipiency, because X rays do not indicate early fibrosis as well as that which has existed longer and is of greater density. The diagnosis of silicosis should be made from the consideration of both physical and X-ray findings.

[37] Public Health Bulletin No. 85.

[38] Tattersall, Norman: The Occurrence and Clinical Manifestations of Silicosis Among Hard Ground Workers in Coal Mines. Jr. Ind. Hygiene, November, 1926.

[39] McFarland, William: Silicosis and Tuberculosis as Seen in the Granite Cutters in Barre, Vt. Jr. Ind. Hygiene, August, 1927.

The series of X-ray pictures of the chests of granite cutters made in this study indicates that silicosis follows a rather definite form in its development. There was a general thickening of each hilum and of the trunk shadows, the latter being indicated by linear markings throughout. In advanced cases there was confluence of shadows, forming consolidations. The nodular formations, or mottlings, frequently referred to by other investigators, were conspicuously absent in these cases. Silicosis in granite cutters differs in this way from the usually described case of the South African workers. When flocculent densities were in evidence, tuberculosis was demonstrable, except in one case, by clinical and physical examinations. The dust to which granite workers are exposed contains approximately 35 per cent of free silica, as quartz. In the cases in other industries in which mottling has been shown by the X ray, there was generally a history of exposure to a dust containing a higher percentage of free silica. It seems that the type of silicosis produced may be intimately related to three factors: The dosage, the duration of exposure, and the percentage of free silica.

The characteristic X-ray findings among granite cutters having silicosis were mainly as follows:

Enlargement of hilum shadows incident to lymphatic blockage and to the deposition of dust in the glands. Hilum shadows are increased in size and density very early, and become more pronounced as the exposure to dust continues. In all the post-mortem examinations, the lymph glands of the hilum were found to be filled and distended with dust.

The densities next in order in appearance and prominence were linear markings, or trunk shadows, which became diffused throughout the lung as silicosis advanced. They extended from the hilum to the outer zone laterally and along the course of the larger bronchi in the lower lobes. These linear shadows in the outer zone at the same level as the hilum were conspicuous even in cases of comparatively short exposure to dust. Linear densities extend upward as silicosis advances, and the apices are the last to become involved. After prolonged exposure to dust, these shadows tend to merge and form consolidations. The definite mottling and nodular formations at the junction of linear shadows were not in evidence in these cases.

The angles of the diaphragm were not always clear, particularly at the cardiac end, because the thickening along the larger trunks overlaps and produces a hazy appearance. The overlapping of thickened pleura also adds to the densities in this region.

Irregularities of the diaphragm were rather constant. Forty per cent of cases had evidence of it, and as the condition advanced there was an increase in changes of the diaphragmatic shadows. There

In the early cases there was slight impairment of resonance, and as the disease progressed this finding became more pronounced. The area of greatest impaired resonance was generally found over the hilus of each lung posteriorly, the impairment being evidently due to enlargement of the lymph glands of the hilus. In advanced silicosis there was indication of consolidation, and because of the great amount of fibrosis the note obtained on percussion was quite dull. Impaired resonance was, then, a very constant finding.

In some of the early cases of silicosis tactile and vocal fremitus were about normal, but as the disease progressed they diminished, because of poor resonating quality of the lung tissues. This tendency is in contrast to the findings in regard to the localized fibrosis of tuberculosis, which gives an increase in these phenomena. These results agree with those of Doctor Lanza's [37] cases in the Joplin, Mo., zinc mines.

In the early cases of the disease there were changes in breath sounds, without a particular type predominating as in the case of tuberculosis; but there was a general softening of the respiratory sounds throughout the chest, evidently attributable to the generalized fibrosis in the alveoli, while it is a localized fibrosis which alters the sounds in cases of tuberculosis. In the bases of the lungs, where vesicular breathing is normally found, the breath sounds were in some cases almost inaudible. Similar changes have been noted by Tattersall,[38] McFarland,[39] and others. Changes in breath sounds, together with impaired resonance, limited chest expansion, and changes in fremitus were the most constant findings in these cases of silicosis.

Tuberculosis or bronchitis as complications of silicosis produced râles, but in the uncomplicated cases, râles were absent.

The absence of toxemia in silicosis is accounted for by the absence of infection.

FINDINGS BASED ON EXAMINATION OF X RAYS

The diagnosis of silicosis by means of the X ray alone is comparatively easy when the condition is fully established, while the physical examination is of more importance when the disease is in its incipiency, because X rays do not indicate early fibrosis as well as that which has existed longer and is of greater density. The diagnosis of silicosis should be made from the consideration of both physical and X-ray findings.

[37] Public Health Bulletin No. 85.

[38] Tattersall, Norman: The Occurrence and Clinical Manifestations of Silicosis Among Hard Ground Workers in Coal Mines. Jr. Ind. Hygiene, November, 1926.

[39] McFarland, William: Silicosis and Tuberculosis as Seen in the Granite Cutters in Barre, Vt. Jr. Ind. Hygiene, August, 1927.

The series of X-ray pictures of the chests of granite cutters made in this study indicates that silicosis follows a rather definite form in its development. There was a general thickening of each hilum and of the trunk shadows, the latter being indicated by linear markings throughout. In advanced cases there was confluence of shadows, forming consolidations. The nodular formations, or mottlings, frequently referred to by other investigators, were conspicuously absent in these cases. Silicosis in granite cutters differs in this way from the usually described case of the South African workers. When flocculent densities were in evidence, tuberculosis was demonstrable, except in one case, by clinical and physical examinations. The dust to which granite workers are exposed contains approximately 35 per cent of free silica, as quartz. In the cases in other industries in which mottling has been shown by the X ray, there was generally a history of exposure to a dust containing a higher percentage of free silica. It seems that the type of silicosis produced may be intimately related to three factors: The dosage, the duration of exposure, and the percentage of free silica.

The characteristic X-ray findings among granite cutters having silicosis were mainly as follows:

Enlargement of hilum shadows incident to lymphatic blockage and to the deposition of dust in the glands. Hilum shadows are increased in size and density very early, and become more pronounced as the exposure to dust continues. In all the post-mortem examinations, the lymph glands of the hilum were found to be filled and distended with dust.

The densities next in order in appearance and prominence were linear markings, or trunk shadows, which became diffused throughout the lung as silicosis advanced. They extended from the hilum to the outer zone laterally and along the course of the larger bronchi in the lower lobes. These linear shadows in the outer zone at the same level as the hilum were conspicuous even in cases of comparatively short exposure to dust. Linear densities extend upward as silicosis advances, and the apices are the last to become involved. After prolonged exposure to dust, these shadows tend to merge and form consolidations. The definite mottling and nodular formations at the junction of linear shadows were not in evidence in these cases.

The angles of the diaphragm were not always clear, particularly at the cardiac end, because the thickening along the larger trunks overlaps and produces a hazy appearance. The overlapping of thickened pleura also adds to the densities in this region.

Irregularities of the diaphragm were rather constant. Forty per cent of cases had evidence of it, and as the condition advanced there was an increase in changes of the diaphragmatic shadows. There

were instances in which angulation of the diaphragm was in evidence, and others which showed indications of extensive adhesions. All the cases autopsied had dense adhesions of the pleura throughout, which had obviously interfered with the function of the diaphragm. It is evident from clinical and X-ray findings that a chronic pleurisy is a definite part of the pathology of silicosis. Pleural changes are attributable to the irritating action of the dust which reaches the pleura through the lymph streams.

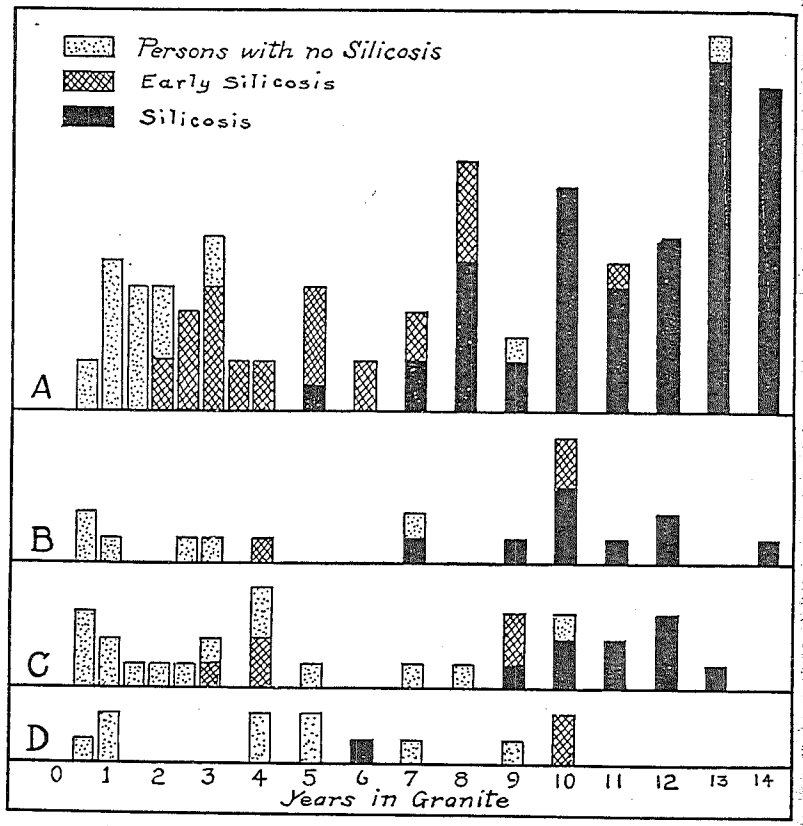


FIGURE 17.—Persons with and without silicosis in the four dust count groups, by length of service

All cases diagnosed as silicosis for the purpose of this report are those in which there is definite evidence of the condition existing, by either X-ray or physical finding.

The classification as to the stages of silicosis used by other investigators (presilicotic, first stage, and second stage; or, as generally termed in America, first, second, and third stage) has not been found feasible in this study. In the first place the X-ray findings indicate a different type of silicosis; secondly, from a final consideration of the cases of silicosis from all angles, it was found practically impossible to classify the cases into definite stages, since the condition was one of progressive development; thirdly, the diagnosis of silicosis in this study was not limited to the examination of the X rays alone but was based on findings from the physical examination and X rays combined.

Although no classification of individuals into stages has been attempted, it has been convenient for statistical purposes to differentiate cases which were in their incipiency and these have been termed "early." For the reasons given above, however, this differentiation has not been retained on the individual case histories.

PERCENTAGE WITH SILICOSIS BY LENGTH OF SERVICE

In Figure 17 is shown the number of persons without silicosis and the number diagnosed as having either early or more developed cases of silicosis according to the number of years the men have been employed in the granite industry, and according to the dust-count group in which they fell. This represents only cases under 15 years of service and is limited to persons who had not been diagnosed as having tuberculosis or suspected tuberculosis. In addition to this figure, Group A has been taken by itself and a percentage of early and more developed cases of silicosis has been determined by length of service.

TABLE 56.—*Percentage with early silicosis and with silicosis, by length of service, Group A, hand pneumatic-tool cutters*

Stage	Years in granite																	
	½	1	1½	2	2½	3	3½	4	5	6	7	8	9	10	11	12	13	14
Percentage:																		
Early silicosis				40	82		100		86		43		6					
Silicosis									14		57		92		93		96	
Number of cases:																		
Early silicosis				2	4	5	2	2	4	2	2	4			1			
Silicosis									1		2	6	2	9	5	7	14	13
Number of persons	2	6	5	5	4	7	2	2	5	2	4	10	3	9	6	7	15	13

The first case of early silicosis appeared after approximately two years of service. If consideration is given to the development of silicosis in the A group, which contains those workers exposed to the heaviest dust concentration, the development of early silicosis continues rapidly until 100 per cent in this group show this stage of silicosis by three and a half to four years of service. (The average amount of dust to which the workers in this group were exposed was practically 60 million particles per cubic foot of air.) In this same group the first case of more developed silicosis occurred in five

years of service, and in nine years approximately 90 per cent had advanced to this stage.

The development of silicosis in the remaining three groups is of considerable interest and seems proportionate to the dust exposure. Of particular interest is the fact that only 1 case of moderately developed silicosis occurred in the D group with 6 years of service and 2 cases of early silicosis after 10 years of exposure.

SYMPTOMS AND PHYSICAL SIGNS DEPENDING ON EXPOSURE TO DUST

The dust hazard among granite workers reflects itself in certain symptoms and physical signs among persons who have not developed tuberculosis. Some consideration was given to this point among workers in Groups A and B (primarily cutters, pneumatic or surface machines). All records of physical examinations among persons with tuberculosis or suspected of having tuberculosis were omitted. To give as large numbers as possible examinations of workers in plants not included in the morbidity study were used as well as those in the morbidity study. Table 57 gives the percentage and number with certain symptoms and physical signs of conditions associated with silicosis.

TABLE 57.—*Percentage of persons with symptoms and physical signs associated with silicosis, by length of service, Groups A and B, without tuberculosis, active or suspected*

	Length of service (years)				
	Up to 5	5 to 9	10 to 14	15 to 19	20 to 24
Percentage with condition:					
Cough	22	8	18	26	21
Expectoration	15	8	11	16	9
Tactile fremitus (diminished)	26	23	54	53	79
Resonance (diminished)	26	31	43	42	58
Breath sounds (abnormal)	30	46	71	69	85
Voice sounds	30	15	25		15
Râles	4				9
Number with condition:					
Cough	[2] 6	1	5	5	7
Expectoration	[3] 4	1	3	3	3
Tactile fremitus (diminished)	7	3	[1] 15	10	26
Resonance (diminished)	7	4	12	8	19
Breath sounds (abnormal)	8	6	[1] 20	13	28
Voice sounds	8	2	[1] 7		5
Râles	[1] 1				3
Number of persons	27	13	28	19	33

[1] Unknown 1. [2] Unknown 2. [3] Unknown 3.

From this table the percentages dealing with workers giving a record of having suffered from dyspnœa have been excluded, as the percentage was necessarily based on the patient's own statement, and as a rule he was inclined to deny that any shortness of breath existed. As a matter of fact, it was the observation of the physician that the

symptom of dyspnœa occurred in nearly all cases of developed silicosis and began early in the course of the condition.

The data are reproduced in Figure 18. They are given primarily to strengthen the diagnosis of silicosis, because they show, with in-

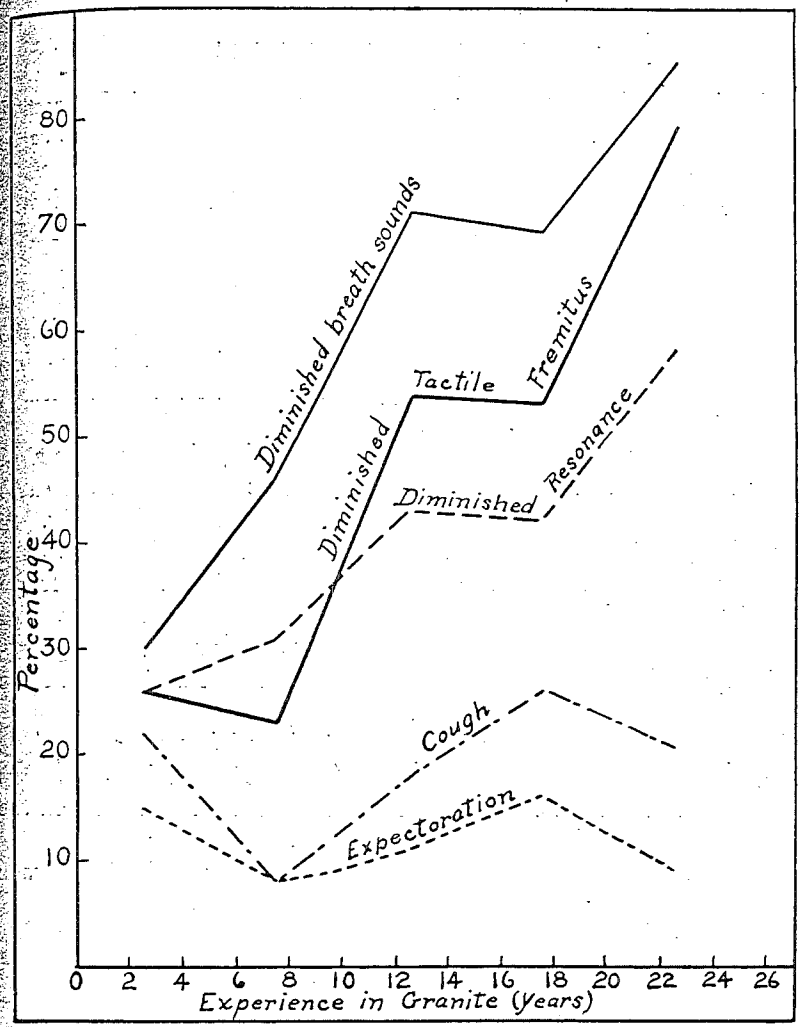


FIGURE 18.—Percentage of persons with symptoms and physical signs associated with silicosis by length of service—Groups A and B without tuberculosis, active or suspected

creasing length of service, an increasing effect of dust exposure. The material must be taken as a minimum statement of the percentage with these signs and symptoms, owing to the tendency to omit the symptom where the diagnosis of the condition (such as silicosis) was also given on the form.

By 12 years of exposure to dust there are diminished breath sounds in about 70 per cent, diminished or absent tactile fremitus in about 50 per cent, and diminished resonance in about 40 per cent. Diminished chest expansion is not included in the graph, as it is being taken up separately (p. 72).

CASE HISTORIES AND X RAYS

Silicosis among the granite workers observed in this study seemed to follow a rather regular course in its development. All the cases X rayed showed an increase in pulmonary densities bilaterally, with a greater amount of pathology indicated in the middle and lower portions of each lung, with a slight predominance in the right. There were, however, some atypical cases, and they also are presented.

Some of the workers with a longer exposure to granite dust than others showed a slighter amount of pathology than was consistent with the length of time they had spent in their trades. It is quite possible that personal susceptibility, as discussed in Public Health Bulletin 176, was a factor.

The X rays, with the corresponding case histories, are given in X ray Nos. 2–14. They are not presented as typical of all cases of silicosis, but are representative of those found in this study. A comparison of these cases with those of other industries where the workers are exposed to a dust of higher silica content but of a lower concentration, or vice versa, the effects of which are perhaps parallel to those of granite dust, indicates that many of the symptoms, physical signs, and X-ray findings are common to all and that tuberculosis is the most frequent complication.

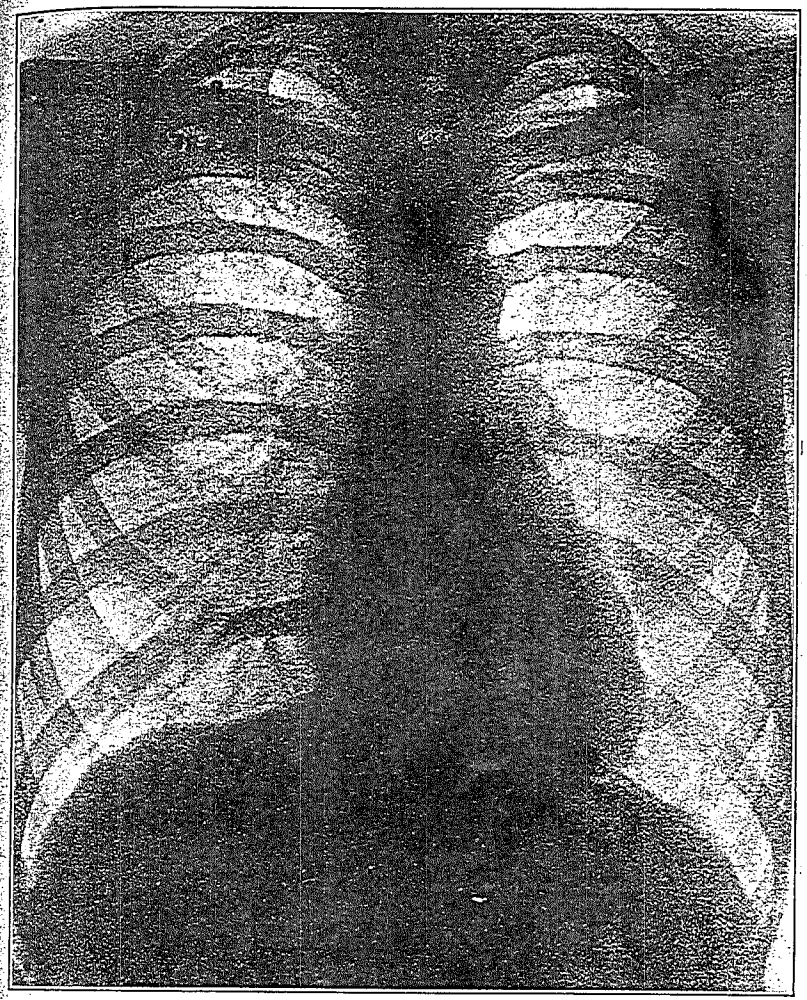
Case histories of silicosis that were not given X-ray examinations are not presented here, because it is believed that the X-ray findings in connection with the case histories give a clearer indication of the condition.

The order of presentation of these prints and case histories was selected to indicate the progress in the development of silicosis.

There were but few cases of silicosis with indications of a gross amount of consolidation and other evidences of greatly advanced disease. Granite cutters seemed to develop tuberculosis before silicosis reached this advanced stage. (X-ray findings in silicosis complicated with tuberculosis are discussed under a separate heading.)

Case No. 353 is a good example of early silicosis. Though not a granite cutter, the worker was employed in a small plant where he worked side by side with granite cutters and was exposed to an excessive amount of dust.

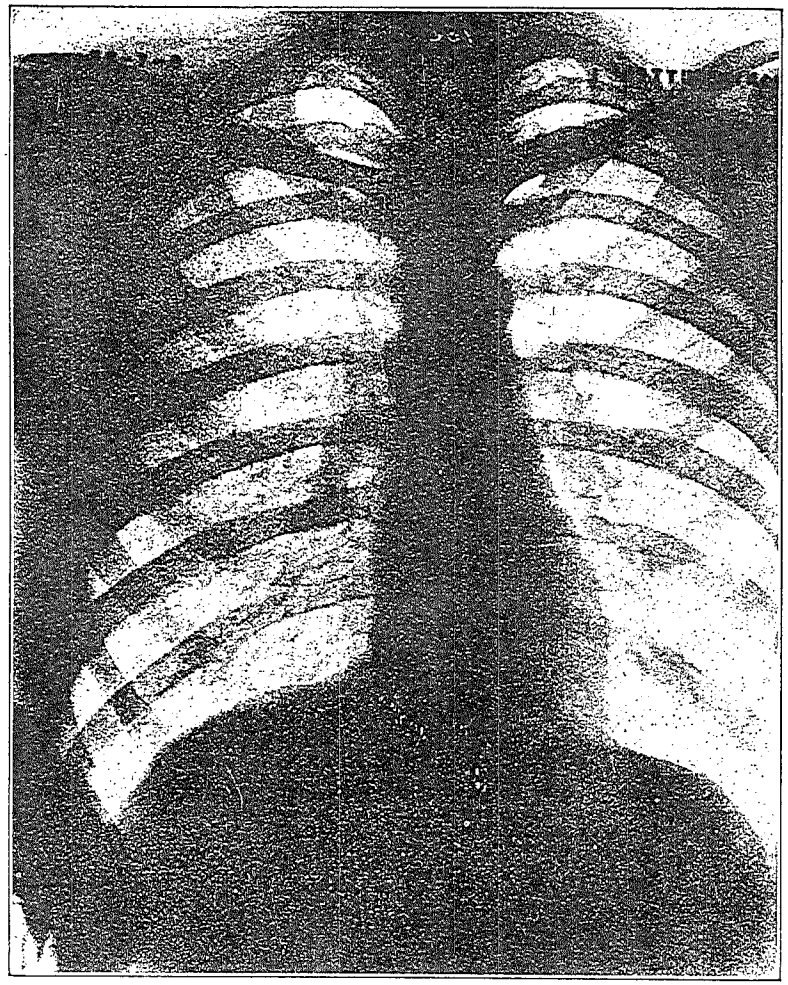
Case No. 397 is interesting and quite typical of silicosis. The pleurisy incident to the condition is shown by an irregular diaphragm on



X ray 2.—Case 353. S. P., examined on August 17, 1925; American (French-Canadian parentage), aged 28 years; married

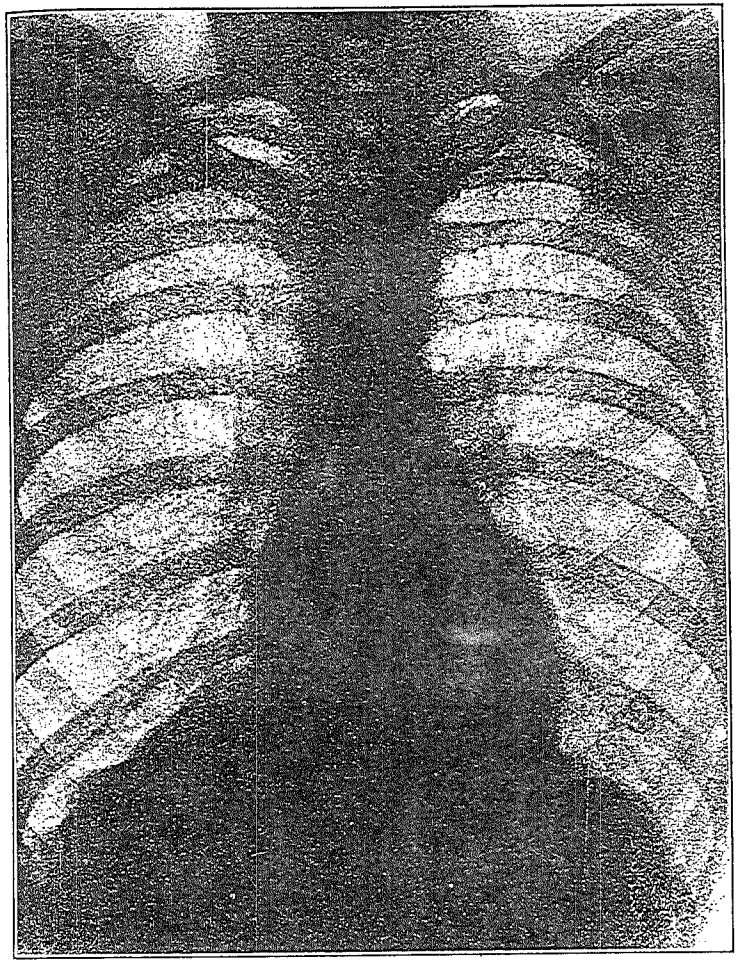
Boxer and bed setter, worked adjacent to cutters for 9 years. This patient had had pneumonia at the age of 4, with a good recovery; influenza in 1918, with a good recovery; occasional attacks of tonsillitis. Habits were good. At the time of this examination he had a cough, with a moderate amount of expectoration, and complained of fatigue on exertion.

Height, 69 inches; weight, 155 pounds; blood pressure, 106 systolic; vital capacity, 4,300 cubic centimeters; chest expansion, 5 centimeters; chronic rhinitis and pharyngitis, varicose veins in left leg; chest showed evidence of early silicosis.



X ray 3.—Case 277. A. C., aged 29 years; American (Italian parentage)

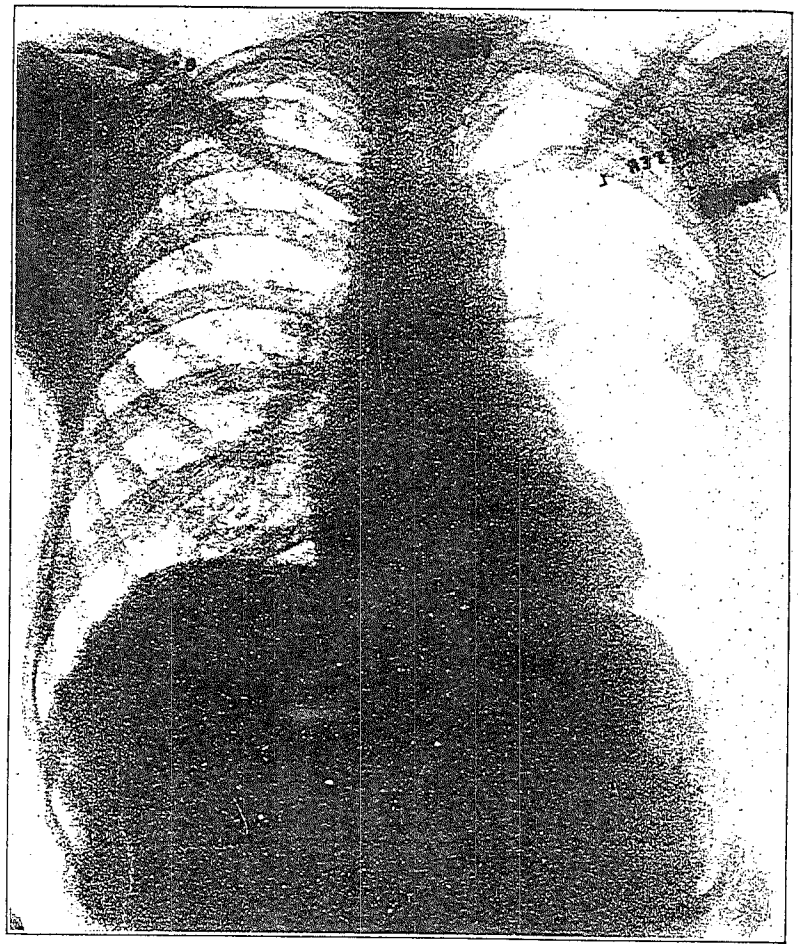
Granite cutter with hand pneumatic tool for 10 years.
Examination: Height, 66 inches; weight, 122 pounds; chronic rhino-pharyngitis and tonsillitis; systolic blood pressure, 128; vital capacity, 4,600 cubic centimeters; silicosis.



X ray 4.—Case 397. C. S., examined on October 6, 1926; Scotch, aged 34 years; married

Granite cutter for 14 years, using hand pneumatic tool. This patient served in the British Navy for two and a half years and was discharged because of partial deafness. He had appendicitis and an operation for it three years before this examination; good recovery. Health had been good otherwise. Habits were good. At time of examination patient felt well, but had a slight cough which was productive.

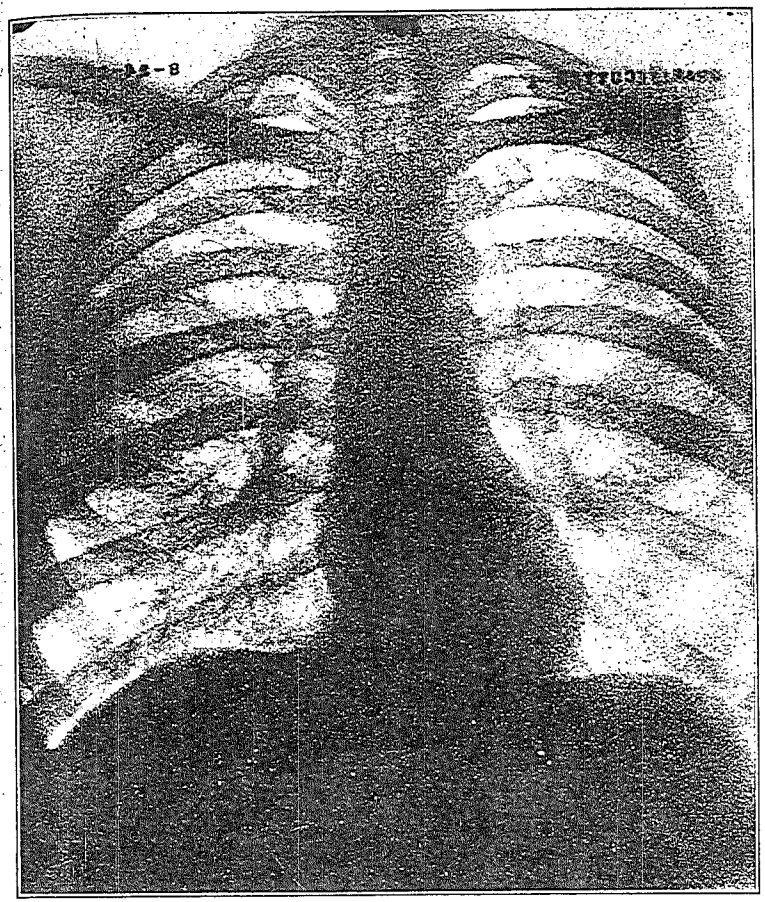
Height, 69 inches; weight, 145 pounds, partial deafness; chronic rhinitis and pharyngitis; marked dental caries; blood pressure, 120 systolic; vital capacity, 3,400 cubic centimeters; chest expansion, 5 centimeters; chest showed evidence of silicosis.



X ray 5.—Case 282. S. C., examined on June 3, 1925; Italian, aged 40 years; married

Granite cutter, hand pneumatic tool, for 23 years; marble cutter in Italy five years previously. This patient had influenza in 1918 and did not work for three months. He was ill for a few days with pleurisy pains 12 years ago. Health generally good otherwise. At the time of this examination he felt well and worked regularly.

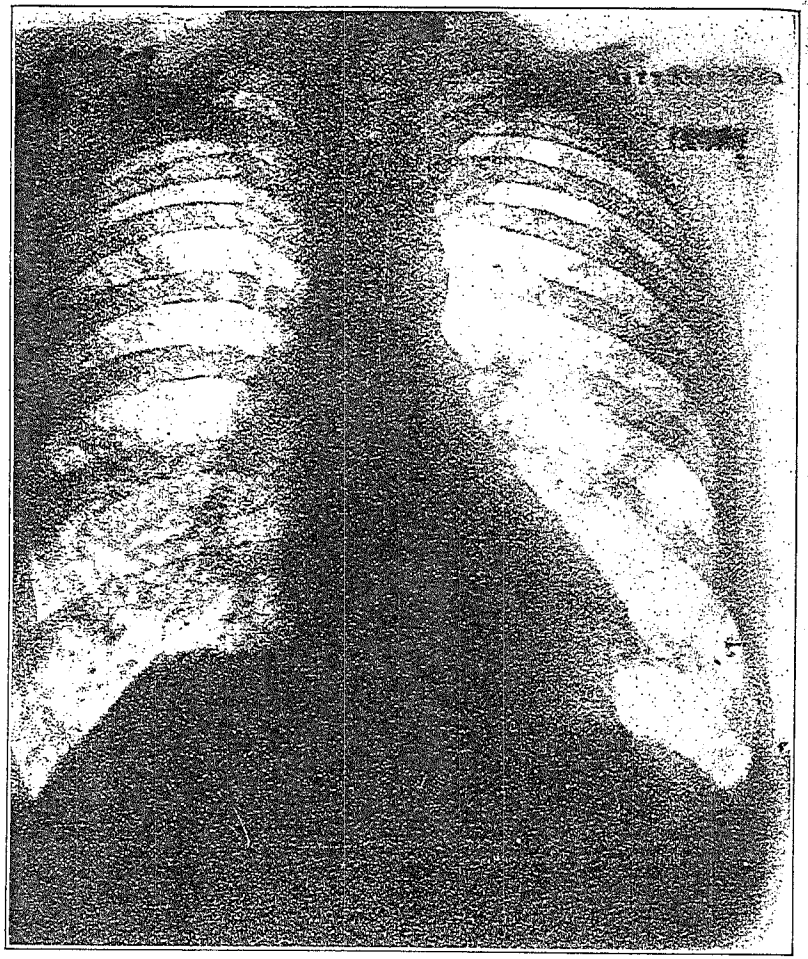
Height, 69 inches; weight, 148 pounds; chronic rhinitis and pharyngitis; blood pressure, 132 systolic; vital capacity, 3,500 cubic centimeters; chest expansion, 4 centimeters; chest showed evidence of silicosis.



X ray 6.—Case 369. J. McA., examined on August 14, 1925; Scotch, aged 40 years; married

Granite cutter, surface-machine operator, for 21 years. His father died of tuberculosis at the age of 62 (granite cutter); his mother died of bronchitis at the age of 36. The patient had had frequent colds, but no serious illnesses. Dyspnœic for a long time. At the time of this examination he complained of dyspnœa; otherwise he felt well. Worked regularly.

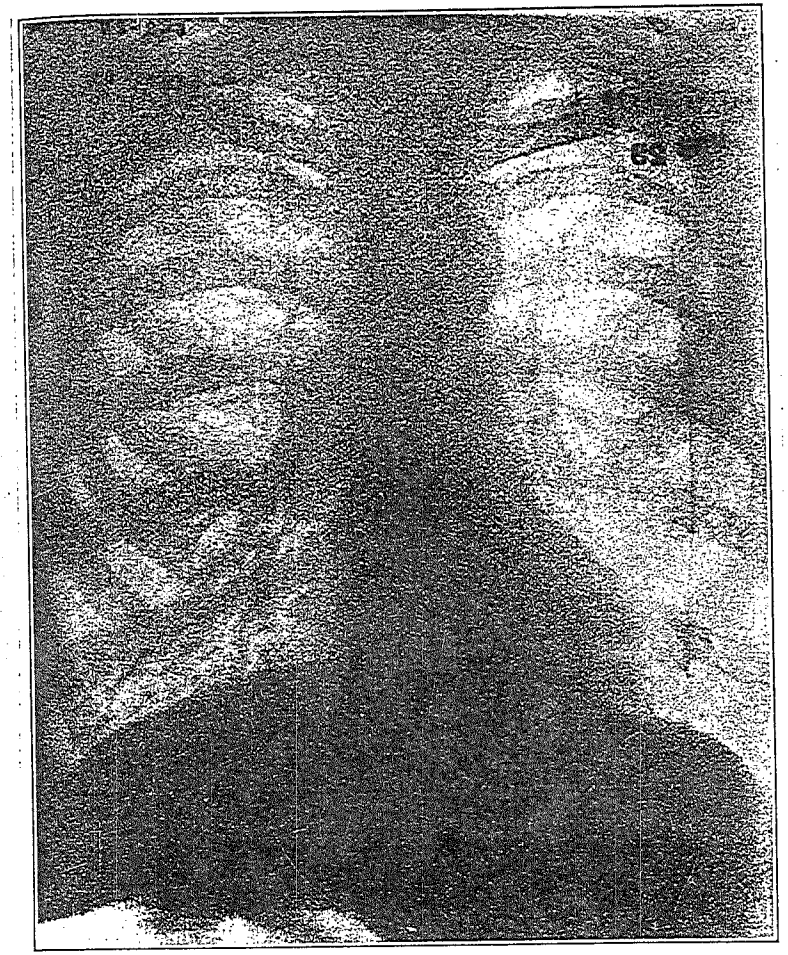
Height, 68 inches; weight, 141 pounds; impaired hearing; dental caries; chronic rhinitis and pharyngitis; blood pressure, 138 systolic; vital capacity, 4,400 cubic centimeters; chest showed evidence of silicosis.



X ray 7.—Case 16. J. B., examined on April 26, 1924; Italian, aged 41 years; married

Granite cutter, hand pneumatic tool, for 21 years. He had cut marble since an early age in Italy until his emigration to the United States. Parents were dead; ages and causes of death not known. The patient's health had been very good and his habits were good. He had no complaint at the time of examination; he was eating and sleeping well, and working regularly.

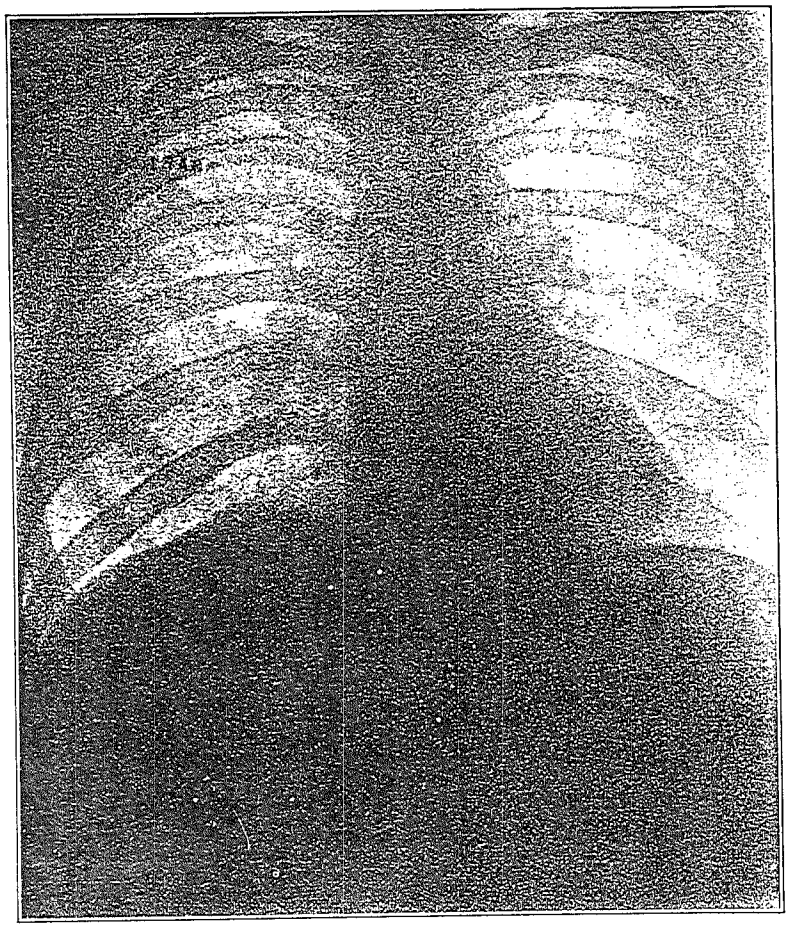
Height, 66 inches; weight, 147 pounds; impaired hearing, dental caries, and pyorrhœa. Blood pressure, 120 systolic; vital capacity, 3,200 cubic centimeters; inguinal hernia; chest showed evidence of silicosis.



X ray 8.—Case 486. F. M., examined on April 10, 1926; Italian, aged 42 years; married

Granite cutter, hand pneumatic tool (letterer and carver), for 26 years. His health had generally been good; no history of any respiratory illnesses other than colds. At the time of this examination he was feeling well, except for a slight cold and hoarseness. He had a very marked phthisiophobia.

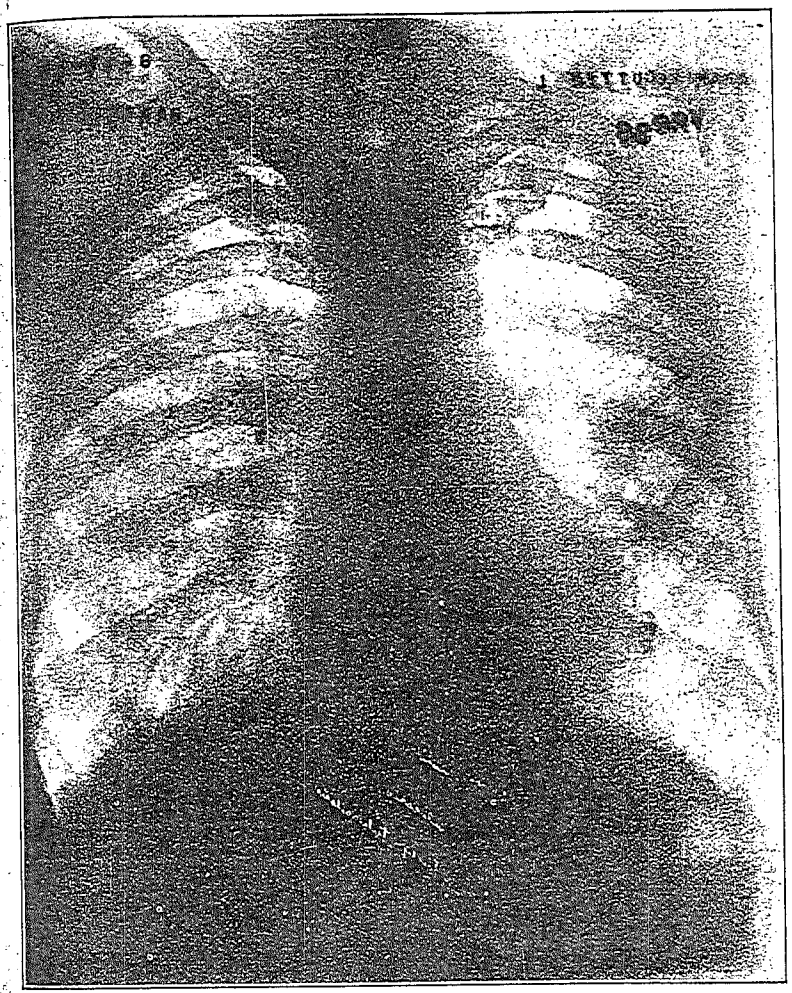
Height, 69 inches; weight, 163 pounds; chronic rhinitis and pharyngitis; blood pressure, 140 systolic; vital capacity, 4,700 cubic centimeters; chest showed evidence of silicosis.



X ray 9.—Case 163. J. S., examined on January 5, 1925; Finlander, aged 42 years; married

Granite cutter, hand pneumatic tool, for 23 years. His father died at the age of 50, of cancer of the liver; his mother died at the age of 52; cause of death unknown. The patient had pneumonia in the winter of 1924–25 and was unable to work for three months; since that time he had been subject to severe pains in the chest when he had a cold. Health otherwise had been very good. Habits good. At the time of this examination he had a cough, with slight expectoration, and suffered from insomnia at times. He was dyspnœic on exertion.

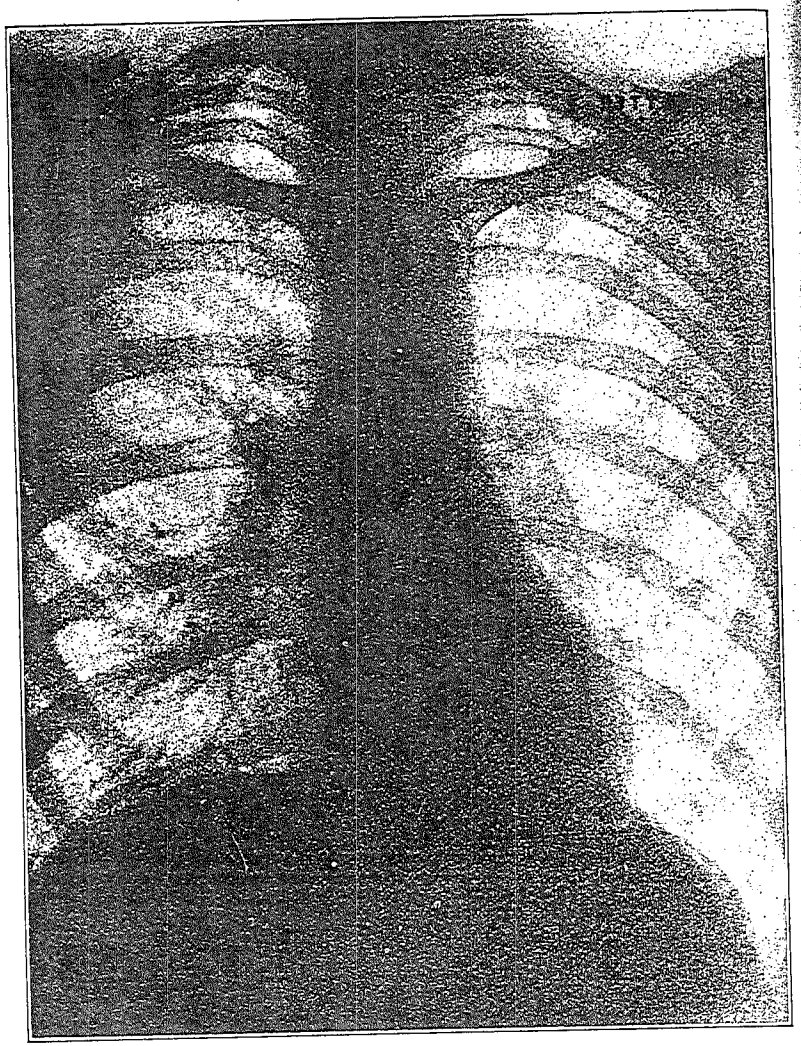
Height, 65 inches; weight, 165 pounds; impaired hearing; chronic rhinitis and pharyngitis; pyorrhœa. Blood pressure, 130 systolic; vital capacity, 2,600 cubic centimeters; chest expansion, 4 centimeters; chest showed evidence of silicosis.



X ray 10.—Case 95. U. M., aged 49 years; Swiss (Italian parentage)

Granite cutter for 25 years; marble cutter previously.

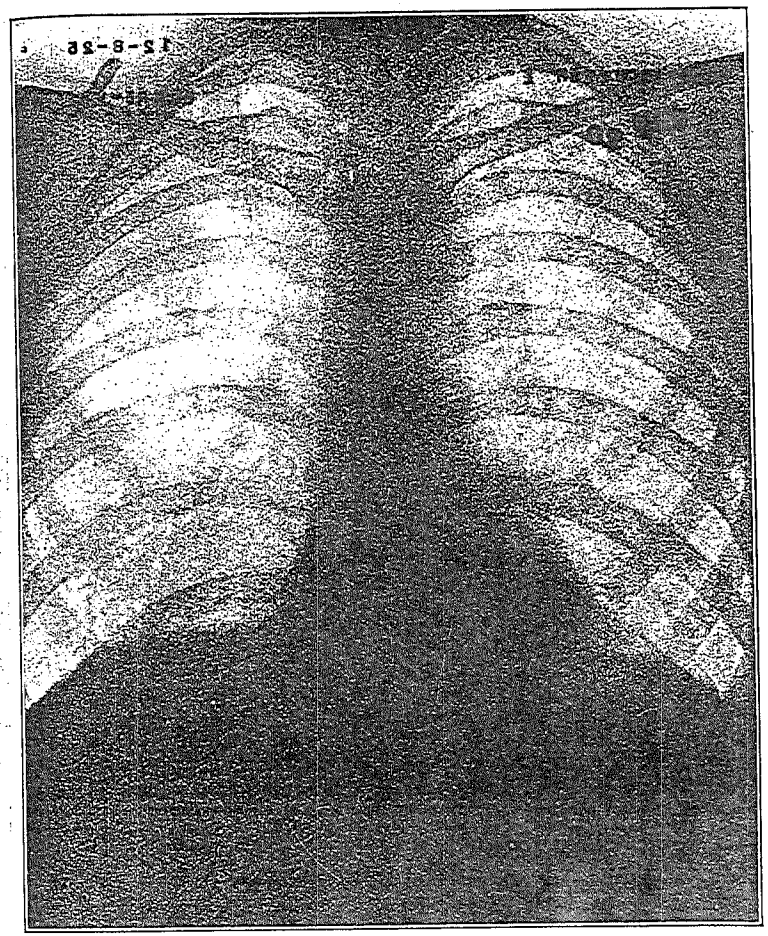
Examination: Height, 67 inches; weight, 161 pounds; impaired hearing; pyorrhœa; chronic rhino-pharyngitis; dental caries; systolic blood pressure, 120; vital capacity, 3,000 cubic centimeters; silicosis.



X ray 11.—Case 220. J. McT., examined on March 12, 1925; Irish, aged 47 years; married

Granite cutter, surface-machine operator for 23 years. Previously worked in a copper factory for five years. His health had generally been very good, although he had had frequent colds during the winter and spring months. He had used alcoholics excessively at intervals. At the time of this examination he complained of cough and expectoration, severe pains in chest, and anorexia.

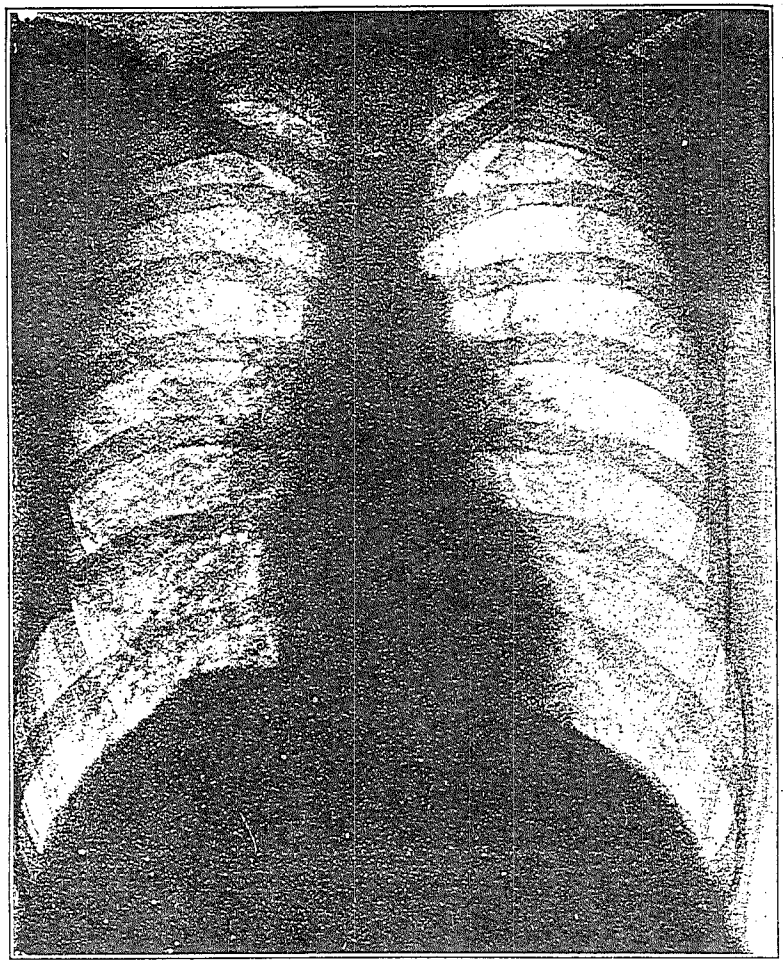
This patient had impaired hearing, chronic rhinitis, and pharyngitis; his teeth had been removed because of caries and pyorrhœa. Blood pressure, 112 systolic; vital capacity, 4,100 cubic centimeters; chest showed evidence of silicosis.



X ray 12.—Case 425. J. R. M., aged 43 years; Scotch

Granite cutter with hand pneumatic tool for 20 years.

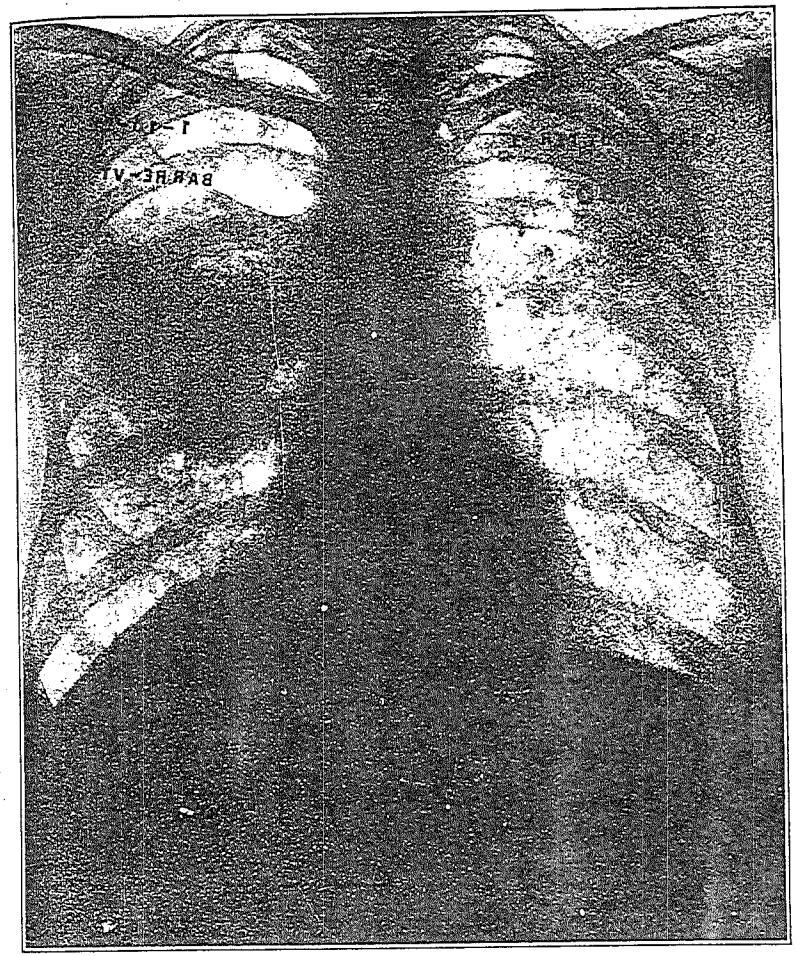
Examination: Height, 68 inches; weight, 146 pounds; dental caries, chronic rhino-pharyngitis; systolic blood pressure, 110; vital capacity, 3,800 cubic centimeters; chronic appendicitis and silicosis.



X ray 13.—Case 200. D. S., examined on February 25, 1925; Scotch, aged 39 years; married

Granite cutter for 20 years, using a hand pneumatic tool. Sand blaster for the past two years (efficiently masked). His father died at the age of 60, of pneumonia; his mother was living. His health had generally been very good; habits good. He was accustomed to play golf extensively during the summer months. At the time of this examination he was feeling well, eating and sleeping well. He had no complaints of any kind.

Height, 67 inches; weight, 152 pounds; impaired hearing, chronic rhinitis, chronic tonsillitis; blood pressure, 146 systolic; vital capacity, 4,400 cubic centimeters (he had athletic tendencies); chest showed evidence of silicosis.



X ray 14.—Case No. 189. C. G., examined on February 13, 1925; American (French-Canadian parentage), aged 48 years; married

Granite cutter (letterer); had used the hand pneumatic tool for 29 years; he had previously been for a short time a derrick man in a granite plant. He was a Spanish-American War veteran, and had had dysentery while in the Army. His health had generally been very good otherwise. At the time of this examination he felt well and had no complaint, and worked regularly. He did not complain of dyspnœa, but is apparently dyspnœic.

Height, 68 inches; weight, 161 pounds; chronic rhinitis and pharyngitis, pyorrhœa, dental caries; systolic blood pressure, 140; vital capacity, 2,000 cubic centimeters; chest showed evidence of an advanced silicosis.

It is interesting that this patient had no apparent illness during study, and he was under observation for the whole period. In September, 1927, he looked well and stated that he had enjoyed good health since the time the morbidity records were closed.

the right. This finding may be observed in the X-ray pictures of other cases of silicosis.

Case No. 189 is representative of advanced silicosis. In addition to the linear densities which were present in earlier stages, the print shows consolidations and fusions of shadows, indicative of extensive pathology. A physical examination and consideration of the patient's clinical condition were necessary to exclude tuberculosis, inasmuch as the consolidations and heavier densities are common in cases of silicosis and tuberculosis with silicosis. This patient was observed throughout the study. He lost no time because of illnesses and was in good health and working regularly in September, 1927.

ATYPICAL CASES

The cases shown in X ray Nos. 2–14 indicate that the silicosis of granite cutters takes a rather regular form in its development; that is, bilateral distribution of densities which predominate in the lower and middle portions of the lung without consolidations or nodular formation in the earlier stages. The cases presented subsequently indicate a departure from this type of cases. The few cases shown in X ray Nos. 15–21 are the only ones found with the X ray that were different in a general way from the others. Although the cases of silicosis complicated by tuberculosis are given in the next section, it has seemed more convenient to include in this section all the atypical cases of silicosis, although a few of them were complicated by tuberculosis.

Case No. 13 has evidence of consolidated areas in each apex. It is the bilateral location of the shadows which tends to differentiate the condition from a tuberculous lesion. Physical examination of this case indicated, as would be expected, impaired resonance and diminished breath sounds over these areas, together with general impairment of resonance and diminution of breath sounds throughout the chest. This case was observed during the whole course of the study and was not ill at any time. He had no evidence of any signs of tuberculosis and no impairment of ability. He was in good health a year after the study was closed.

Case No. 428 simulates at first glance that of a miliary tuberculosis, but there was no indication of this from physical findings. His wife had tuberculosis several years ago, and from the history given it was doubtful if she was an open case. This patient had cut granite for 32 years and at time of examination weighed 177 pounds, and his general condition was excellent, although with such extensive pathology in the chest it may be possible that he had a latent tuberculous condition.

Case No. 146 was rather atypical because of the consolidation which the patient had at the time of the first examination and X ray, December 18, 1924. He was very dyspnoeic, as the extensive amount of involvement shown in the X ray would indicate. The physical examination indicated consolidations in the lower portion of both lungs with râles and absence of breath sounds.

The patient was looked over the following August and there was indication that consolidation had partially cleared up. The patient was less dyspnoeic than at previous examination. Further examination and X ray, January 17, 1926, indicated that the patient had changed but little since previous examination. This case is shown because of its unusual nature, having the physical signs of a pneumonia without the toxic symptoms. Case No. 301 (X ray No. 49) had a similar consolidation, although unilateral. There was a history of a sudden onset and a slow course, but during resolution tuberculosis became evident both physically and clinically.

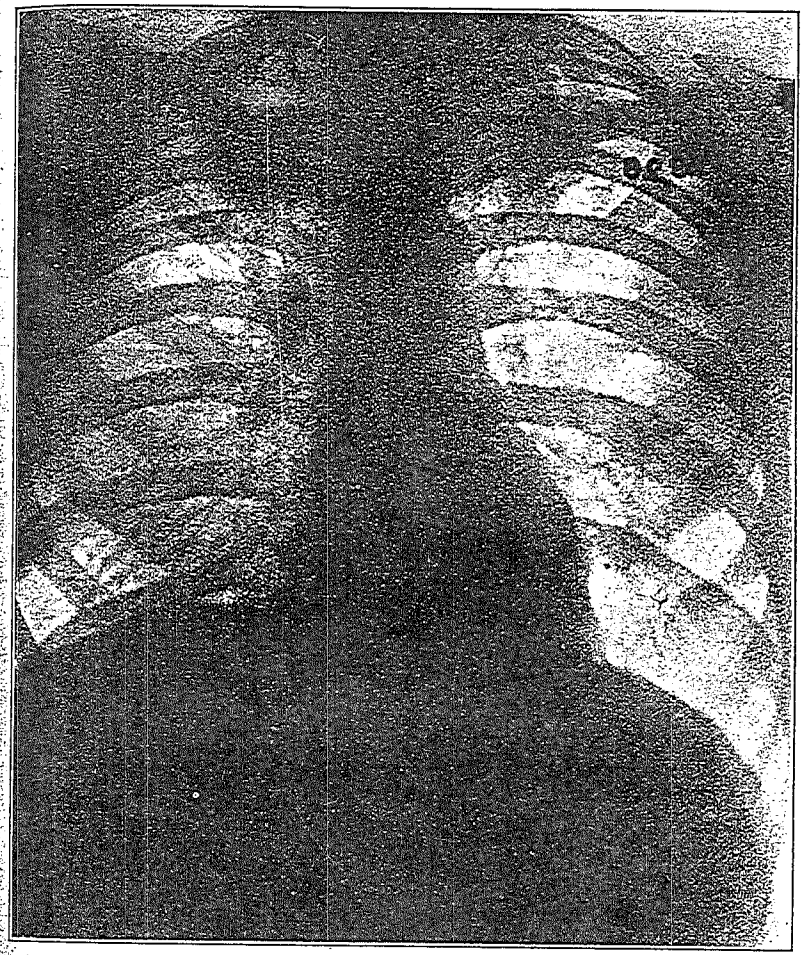
The fact that these cases have atypical manifestations of silicosis does not seem to alter in any way their tendency to develop tuberculosis.

Case No. 53 is a case of atypical silicosis with tuberculosis. This case simulates Case No. 13 as to the bilateral consolidations.

One of the cases (No. 450) case to autopsy and while there is no X ray of the case available, it is of particular interest because of the autopsy finding, which showed a bilateral consolidation, similar to case No. 13.

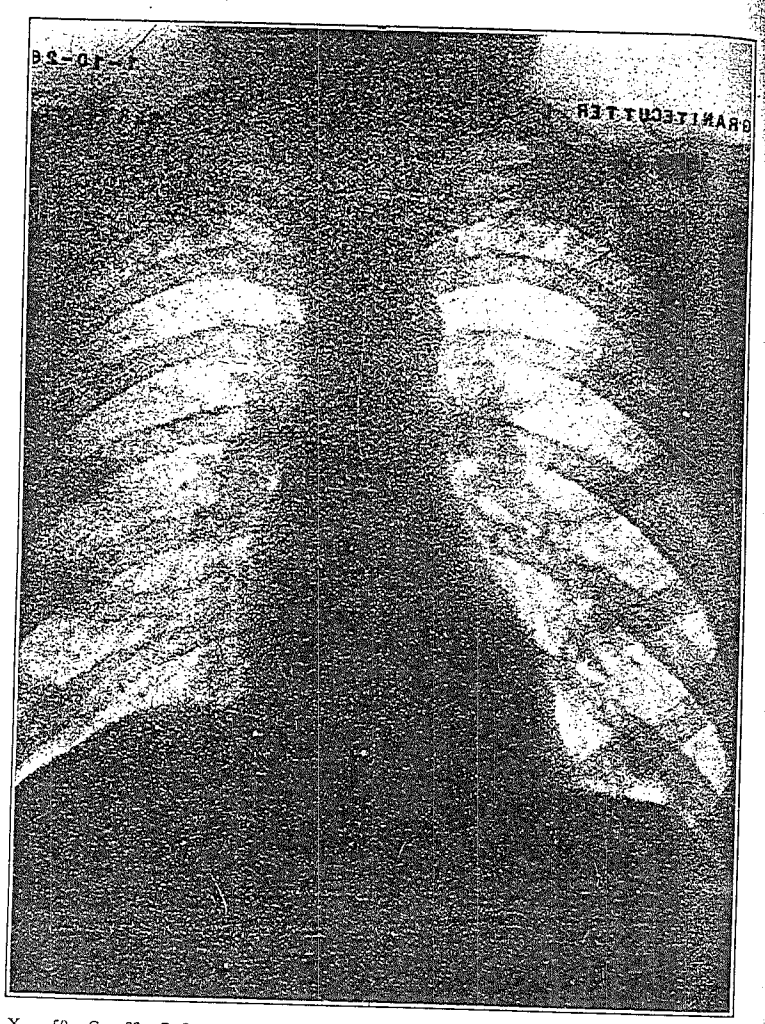
Case No. 153 was interesting and quite different from other cases observed in the study, inasmuch as he was not very toxic and his illness lasted longer than most of the other cases. The dyspnoea in this patient was the most severe that was observed. In fact, it seemed that at times he would die of asphyxiation. This is probably due to the fact that silicosis, because it was far advanced, was the major disability in this case and that the tuberculosis was only incidental.

Case No. 159 is presented because of the unusual nature of the progress of the disease. This patent had tuberculosis about the time he began work in the industry and this may account for the unusual length of the illness. The family physician of this patient, having thorough knowledge of tuberculosis among granite cutters, stated that this case was a medical freak, having reference, of course, to the length of duration and of exposure to granite dust. This was the only case of its kind found in the study. It is quite possible that this patient had been a source for infection for many of his fellow workers. He stated that he had seen many of them go with the disease. Since he was not regularly employed in any one plant, it



X ray 15.—Case 13. G. P., examined on May 15, 1924. Irish (Scotch-Irish parentage) aged 39 years; married

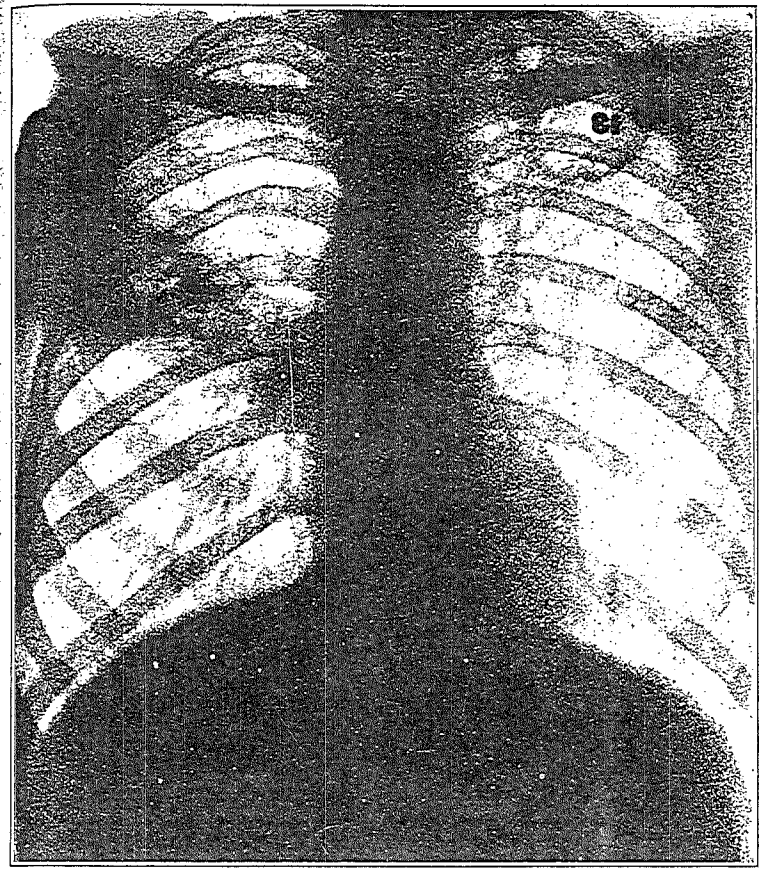
Granite cutter with hand pneumatic tool for 24 years. Health had usually been very good, and he was feeling well when examined. Came for examination because of solicitation. Height, 71 inches; weight, 174 pounds; blood pressure, 160 systolic; chest expansion, 4 centimeters; vital capacity, 4,700 cubic centimeters; chest showed evidence of silicosis.



X ray 59.—Case 22. P. G., examined on June 5, 1924; American (English stock); aged 33 years; married

Sand blaster for 17 years; carved letters part of the time. Father was a granite cutter and died at age of 48, of tuberculosis; mother living. Patient had had attacks of dry pleurisy at times, otherwise he usually had good health. At time of examination he was feeling well and working regularly.

Examination: Height, 71 inches; weight, 180 pounds; dental caries; impaired hearing; chest expansion, 11 centimeters; vital capacity, 5,600 cubic centimeters; chronic pharyngitis and varicocele. On physical examination there was evidence of silicosis and a latent tuberculous lesion in the right apex.



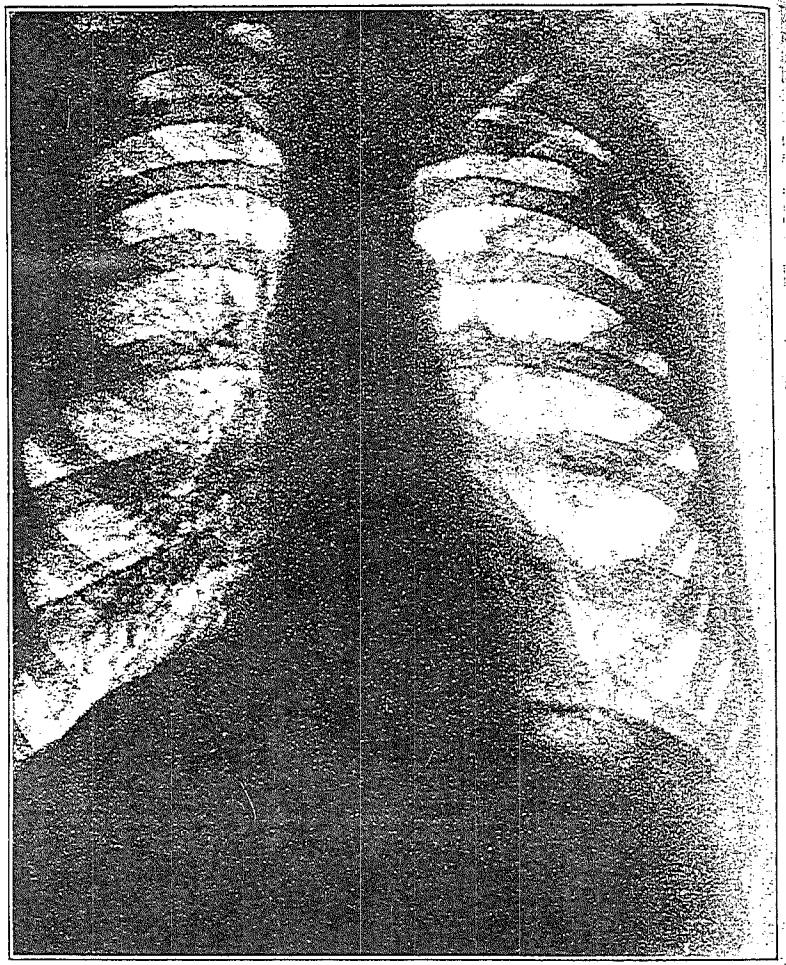
X ray 60.—Case 465. V. P., examined on March 3, 1926; Italian, aged 31 years; single

Granite cutter with hand pneumatic tool for 13 years. Father was a granite cutter and died of tuberculosis at age of 60; mother living and well. Patient's health had been good, except for sore throat occasionally. At time of this examination he complained of cough and expectoration, afternoon rise in temperature, loss of weight, dyspnœa, fatigue.

Examination (at patient's home): Chronic rhinitis and pharyngitis; systolic blood pressure, 104; early silicosis and tuberculosis; sputum contained tubercle bacilli.

Patient died on July 6, 1926.

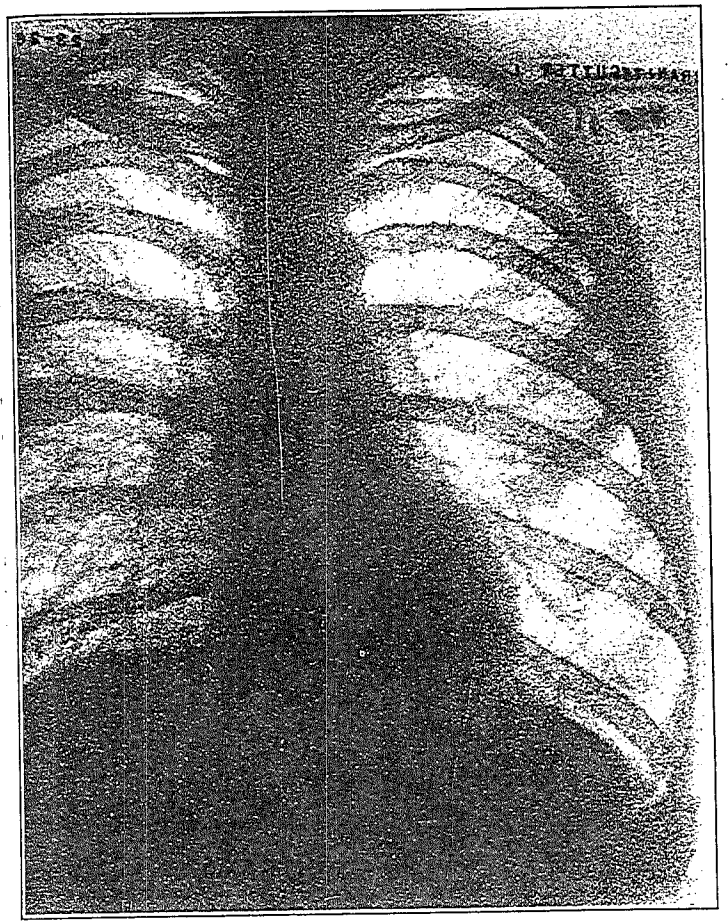
A niece died of tuberculosis a few months after the death of the patient, who had slept and eaten at his sister's home until a few months before his death.



X ray 57.—Case 484. F. S., aged 35 years, Italian

Father, granite cutter, died of tuberculosis at age 47. Brother-in-law (case 218) also a granite cutter, died of tuberculosis in patient's home. Blacksmith and tool grinder 19 years (patient exposed to spray from grindstone and to granite dust from general plant atmosphere).

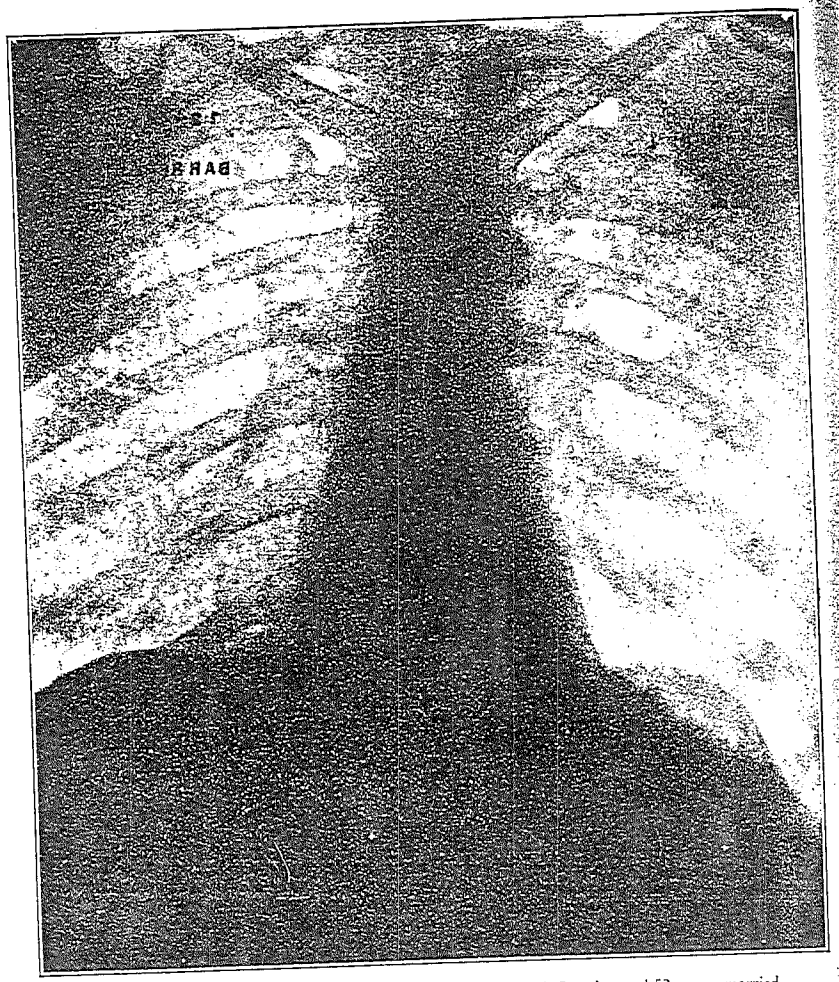
Examination: Height, 68 inches; weight 160 pounds; chronic rhino-pharyngitis; systolic blood pressure, 130; vital capacity, 3,900 cubic centimeters; silicosis and latent tuberculosis.



X ray 58.—Case 498. W. B., examined on May 17, 1926; American (German parentage); aged 29 years; married

He had never cut granite, but had been a foreman in a granite plant and exposed to the dust of the general atmosphere for 10 years. Father was a granite cutter and had been ill with tuberculosis for some time; mother living and well. Health had generally been good, except for a mild nephritis three years ago; patient stated that he fully recovered from this. At time of examination he had a dry cough, which was nonproductive. He was feeling well otherwise and working regularly.

Examination: Height, 72 inches; weight, 155 pounds; chest expansion, 7 centimeters; vital capacity, 5,100 cubic centimeters; chronic rhinitis and pharyngitis, silicosis, and evidence of a latent tuberculosis.

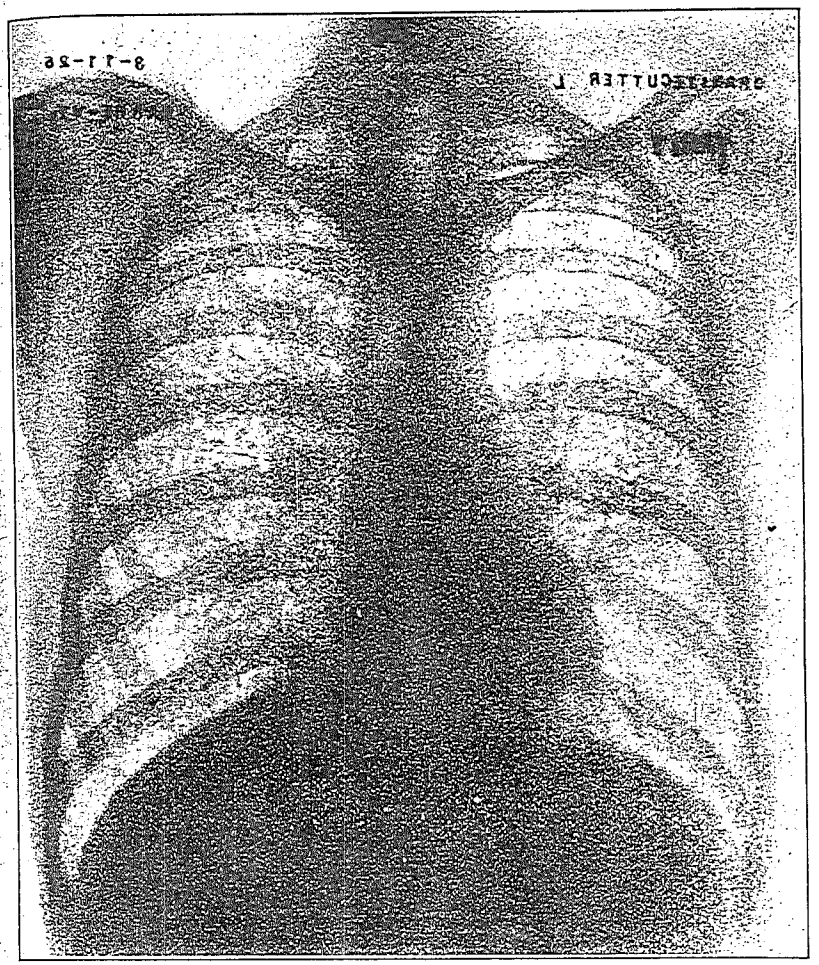


X ray 16.—Case 428. J. P. B., examined on December 11, 1925; Scotch; aged 52 years; married

Granite cutter, operated a surface machine for 32 years. Father died at age of 80 of kidney disease; mother died at age of 80 of senility. Wife had tuberculosis several years ago but took treatment in a sanatorium and recovered. Patient had influenza and pneumonia at age of 45 (1918). Two years ago he had severe dyspnœa, and lost 20 pounds of weight, and had cough and expectoration.

At time of this examination he complained of dyspnœa, which he had had for several years and which had recently been much worse; at times it was so difficult for him to get his breath that it seemed as if he had asthma. He had a dry cough and was quite concerned over his condition.

Height, 71 inches; weight, 177 pounds; impaired hearing, chronic rhinitis and pharyngitis; systolic blood pressure, 120; vital capacity, 3,800 cubic centimeters; chest expansion 5 centimeters; inguinal hernia.



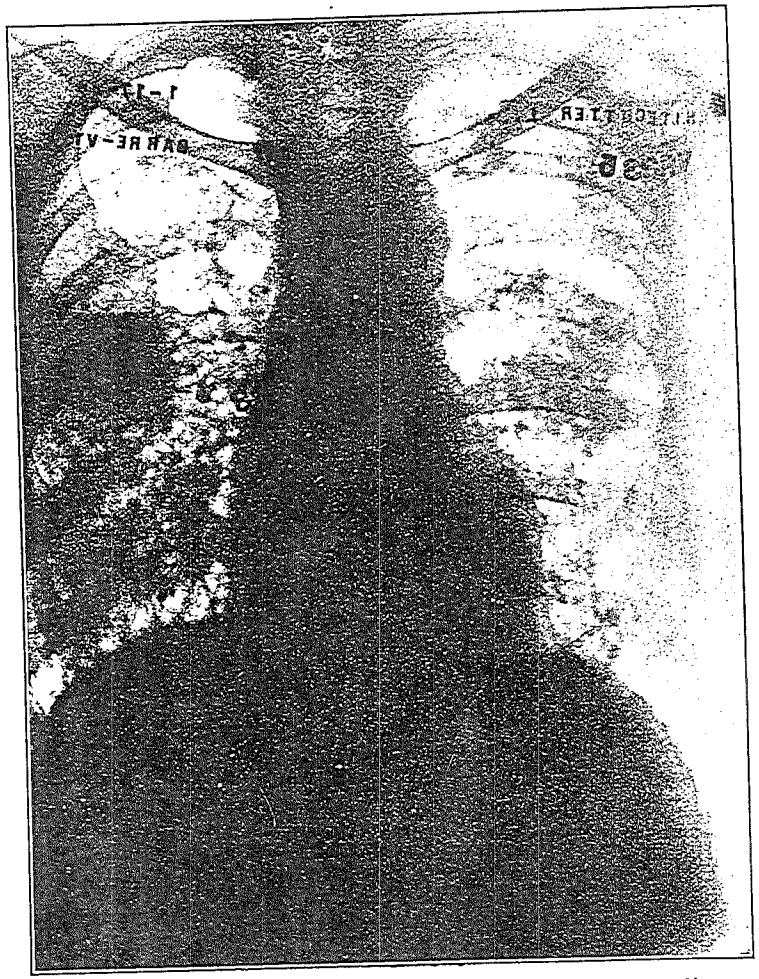
X ray 17.—Case 218. A. G., examined on March 10, 1925; American (Italian parentage); aged 33 years; single

Sand blaster for 9 years; granite cutter, with hand pneumatic tool, for 8 years. Did not wear a mask while sand blasting. Patient stated that he had had very good health until the time of the examination. His habits were good. He had become ill three months previously with pleurisy, pains, cough and expectoration, loss of weight and strength, fatigue, and dyspnœa. These symptoms had persisted, and when examined, he was having, in addition, fever, anorexia, and night sweats.

Height, 64 inches, weight, 124 pounds; deflected nasal septum; chronic rhinitis and pharyngitis; systolic blood pressure, 120; vital capacity, 2,700 cubic centimeters; chest showed evidence of silicosis in both lungs and of advanced tuberculosis, with the greater amount of involvement in right lung; sputum contained tubercle bacilli.

The patient died on March 30, 1926.

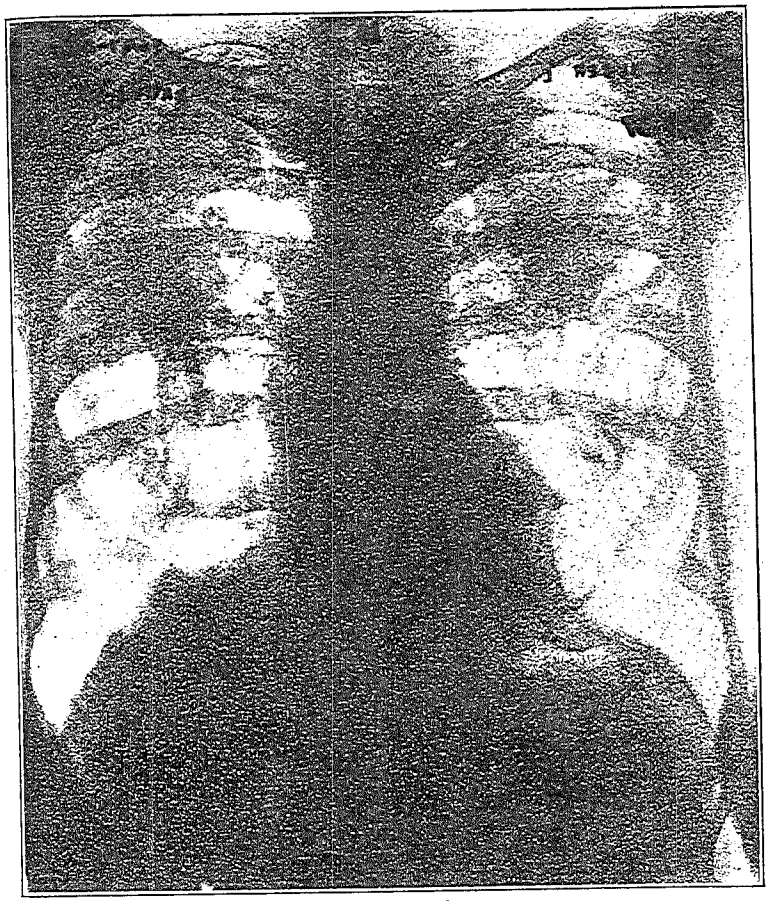
This patient was exposed to a higher amount of free silica and developed tuberculosis at an earlier period than the average granite cutter. Note the difference in the lung markings in this case and those of other granite cutters shown in this study.



X ray 18.—Case 146. C. A., examined on December 18, 1924; Italian, aged 56 years; widower

Cut granite for 35 years.

Height, 63 inches; weight, 133 pounds, having lost 7 pounds during the 6 months previous to examination; impaired hearing; chronic rhinitis and pharyngitis; dental caries; systolic blood pressure, 110; vital capacity, 50 cubic centimeters (questionable as to whether this low value really represents the man's actual vital capacity); advanced silicosis.



X ray 19.—Case 53. F. F., examined on August 4, 1924; Italian, aged 48 years; married

Granite cutter with hand pneumatic tool for 27 years; marble cutter in Italy a few years before coming to the United States.

Past health had been good until two years before his examination, when he had bronchitis, was ill for three days. Habits have been good. Stopped work about a year prior to this examination because of severe dyspnœa, cough, and nervousness. Complaints at time of first examination: Severe dyspnœa, nonproductive cough, fatigue, loss of strength but not loss of weight; nervousness.

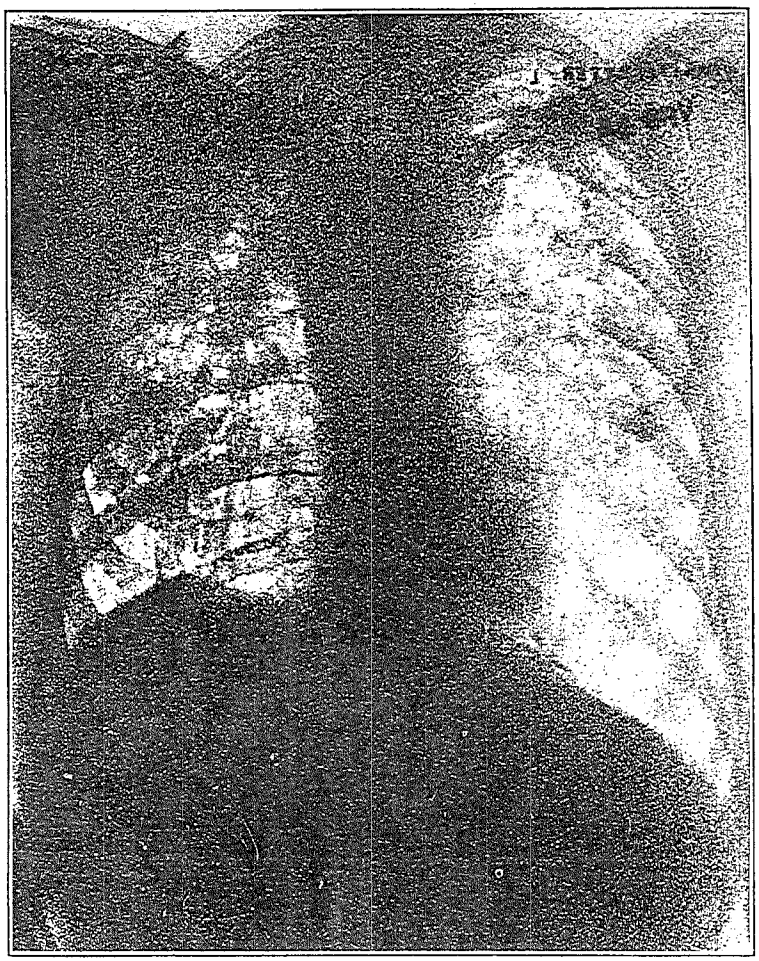
Examination: Height, 58 inches; weight, 154 pounds; impaired hearing; chronic rhinitis; loss of teeth; systolic blood pressure, 130; vital capacity, 2,800 cubic centimeters; advanced silicosis and early tuberculosis.

Reexamination, July 17, 1925: Patient had lost 13 pounds, nervous and dyspnœic; chest condition has remained about stationary.

Reexamination, June 18, 1926: Patient was extremely dyspnœic and unable to walk across room without stopping to get his breath; pains in chest, cough and expectoration (patient had not been raising any sputum until recently). Sputum contained tubercle bacilli.

He continued very much the same except that his dyspnœa was so severe that he was unable to get out of bed.

He died August 23, 1926.

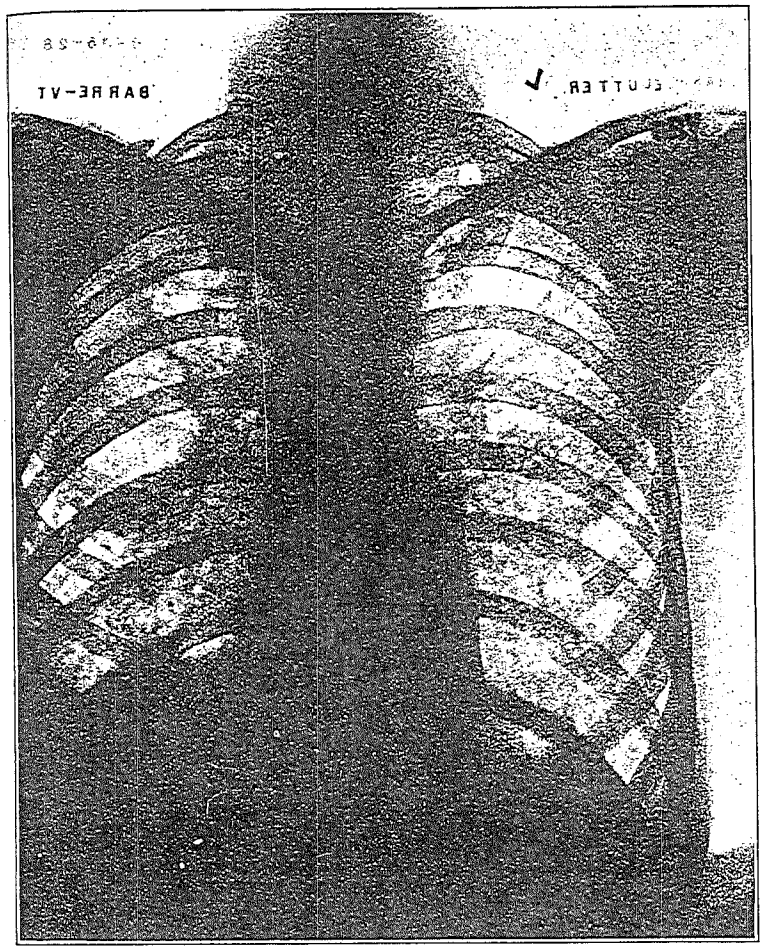


X ray 20.—Case 159. W. M., Scotch, aged 56 years; married

Granite cutter, using the surfacing machine for 32 years. He had used alcoholics excessively for many years. He had not been in good health for many years; in 1896 he was refused insurance because of pulmonary tuberculosis. He has had pleurisy, cough, and expectoration for a number of years. His family physician stated that the patient's sputum contained tubercle bacilli five years ago.

Complaints at time of examination: Pleurisy, cough and expectoration, dyspnœa. He is not able to work regularly, especially during the winter months. Pains in stomach, which the patient attributes to excessive use of alcohol.

Examination: Height, 66 inches; weight, 136 pounds; partial deafness; chronic rhinitis and pharyngitis; loss of teeth; systolic blood pressure, 110; chest expansion, 3 centimeters; cirrhosis of the liver, silicosis, and pulmonary tuberculosis; sputum contained tubercle bacilli.



X ray 21.—Case 527. T. H., examined July 27, 1926; French-Canadian, aged 56 years; married

Blacksmith and tool grinder for 26 years. He ground tools 12 years prior to this examination, and was in a building separate from the granite-cutting sheds, and was exposed to silica in the spray from the grindstones.

He had pneumonia when a child and has had severe dyspnœa for several years. He has had pains in chest, cough and expectoration for some time; at times he expectorated blood; hoarseness and loss of voice; fever, severe dyspnœa, night sweats; lost 20 pounds in weight, and had marked fatigue.

Examination: Height, 68 inches; weight, 104 pounds; chronic rhinitis and pharyngitis; pyorrhœa; systolic blood pressure, 96; vital capacity, 2,400 cubic centimeters; silicosis and tuberculosis, with caseation and excavation in right lung; sputum contained tubercle bacilli.

Patient died August 2, 1927

was not possible to obtain accurate information as to the prevalence of tuberculosis among those who worked adjacent to him.

This case is most unusual inasmuch as he has had pulmonary tuberculosis for many years, has been overindulgent in alcoholics, kept irregular hours, worked in an atmosphere of silica dust, and yet his condition has remained about the same. Tuberculosis in this instance is what is commonly called fibroid phthisis, and his trade evidently had very little to do with its onset and progress.

One of his children developed tuberculosis and died at the age of 7; another has positive signs of latent disease.

Case No. 527 is perhaps the best instance of silicosis among tool grinders observed in the industry in Barre. This patient had been a tool grinder for 26 years, the first 14 years of which he worked in the plants and not far removed from the cutters, evidently exposed to a certain amount of granite dust in addition to dust from the grindstone. For the 12 years prior to this examination he worked in a separate building. It is the custom of tool grinders to change occupations frequently, but this case continued in the same occupation. Many cutters had been tool grinders before the apprenticing of their trade. This is the only instance in tool grinders where a definite case of concurrent silicosis and tuberculosis[40] was found.

[40] See page 99.

VI. TUBERCULOSIS COMPLICATING SILICOSIS

GENERAL COMMENTS

There were really two aspects to the sickness records obtained in the study of granite workers: First, the identifying of workers with tuberculosis by means of the physical examination, X ray, and sickness records; and, second, the observation of sickness from causes other than tuberculosis. In considering the prevalence of tuberculosis, it has appeared preferable to base it primarily on the physical examination (i. e., on the number of persons found to have the disease) rather than on the incidence of disabling illness from tuberculosis. In the latter instance there would occasionally be two or more for a single person; and, furthermore, there would be some individuals with active cases of tuberculosis who were still at work and had not yet had disabling sickness from this cause. The present section, therefore, deals with the number and percentage of persons with tuberculosis, rather than the rate of illness from tuberculosis per thousand years observed. It is evident that this is the logical procedure, since an individual developing a case of tuberculosis, even if employed for a single week, in one of the plants carrying morbidity records would be included in the record. The chance of detecting the presence of tuberculosis in a worker did not depend on the number of weeks his morbidity record was continued. Later in the section, however, the number of calendar days sick from tuberculosis becomes an important factor. In this case, of course, the period of observation, not the individual, is taken as the base in calculating rates.

In interpreting data showing the percentage of workers having tuberculosis, an additional factor is of importance, namely, that the period of observation was two and one-fourth years. There was no possibility of ascertaining the number of new cases of tuberculosis developing each year. In a way, therefore, the record of percentage with tuberculosis is a cross section; but it is not entirely so, as two and one-fourth years were taken in obtaining the results. Some individuals included in the records did not develop active tuberculosis until the study was well under way; thus, a cross section at any one time would yield a somewhat smaller result. This point is of considerable significance, in view of the rapid course of cases of silicosis complicated by active tuberculosis.

The general term "tuberculosis" is used throughout for brevity, but "pulmonary tuberculosis" is to be understood, as almost no nonpulmonary tuberculosis appears in the records, except as associated with the pulmonary disease.

When a silicotic patient develops active tuberculosis certain changes are to be observed in his physical condition, evidenced chiefly by signs and symptoms consistent with the toxemia incident to an early tuberculous lesion. In many cases, however, such signs and symptoms are not sufficiently marked to warrant a positive diagnosis. Such cases were diagnosed as suspected tuberculosis, and, usually, as time went on, the clinical and physical evidence became definite enough to justify a final diagnosis. In many instances the patients were not aware of what was taking place, inasmuch as they attributed symptoms which were plainly referable to the chest to causes other than tuberculosis.

The greatest difficulty encountered in many studies has been the differentiation between silicosis alone and silicosis complicated with tuberculosis. This difficulty is due mainly to the fact that not enough attention has been given to making accurate chest examinations and to the use of laboratory methods in the differential diagnosis. In a silicotic chest tuberculous lesions present definite and consistent signs, though if the silicosis is advanced the diagnosis of early tuberculosis may not be particularly easy because of the enormous amount of pathology present and its interference in breath sounds and the production of râles. The diagnosis can usually be confirmed, however, by the clinical signs and laboratory methods. At such a stage X rays are of less value in the differential diagnosis than in cases in which the tuberculosis develops in an earlier stage of silicosis.

Since tuberculous lesions in silicotic cases occur in tissue which is already disabled, they do not take a definite form as in uncomplicated cases. This finding is true, particularly in regard to the location of the lesions and the progress of the disease. Yet, although abnormally located, the lesions do not lose the definite and consistent signs of tuberculosis.

DISCUSSION OF TWO GROUPS OF CASES

Two distinct groups of cases of tuberculosis were found among the granite cutters, the principal differences between them being found in the ages of the patients, the length of exposure to granite dust, the location of lesions, and the course and prognosis of the disease.

First group of cases.—The first group of cases of tuberculosis was comprised of workers who had a well-advanced stage of silicosis, the average age of workers whose histories are given in this section being 49, while the average length of exposure to dust was 28 years. In

contrast to those of the second group, none of these patients had any knowledge of prolonged exposure to tuberculosis earlier in life, although a number of them were exposed to the disease at intervals in working beside cutters who were tuberculous. The onset of tuberculosis in these cases was rather sudden and the disease ran a rapid course, terminating fatally in most instances. The general location of the tuberculous lesion in these cases was basal. The lesion was frequently of a pneumonic type, with variations in the extent of pathology in different cases. The onset and course of the disease in these instances were also indicative of a pneumonic process.

There were 71 cases in the first group and 54 of them died, and there are 4 whose whereabouts and conditions are unknown.[41] The high incidence of tuberculosis so late in life would not have occurred unless some specific condition had been present which favored its development. This condition was silicosis, which had disabled the pulmonary tissues to such an extent as to cripple their resistance to the onset of tuberculosis and to encourage its development.

According to Collis's observations in his mortality studies, the occurrence of tuberculosis at a correspondingly late age is also quite frequent in other dusty trades in which silica is present. The ages of the workers studied by Collis ranged from 54 to 64.[42] Allison [43] showed about the year 1820 that the highest incidence of tuberculosis was found at a rather late age in people who were exposed to noxious dust, and that in such cases the disease was more of the nature of a terminal complication than of a primary disease. Ickert [44] also refers to the late incidence of tuberculosis among workers with silicosis in the copper mines of Mansfeld, Germany. Most of his cases were between 50 and 60 years of age.

In this group the disease usually ran a rather acute course and terminated fatally. There were no periods of quiescence in any of the cases which came under observation, nor were there any recoveries. Our experience here parallels that of Doctor Lanza in his observation of cases of silicosis in zinc miners. He said, "Usually a tubercle infection implied a more rapid downward progress and an almost hopeless prognosis." (Public Health Bulletin No. 85.) Tattersall [45] observed that all the cases he studied experienced a steady decline.

[41] Nearly all the 71 had died by the time this bulletin was in proof.

[42] Collis, E. L.: Statistical Characteristics of Dust Phthisis (Pulmonary Tuberculosis) Jr. Ind. Hygiene, November, 1926, Vol. VIII, p. 457.

[43] Allison, Trans. Med. Chir. Society, Edinburgh, 1824, I, 373.

[44] Ickert, F.: Staublung und Tuberkulose bei den Bergleuten des Mansfelder Kupferschieferbergbaues, Deutsche Med. Wchnsch., June 20, 1924.

[45] Tattersall, Norman: "The Occurrence and Clinical Manifestations of Silicosis Among Hard-Ground Workers in Coal Mines." Jr. Ind. Hygiene, November, 1926.

Doctor Landis's experience indicates that silicotic potters resemble more the cases in the second group of silicosis, referred to later. The small number of these cases does not warrant the statement that they usually run a more prolonged course than uncomplicated tuberculosis, although apparently they were not more rapid. If it could be shown that these early cases consistently run a longer and milder course than ordinary tuberculosis, such a finding would be favorable to the theory of silica therapy in the treatment of tuberculosis. Doctor Landis says, "I now have knowledge of several potters who became tuberculous, had their disease arrested, and returned to their former work. * * * It is not to be understood that tuberculosis can not develop in the presence of existing fibrosis of the lungs. It undoubtedly does; but when it occurs—and this is true in potters—it commonly runs a latent and more prolonged course than in the case of uncomplicated phthisis." [46]

Those of the cases observed in this study who received institutional treatment were perhaps more comfortable, and obviously they were less of a menace to their families and to the public than those who were cared for at home; but it is doubtful if the course and prognosis of the disease were altered by hospital treatment. It is a popular idea among granite cutters that they would live longer without hospitalization, because in an institution their attention is constantly centered on their disease, which they regard as fatal.

Second group of cases.—The form of tuberculosis observed in the second group of cases resembled tuberculosis in persons not exposed to dust; and it is quite probable that one of the major factors in the causation of this form of the disease was the fact that the workers who developed it had had a latent infection before entering the industry or had been exposed to a massive infection during their early industrial life. It is possible that a number of these workers would have developed the disease regardless of their occupation. The cases of this group are comparable with the cases of silico-tuberculosis mentioned in the reports of the South African workers, except that some of the patients under observation in this study had histories of prolonged exposure to tuberculosis before their entrance into the industry.

In this group of cases the lesions were usually located in the apices, and the course of the disease was slower than in older cutters. Only two of these cases had died of tuberculosis at the time of publication. The ages of this group ranged from 24 to 38 years, averaging 31 years, and the length of exposure to dust was from 3 to 13 years, averaging 8 years.

[46] Landis, H. R. M.: The Pathological and Clinical Manifestations Following the Inhalation of Dust. 15th Rept. of the Henry Phipps Institute.

Immediately following are given cases which have been described above as belonging to the first group. Those belonging to the second group of cases are described in a later chapter, Development of Concurrent Silicosis and Tuberculosis. (See p. 129.)

HISTORY AND SYMPTOMS

In addition to a history of exposure to dust and of symptoms referable to silicosis, the patients have usually had minor illnesses which immediately preceded the development of active tuberculosis and which produced an anxiety state because of their morbid fear of tuberculosis. There was invariably a history of sudden and marked increase in dyspnœa and an increase in cough and expectoration. There were pains in the chest, usually acute, and in some instances so severe as to require the administration of opiates. Fatigue was also an early symptom. Hemoptysis was usually present in the cases in which accurate histories were given. Patients who evaded complaining of symptoms referable to their chests usually denied hemoptysis, even though, as in some instances, hemorrhage from the lungs had been reported by members of their families. Often a history of pulmonary hemorrhage was given by the patient as the first symptom of his illness. Other disabilities complained of were fever, night sweats, and loss of weight and strength. Loss of weight was not an early symptom, however, as it is in uncomplicated tuberculosis. As tuberculosis became more advanced, there were no great differences in its clinical manifestations from those of a fulminating type of the disease in a nonsilicotic. Tuberculosis ran a much longer course in a few of the cases presented herein than in others, and the clinical picture in such instances was that of far-advanced disease, with which every diagnostician is familiar, showing marked emaciation, etc.

BASIS OF DIAGNOSIS

The following physical signs were taken as the basis of the diagnosis of silicosis complicated by tuberculosis:

Unilateral limitation of expansion.

Areas of dullness in addition to the general impaired resonance already existing.

Increase of tactile fremitus over the tuberculous lesion—although this was not such a constant finding as in uncomplicated cases. The breath sounds were not greatly changed except in cavity formation. Bronchial breathing was in evidence near the tuberculous lesion in a number of cases, although the diminished breath sounds of silicosis made this type of breathing rather inconspicuous.

The presence of râles was the most constant finding in cases of tuberculosis, and the râles were of the latent or post-tussic type. This kind of râle is considered pathognomonic of a tuberculous lesion, and much reliance is placed on it in diagnosing tuberculosis. In these cases it was constant, although the lesions were in many instances abnormally located. The importance of the latent or post-tussic râle is well reviewed by Doctor Bray. "The latent râles are those heard only on inspiration after an expiration and cough. These are not heard on ordinary breathing. The forcing of the walls of the infected alveoli together with the coughing causes them to stick, and when inspiration takes place, the walls separate and produce the typical râle. Phthisiologists generally consider this phenomenon as pathognomonic of a tuberculous infection. It may become coarse enough to be heard at ordinary inspiration as the disease progresses, but once recognized, it will be remembered." [47]

These physical signs, considered in connection with the clinical symptoms of the patient, were the points on which the diagnosis was made. This diagnosis was confirmed by laboratory examination and X ray, when possible; not all patients would cooperate in providing specimens.

SPUTUM ANALYSES

Sputum analyses of the cases of silicosis with tuberculosis observed in this study showed that bacilli were present in the first specimen in 20 cases; in the second specimen, in 4; and in the third specimen, in 3. The cases which showed absence of bacilli in the sputum were 8 in number. An average of $2\frac{4}{17}$ specimens on each case were examined. In this study any extended series of tests was not feasible, because the patients would not supply the specimens. An average of less than three specimens of the negative cases were examined. No phthisiologist would pronounce a case of tuberculosis to have a negative sputum unless a series of 10 specimens had been examined. The other reports of positive sputum mentioned in this paper were obtained from the hospitals. Since only emergency treatments were given at the city hospital, only a short series of sputums could be obtained on these cases.

The records of the State sanatorium at Pittsford, Vt. (an institution for early cases of tuberculosis), showed that 88 granite workers had been admitted and that 76 of this number had tubercle bacilli in the sputum. Eleven had negative tests and no report was obtained on the other case. The records of the Washington County Hospital at Barre, Vt. (an institution for advanced cases of tubercu-

[47] Bray, H. A.: The Latent Râle in the Diagnosis of Incipient Tuberculosis. Jr. of the Amer. Med. Asso., Mar. 11, 1916.

30411°—29——10

losis), showed that 44 granite cutters had been admitted. Of 34 cases on which sputum reports were received, 33 had tubercle bacilli in the sputum and 1 had a negative test.

GENERAL PREVALENCE OF CASES OF SILICOSIS COMPLICATED BY TUBERCULOSIS

In an industry in which 73 persons out of a group of not more than 2,000 workers died during a period of three years from what was diagnosed by local physicians as tuberculosis, and confirmed by the Public Health Service investigators and laboratory examinations, it becomes necessary to treat this disease as more or less the cornerstone of the study. The gross findings with respect to this disease are given in Table 58.

TABLE 58.—*Number of workers diagnosed on physical examinations as having tuberculosis*

	Per-centage	Number
Active cases (except "Early"):		
Total	5.66	55
With known positive sputum	2.78	27
Died of tuberculosis during study:		
Total	2.57	25
With known positive sputum	1.13	11
Died of tuberculosis after close of study: [1]		
Total	1.65	16
With known positive sputum	.93	9
Early tuberculosis	.82	8
Suspected or latent tuberculosis	3.82	37
Others with sickness termed "fatigue"	.72	7
Total number of workers in plants carrying sickness records		972

[1] Approximate.

As has been pointed out, not all of the workers were given physical examinations. It is felt, however, that examination was made of all active tuberculous cases in the plants carrying morbidity records, with the exception of two cases. Although not given physical examinations, the diagnosis in these two cases was confirmed by the family physician.[48] The authors feel, therefore, that the percentage given in this table for the plants carrying morbidity records is quite accurate—a total rate of 5.7 per cent or 6.5 per cent if the "early" cases are included. In plants without a morbidity record, some cases may have occurred about which information was not obtained.

Quite a different situation exists as to the cases diagnosed as "suspected" or "latent." Here it is altogether unlikely that the total number of such cases were secured. As a matter of fact, it might be much nearer the truth to use the percentage of persons with suspected tuberculosis out of those given physical examinations, rather than out of the total number in the plants studied. This would give, for the plants carrying morbidity records, about 12 per cent instead of less than 4 per cent for "suspected" or "latent" cases. The number appears to lie somewhere between these limits.

[48] One of the two died and the death certificate read "pulmonary tuberculosis."

In considering the preceding table, it should be kept in mind that these figures are of a different character from what would be found on an ordinary cross-section survey. They represent cases found over a period of 2¼ years and include persons not able to work. It is not felt, therefore, that a comparison with cross-section surveys would be profitable.

Of all cases diagnosed as having active tuberculosis (excluding the "early" cases), one-half had known positive sputa. In view of the great difficulty of getting the workers to submit any extended number of samples (an average of a little more than two tests were made on each person who did not have a positive result recorded), it is quite evident that most of the other cases were unmistakably tuberculous. The family physicians who were consulted in all of these cases concurred in the diagnoses.

What percentage of the suspected cases and of those persons who were sick from an undefined condition which was termed "fatigue" actually had an impending tuberculosis, it is not possible to state, but numerous cases occurred in which absence put down as due to "fatigue" occurred among persons later developing active cases of tuberculosis.

AGE DISTRIBUTION OF CASES

The reader who has in his mind a picture of the age distribution of pulmonary tuberculosis in the general population, gathered either from mortality data or from sickness records, will be surprised to find how differently the disease manifests itself among granite cutters. The characteristic high point in middle adult life has disappeared, and instead the curve rises steadily to the end of life. This is also true of the mortality, as will be shown later in this report.

Table 59 presents the percentage diagnosed on the basis of physical examinations as having tuberculosis in each age group. In all such comparisons it has been necessary to limit ourselves to the plants in which morbidity records were carried in order to have specific information about the population among whom the cases occurred. The percentages in this and following tables are based, not on the number given physical examinations but on the number carried on the morbidity records.

TABLE 59.—*Prevalence of tuberculosis, by age*

Age	Percentage			Cases			Number of persons
	Total	Active only	Suspected or latent	Total	Active only	Suspected or latent	
Up to 20							87
20 to 24	2.4		2.4	2		2	82
25 to 29	5.1	3.1	2.0	5	3	2	98
30 to 34	6.7	1.0	5.7	7	1	6	105
35 to 39	8.4	3.5	4.9	12	5	7	143
40 to 44	6.9	5.2	1.7	12	9	3	173
45 to 49	17.1	12.3	4.8	25	18	7	146
50 to 54	19.6	14.1	5.4	18	13	5	92
55 to 59	26.2	19.7	6.5	16	12	4	61
60 and over	9.1	6.1	3.0	3	2	1	33
All ages	10.3	6.5	3.8	100	63	37	970

The percentages rise from 4 and 5 per cent in the middle period of industrial life to 18 and 19 per cent at the end for the active cases.

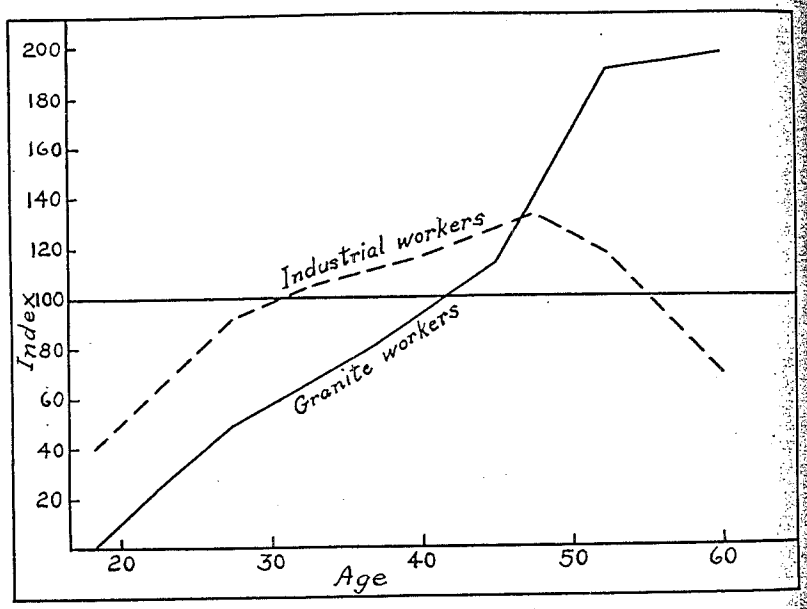


FIGURE 19.—Relative prevalence of tuberculosis by age among granite workers and industrial workers generally. (Ratio of rate in each age to that in all ages)

What is of particular interest is to compare this curve with that of industrial workers generally. Such a curve was given in Public Health Bulletin No. 162 Appendix—Table XVI, page 161, for 10 industries (garment, post office, chemical, foundry, glass, steel, pottery, cigar, gas, cement). The data were obtained in cross-section surveys of men at work, so that the actual rates are not comparable with those of the present study; but the curve by age is thought to

be fairly comparable. Since in those surveys suspected cases were included in some instances and since none of the men was disabled at the time of examination, it seems more logical to include the "suspected" cases among granite cutters in the comparison.

Table 60 gives the rates by age for the granite workers and for the industrial workers generally. To place the two groups on a comparable basis, these rates were divided by the rate for all ages and the resulting indices are included in the table. The two index curves are plotted in Figure 19.

TABLE 60.—*Prevalence of tuberculosis, by age, among granite cutters and industrial workers generally, rates and indices*

Age	Percentage		Indices	
	Granite	Industrial workers [1]	Granite tuberculosis and suspected tuberculosis	Industrial workers
Up to 20		1.0		40
20 to 24	2.4	1.6	23	64
25 to 29	5.1	2.3	49	92
30 to 34	6.7	2.6	65	104
35 to 39	8.4	3.7	82	116
40 to 44	11.6	2.1	113	132
45 to 49		3.3		
50 to 54	19.6	2.9	190	116
55 to 59	20.2	1.3	196	72
60 and over		2.3		

[1] Public Health Bulletin No. 162, appendix Table XVI, p. 161.

The contrast is very striking. Above 50 years of age, the granite workers' curve keeps rising rapidly, while the general industrial curve begins to decline. A discussion of the meaning of this difference is postponed until the curves according to the length of service are considered; but it may be pointed out that this late period of development of tuberculosis among persons exposed to silica dust has previously been observed. It is paralleled in the mortality data.

TUBERCULOSIS BY DUST-COUNT GROUPS AND YEARS IN GRANITE

To show the association between the high tuberculosis prevalence among granite cutters and the dust hazard of the industry, it becomes necessary to consider both the years the workers have been in the granite industry and the class of work they have been carrying on. Use will be made of the four groups of occupations based on the amount of dust exposure. Group A, it will be recalled, were hand-pneumatic tool cutters, with the highest dust exposure; Group B consisted of other occupations having more than the average dust exposure of the sheds; Group C was identical with that of the

sheds; and Group D was less than that of the sheds. Group D alone had an exposure lower than the standard set in South Africa, which has already been discussed. In this group no cases of active tuberculosis were found on physical examination.

Table 61 presents the percentage and number of cases occurring in the four groups for different periods of service in the granite industry. These are active cases found on physical examination among workers employed in the plants carrying morbidity records. As previously emphasized, it is believed that they include all cases in these plants occurring during the study—in other words, that no active cases were missed (except two found from the morbidity records and included).

TABLE 61.—*Prevalence of tuberculosis (active), by length of service and dust-count groups*

Dust-count groups	Prevalence according to years of service in granite						
	Up to 5	5 to 9	10 to 14	15 to 19	20 to 24	25 to 34	35 and over
	Rate per 100						
A	0.8		2.0		10.2	15.1	15.5
B	---		4.8		7.1	19.1	
C	2.6			1.5			
D							
	Cases						
A		1	3		13	21	11
B			1		1	3	6
C	1	1		1			
D							
	Persons [1]						
A	85	40	78	73	128	139	71
B	14	8	10	11	14	32	15
C	39	19	20	23	21	19	7
D	21	21	11	17	21	11	

[1] Total number of persons in plants carrying morbidity records.

The percentages are also graphed in Figure 20. The contrast between the A and B groups and the C and D groups is extremely significant. As stated, Group D furnished no cases. Group C furnished but three cases.[49] With Groups A and B, however, the story is

[49] The three cases of tuberculosis found in Group C require special consideration.

Case No. 12.—Age 34. Surface machine operator, 5 years; derrick man, 5 years; previously in quarry 6 years. The only "quiescent" case found in the study. On first examination, rales found over both apices. Should possibly be regarded as a case of concurrent tuberculosis and silicosis, but one can not be sure. The case was certainly not typical of

entirely different. The rise is so unmistakable and so rapid that there can be no question but what it is associated with the hazards of the industry. No other graph to be presented is of more importance or

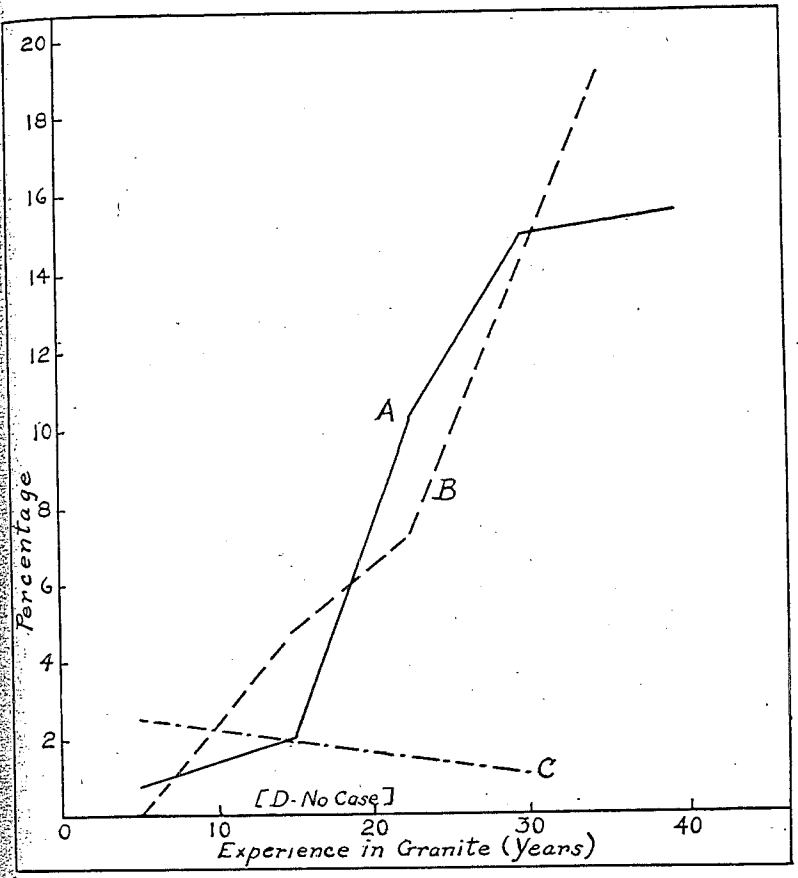


FIGURE 20.—Prevalence of tuberculosis (active) by length of service and dust count groups. (Percentage of workers diagnosed on physical examination as having the disease)

carries more conviction than this striking picture of a rapidly increasing prevalence of tuberculosis with increasing years of service in

tuberculosis developing after excessive exposure to silica dust. Had a pulmonary abscess, which would further alter the chest findings.

Case No. 292.—Age 26. Lumper and tool carrier for 3 years. Had "early" tuberculosis. Father died of tuberculosis. The case has been classed as "concurrent tuberculosis and silicosis," and the case history is given elsewhere. (See p. 130.)

Case No. 396.—Age 39. Lumper 18 years. Tuberculous process in both apices. Patient died. Two brothers died of tuberculosis. Evidently a case of "concurrent tuberculosis and silicosis."

From the nature of these cases it is apparent that, although they would not have perhaps developed independent of dust exposure, yet they can not be ascribed solely to this factor. They are on quite a different footing from the large number of cases found to occur in Groups A and B after prolonged exposure to dust.

two groups exposed to a very high dust content, beside a nominal amount of tuberculosis in two groups exposed to the average dust atmosphere of the sheds or less.

So important do these data appear that an additional table has been given to show the same facts for all cases, including "suspected" tuberculosis.

TABLE 62.—*Prevalence of tuberculosis, including suspects, by length of service and dust-count groups*

	Years of service in granite							
	Total	Up to 5	5 to 9	10 to 14	15 to 19	20 to 24	25 to 34	35 and over
	Percentage							
All tuberculosis:								
A	11.6	2.4	2.5	4.6		14.1	18.7	23.9
B	15.4				8.6		18.7	46.7
C	6.2							
D	3.7							
	Number of cases							
A	71	2	1	6	1	18	26	17
B	16			2		1	6	7
C	9	2	1	3	2		1	
D	4		1		3			
	Number of persons							
A	614	85	40	78	71	128	139	71
B	104	14	8	10	12	14	32	15
C	146	39	19	20	7	21	19	5
D	108	21	20	11	13	21	11	7

When the suspected cases of tuberculosis are included, the rate rises rapidly as before in the advanced length of service periods for both A and B groups.

TUBERCULOSIS IN CERTAIN OCCUPATIONAL GROUPS

It is difficult to treat of the specific occupations, because the numbers are so small outside of cutters themselves, but a rough comparison is given in Table 63:[50]

TABLE 63.—*Prevalence of tuberculosis (active) in certain occupations*

Dust-count group	Occupation	Percentage	Cases	Persons
A	Total	8.0	49	614
	Hand pneumatic-tool cutters	8.0	47	590
	Carvers and letterers	8.3	2	24
B	Total	10.6	11	104
	Surface machine cutters	13.2	9	68
	Others	5.5	2	36
C	Total	2.0	3	146
	Lumpers	1.5	1	66
	Others	2.5	2	80
D	All			108

[50] To avoid confusion due to workers transferring from one occupation to another, these have been assigned to appropriate occupational groups.

What stands out particularly is the high rate among surface-machine cutters (13.2 per cent). Of the 9 cases of tuberculosis occurring in this occupational group, 1 was in a worker with between 20 to 24 years of exposure to granite dust, 3 with from 25 to 34 years of exposure, and 5 with 35 or more years of exposure. The percentages in these three length of service groups for surface-machine cutters are 7.7, 10.0, and 45.5, respectively. The excessively high rate in the 35 years and more length of service group is very striking.

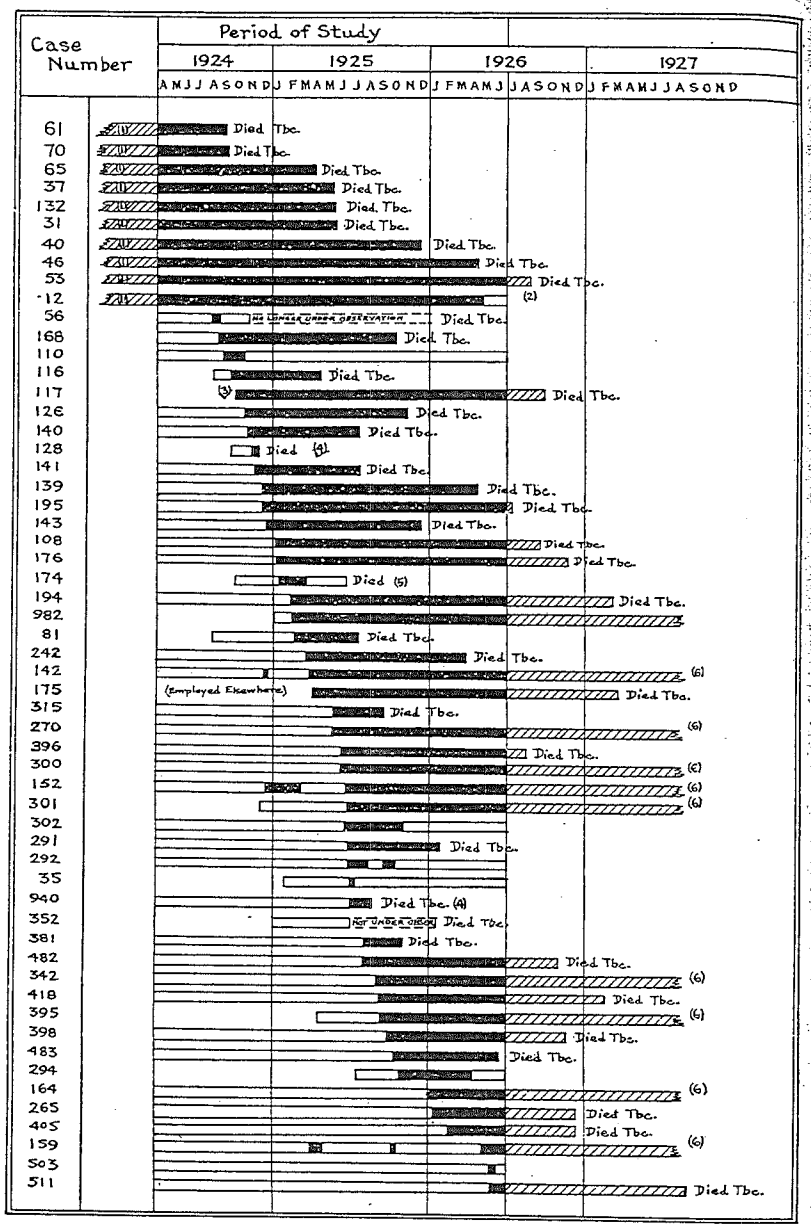
Included in the "other" group (B) are the tool grinders. Twenty-six of these were classified as tool grinders throughout their period of service in granite, and four were tool grinders preceded or followed by another occupation. Among these one case of tuberculosis was found, giving a rate of 3.3 per cent.

MORBIDITY FROM TUBERCULOSIS

General picture of duration of disability from tuberculosis.—Perhaps no more vivid conception of the tuberculosis problem among workers exposed to silica dust is possible than that given by Figure 21.[51] Here the individual cases of tuberculosis are taken up chronologically, the black portion of the bars showing the periods during which the individuals were disabled from tuberculosis during the period of the study, and cross-hatched portion of the bars representing disability before the study opened or after its close. No cases of sickness merely suspected of being tuberculous in nature are included.

The cases are arranged in chronological order on the basis of the date when the disability began. The termination of the case is also indicated. At the top of the graph are given nine cases which originated prior to the beginning of the study. All nine died from tuberculosis during the period of the study or shortly after its close. These nine persons were employed in the plants carrying morbidity records at the time when their disability developed—i. e., they are strictly a charge upon those plants and, from the point of view of severity, should be carried along, just as would any person developing disabling sickness from tuberculosis after the study began. No persons in outside plants are included. If it is desired to estimate the amount of disabling sickness from tuberculosis at any given instant during the study period, it is necessary to consider all persons in the plants carrying morbidity records, no matter how long they have been disabled. The question as to whether their disability

[51] Throughout the discussion of the severity rates from tuberculosis, absences due in part to another cause are ascribed to tuberculosis or suspected tuberculosis, as the case may be. There were only 8 such absences, with a total days lost of 965, or 5.2 per cent of the days lost from tuberculosis (actual and suspected cases). A small but undefinable part of this disability is not correctly ascribable to tuberculosis.



(1) Disability began before April 1, 1924. Cases arranged in accordance with date of death.
(2) Arrested case.
(3) Not under observation until 1925, but diagnosed as having active tuberculosis on Oct. 1, 1924.
(4) Cause of death tuberculosis and tuberculous meningitis.
(5) Pneumonia immediate cause of death.
(6) Lost tract of because of leaving city.

FIGURE 21.—Duration of disability from tuberculosis (active) according to date of onset

began before the date when the study opened, or not, would be of no moment.

In some few instances a person returned to work following disabling sickness from tuberculosis. In these cases the black bar is interrupted by a section of white; but, of course, the tuberculous condition continued.

What would be desirable in summarizing this graph is to give the average duration of the cases from the time disabling sickness began until death. Although no precise mean can be obtained, so long as any of the cases remain alive, it is possible to obtain the median duration (or central item in the arrayed series), knowing that all cases which were still alive at the time of sending the bulletin to press have a duration greater than the median. Such an average, leaving out of consideration cases lost track of because they left the city, yields 15 months, the calculation being based on 40 persons, and therefore quite stable. To one familiar with the normal course of tuberculosis when not associated with silicosis, this is a surprisingly short period of time. Taken in conjunction with the absence of quiescent cases and failure of cases to recover, it is extremely significant. Out of the 40 deaths, 13 lived for less than one year from the beginning of disabling sickness, and 5 for less than six months. It is interesting to observe that for the first half of the study (during which period only one case had survived up to the date of publication), the mean is 14.7 months—a substantial verification of the median as calculated above.

Days lost by dust-count groups and years in granite.—In analyzing the sickness due to tuberculosis, one should ascertain whether the same relation to dust-count groups and years in the granite industry is maintained as found in the case of percentage of persons with the disease. Accordingly, Table 64 gives the calendar days lost per person per year observed. Only active cases of tuberculosis are included. To obtain the years of observation the summation of the number of weeks each individual was carried on the morbidity records (after deducting absences during which he would not be under observation) was divided by 52. As the average duration of the observation period was about a year and a half, the number of different persons in each dust count and length of service group may be obtained roughly by subtracting one-third from the years of observation.

TABLE 64.—*Days lost from tuberculosis (active)[1] by length of service and dust-count groups*

Group	Years of service						
	Up to 5	5 to 9	10 to 14	15 to 19	20 to 24	25 to 34	35 and over
	Days lost per person per year						
A	0.3			11.7		31.4	
B				8.1		19.9	
C	.6				8.5		
D							
	Total days lost						
A		49	578		3,590	6,276	2,953
B			407		69	465	990
C	45		738	391			
D							
	Years observed						
A	95.6	51.1	103.4	82.1	171.0	192.5	101.4
B	18.4	9.3	17.2	20.9	21.0	48.9	24.0
C	49.8	26.6	31.9	36.1	31.2	28.8	4.8
D	26.3	34.9	19.3	32.6	36.3	16.3	14.7

[1] Days lost from absence due in part to other causes are included.

Again there is a striking rise in the rates with length of service for the A and B groups and little or none for the C and D groups. In fact, the picture is quite parallel with that furnished by the prevalence of cases of tuberculosis and confirms the conclusion reached as to the relation between the tuberculosis found and the dust hazard. When it is realized that hand pneumatic-tool cutters (Group A) had on the average more than 31 days' sickness per year from tuberculosis, the extent of the disability is readily understood. These are average figures and are due to much longer durations of sickness on the part of relatively few persons in the group.

RACIAL SUSCEPTIBILITY

The question of racial susceptibility to tuberculosis resulting from exposure to granite dust was studied, especially in view of the fact that certain observers had felt that a lower rate existed among Italians than among others. In only two groups (Italians and Scotch) were the numbers sufficiently large to be sure of the accuracy of the rates. The Scotch showed a rate of 13.6 for workers in Groups A and B; Italians, 19.1. The remaining groups of Americans, French-Canadians, and others were too small for use. In general, it was felt that there was no distinct racial susceptibility indicated by the data. This conclusion is borne out by an analysis of the death certificates of persons dying in Barre from 1900 to 1925.

The material is based on country of birth. Table 65 presents the percentage of deaths due to tuberculosis among cutters.

TABLE 65.—*Percentage of deaths due to tuberculosis (1900–1925) among cutters born in Italy,[1] Scotland, and "other countries"*

	Percentage	Total number of deaths excluding accidents	Deaths from tuberculosis
Italy	62	189	117
Scotland	74	224	57
Other countries	65	245	167

[1] Persons born in United States, with both parents born in Italy are included, similarly as to Scotland.

In this case the percentage is slightly higher for the Scotch, suggesting that the higher rate among Italians in the study proper was not significant.

In connection with the study of incidence of sickness from other causes, an opportunity was made to study the difference in racial susceptibility, if such existed. The groups which were made use of were Italian, Scotch, French-Canadian, American, Spanish, English, Swedish, and others. There was no clear suggestion of higher rates in any particular race, but in view of the small numbers and consequent impossibility of taking into account such factors as occupation and age, no very definite conclusions were possible. The data did indicate marked differences for the same races in the various dust-count groups, which is consistent with previous findings.

MORTALITY IN STUDY

General death rate from tuberculosis in group studied.—The deaths from tuberculosis in the plants carrying morbidity records and also among workers in other plants have been given in a previous section. (Table 46.) In arriving at a death rate for comparison with other studies, it becomes necessary to make adjustment for the fact that the deaths covered a considerable period. The study started on April 1, 1924, and closed June 30, 1926. The deaths not only cover this period (with the possible exception of a few which may have been missed in the first few months) but the record of them has also been carried along from information obtained from Barre, Vt., up to the time when the report was prepared (summer, 1927).

Information has since been received in regard to 22 further deaths, all but one of which was due to tuberculosis complicating silicosis, and it is believed that many more have died about whom information has not been received. It is known that a large number with active cases of the disease left the city, most of them going back to Europe.

The large number of deaths occurring since the middle of 1927 is very strong evidence that the death rates found during the course of the study itself have not since declined, and in fact it is hard to escape the feeling that they have increased.

Some of the recent deaths occurred among persons having tuberculosis diagnosed on physical examination during the course of the study. In other cases, there was a suspicion that the worker had an incipient case, this suspicion being borne out by the ultimate death of the person from tuberculosis. On the other hand, some of the recent deaths have occurred among persons who gave no signs during the study of being on the point of breaking from the disease.

As stated above, the record of deaths used in this section does not include these 22 deaths and may be regarded as covering a period of three years. In obtaining annual death rates, accordingly, only one-third of the apparent rate has been used. Out of a population of 972 (in plants carrying morbidity records), 41 persons died from tuberculosis, yielding an annual death rate from tuberculosis of 14.1 per 1,000. Such a rate is obviously excessive, but the comparison with other groups can best be made after considering the age at which the deaths occurred. The age distribution of the general population varies so widely from that of an industrial population that no comparison is practicable without considering that factor.

Tuberculosis death rate according to dust-count group.—Calculating the annual death rate in the same way, it is found that there was a rate of 19.5 in dust-count Group A; 12.8 in dust-count Group B; 2.3 in dust-count Group C (1 death only); and no deaths in dust-count Group D. A sharp contrast, indeed, among the workers depending upon their exposure to dust. Included in the population for all the groups, however, are a large number of persons with short exposure to dust, who have not had time to develop tuberculosis. More meaning can be obtained from the record if the length of service of the worker is considered. Table 66 was prepared to bring this out.

TABLE 66.—*Death rate from tuberculosis by length of service and dust-count group*

Group	Years of service							
	Up to 5	5 to 9	10 to 14	15 to 19	20 to 24	25 to 34	35 and over	Total
	Annual death rate per 1,000							
A	2.7		2.2		28.6	33.6	42.3	19.5
B						10.4	66.6	12.8
C								2.3
D								

TABLE 66.—*Death rate from tuberculosis by length of service and dust-count group*—Continued

Group	Years of service							
	Up to 5	5 to 9	10 to 14	15 to 19	20 to 24	25 to 34	35 and over	Total
	Number of deaths							
A		1	1		11	14	9	36
B						1	3	4
C				1				1
D								
	Number of persons							
A	85	40	78	73	128	139	71	614
B	14	8	10	11	14	32	15	104
C	39	19	20	23	21	19	5	146
D	21	20	11	17	21	11	7	108

For Groups C and D a comparison by length of service is impossible, because only one death occurred in these groups. This death was that of a lumper, who had been employed in that occupation for 18 years. He had a positive sputum, and his death appears to be ascribable to the dust hazard. The annual rate for Groups C and D was 1.3 per 1,000.

If Groups A and B are combined, the annual death rate from tuberculosis is 25.8 per 1,000 for the length of service group 20 to 24 years; 29.2 for length of service group 25 to 34; and 46.5 for longer periods of exposure to granite dust.

By way of summary of what has previously been presented, Figure 22 makes a graphic comparison of tuberculosis among granite workers in Barre with certain other groups, both with respect to sickness and death. In the case of sickness the percentage of persons diagnosed as having tuberculosis is, of course, not available for the other groups. Therefore the comparison has been made instead on the basis of the annual frequency of absences from tuberculosis in each group. It is clear that there is an excess even in Group C, but, as pointed out before, these cases occurred among persons without a long period of service, and the relationship to the dust hazard is not so evident. With respect to deaths, comparison is made with rural Vermont (males), age 20 to 59, or, in other words, the industrial age.

Age curve of mortality from tuberculosis.—The death rate from tuberculosis among adults is usually more or less the same at different ages. Under some conditions there is a peak in young adult life, but such peaks used to be more pronounced than they are to-day. Among granite cutters the difference is so striking that a graph (fig. 23) has been prepared comparing the age curve of mortality

for granite cutters with that for rural Vermont (males). Rural Vermont is chosen in order to have data relatively free from the influence of other industrial conditions on the tuberculosis death rate, but the

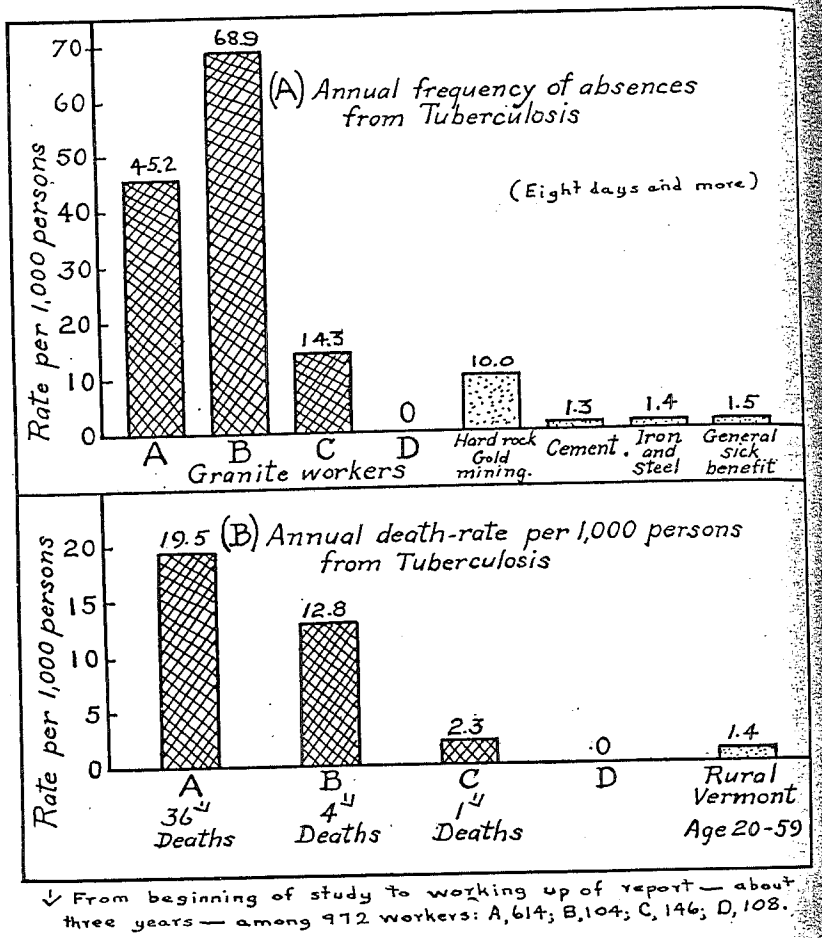


FIGURE 22.—(A) Annual frequency of absences from tuberculosis (eight days and more); (B) Annual death rate per 1,000 persons from tuberculosis

comparison is not altogether felicitous, owing to the retirement of some granite cutters to rural districts of Vermont. This fact causes the curve to stand out a little from the usual rural curve. None the less the actual rates are considerably under those for males in the registration area generally. The data are given in Table 67.

TABLE 67.—*Age curve of mortality from tuberculosis among hand pneumatic-tool cutters and in rural Vermont (males)*

Hand pneumatic-tool cutters				Rural Vermont (1908–1912)			
Age	Annual rate per 1,000	Number of deaths	Population	Age	Annual rate per 1,000	Number of deaths	Population
All	19.58	[1] 36	613	20 and over	1.42	146	103,105
Up to 35	1.72	1	194	20 to 29	1.40	35	24,941
35 to 39	10.64	3	94	30 to 39	1.21	28	23,091
40 to 44	14.01	5	119	40 to 49	1.39	27	19,420
45 to 49	35.26	11	104	50 to 59	1.52	24	15,842
50 to 54	45.98	8	58	60 and over	1.61	32	19,811
55 and over	60.61	8	44				

[1] Total number during period of study, but rate is based on number per year.

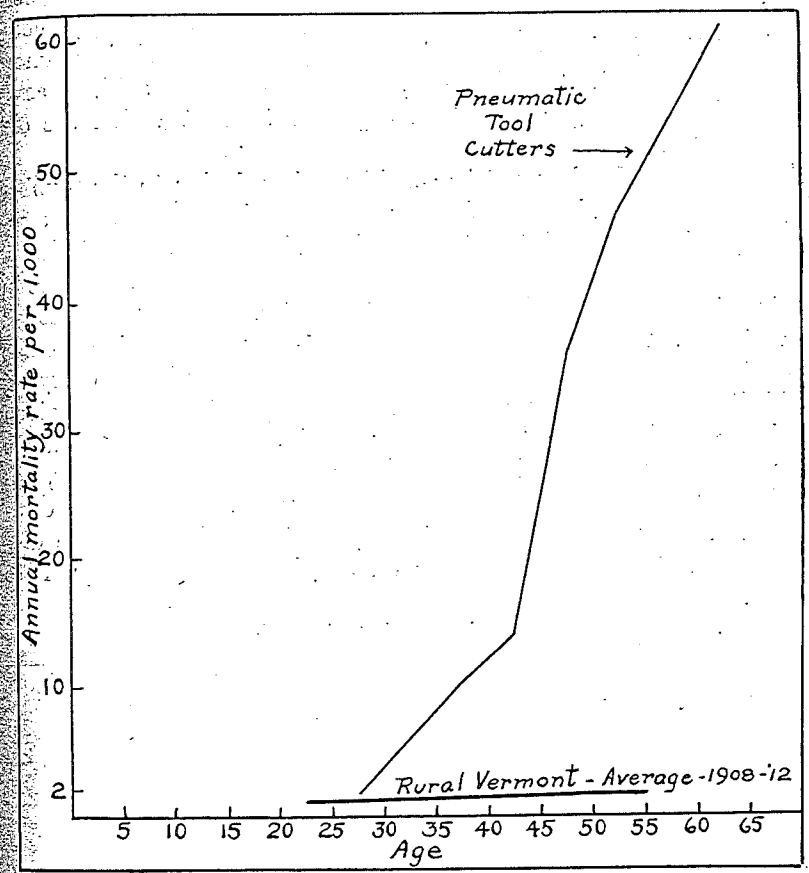


FIGURE 23.—Age curve of mortality from tuberculosis among hand-pneumatic tool cutters and in rural Vermont (males)

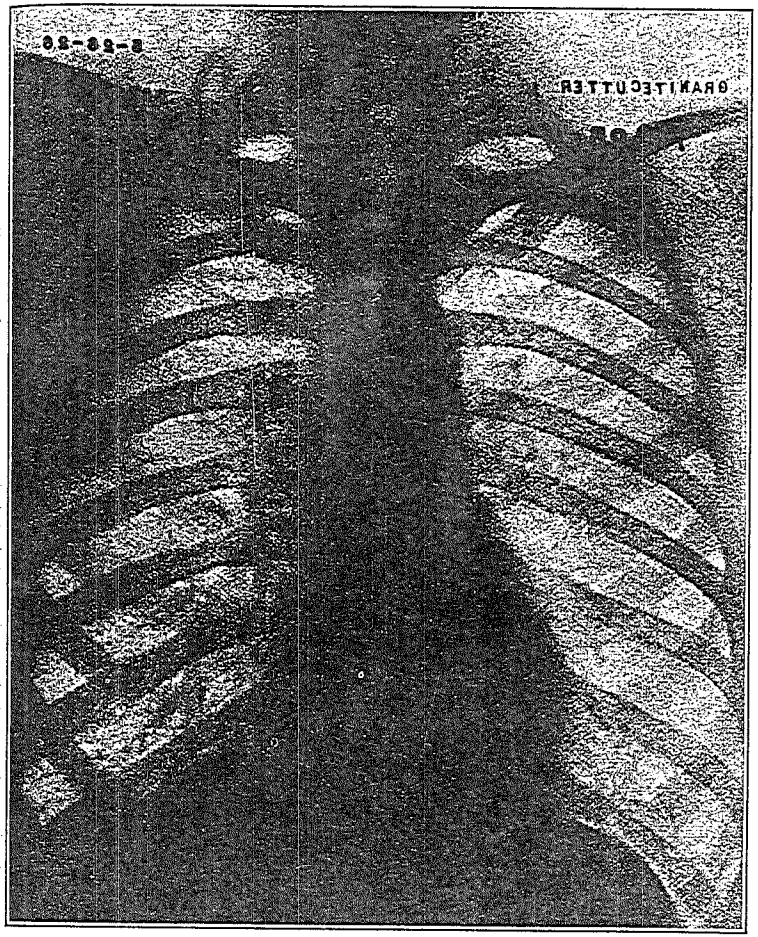
It has been necessary to employ a much condensed scale in order to bring the curve for cutters within the limits of a graph, and for this reason the curve for rural Vermont must necessarily strike one as being very flat. It is a limitation of arithmetic scaled paper.

At the beginning of industrial life, the mortality among granite cutters compares favorably with that of rural Vermont. No exact comparison of the two groups is possible because of the smallness of the group of cutters. By the 35-year age period, however, the rate for cutters has begun to rise. The contrast becomes more marked with each year of dust exposure. By the time the granite workers are about 60 years old they appear to have a rate approximately 35 times as great as that of rural Vermont. Again, at this end of the curve, considerable allowance must be made for fluctuations due to small numbers, but there is no necessity of reducing the contrast to exact figures. While under normal conditions the tuberculosis death rate remains almost stationary during adult life, among granite cutters it rises with great rapidity, the increase being almost unbelievably great. The increase, it need hardly be said, is associated with the longer period of exposure to dust which the old workers have.

Although the deaths must be considered in relation to the number of persons with a risk of dying, as was done in the previous comparison, it is of some interest to consider simply the age at death. In fact, for the deaths occurring among granite workers who were in plants not carrying morbidity records this is the only possible method of treatment. Table 68 has, therefore, been prepared to give the age at death for all deaths occurring either in the plants carrying morbidity records or among persons in other plants who were given physical examinations. The table also gives deaths from causes other than tuberculosis. It is based on all deaths in the study, not simply on hand pneumatic-tool cutters, as was the preceding comparison. As a matter of interest also, the table gives the age distribution of deaths of persons who had yielded a known positive sputum.

TABLE 68.—*Age at death*

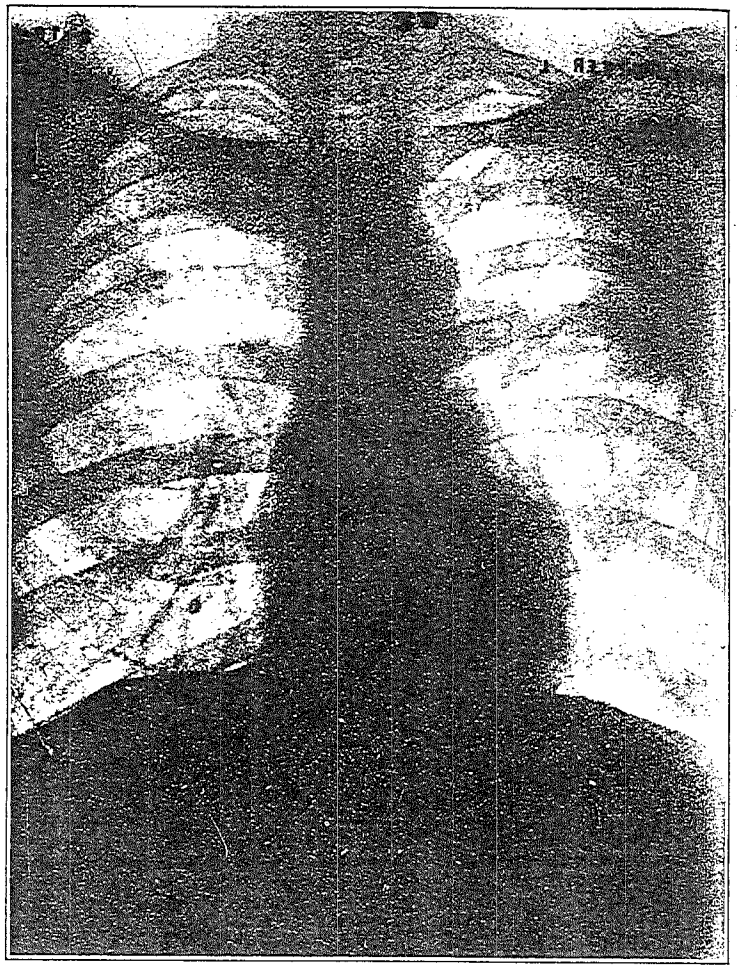
Age groups	Deaths from tuberculosis						Deaths from other causes		
	Any tuberculosis			With known positive sputum					
	Total	In plants with morbidity records	In plants without morbidity records	Total	In plants with morbidity records	In plants without morbidity records	Total	In plants with morbidity records	In plants without morbidity records
All ages	73	41	32	44	20	24	20	15	1
Under 25							1		
25 to 29	1		1	1		1	1	1	
30 to 34	3	1	2	2		2			
35 to 39	6	3	3	4	1	3	1	1	
40 to 44	10	6	4	7	4	3	2	1	
45 to 49	19	11	8	12	7	5	4	4	
50 to 54	12	10	2	6	4	2	6	5	
55 to 59	16	8	8	7	3	4	2	1	
60 to 64	5	2	3	4	1	3	1		
65 and over	1		1	1		1	2	2	
Average age at death	49.4	49.6	49.2	48.7	49.2	48.3	49.5	50.2	47.0



X ray 22.—Case 503. F. R., examined on May 24, 1926; Italian, aged 46 years; married

Granite cutter with hand pneumatic tool for 25 years; cut limestone for seven years previously. His health had been good except for an occasional cold. No serious illnesses. At the time of the examination he complained of cough and expectoration, dyspnœa, pains in chest, loss of weight and strength, and fatigue.

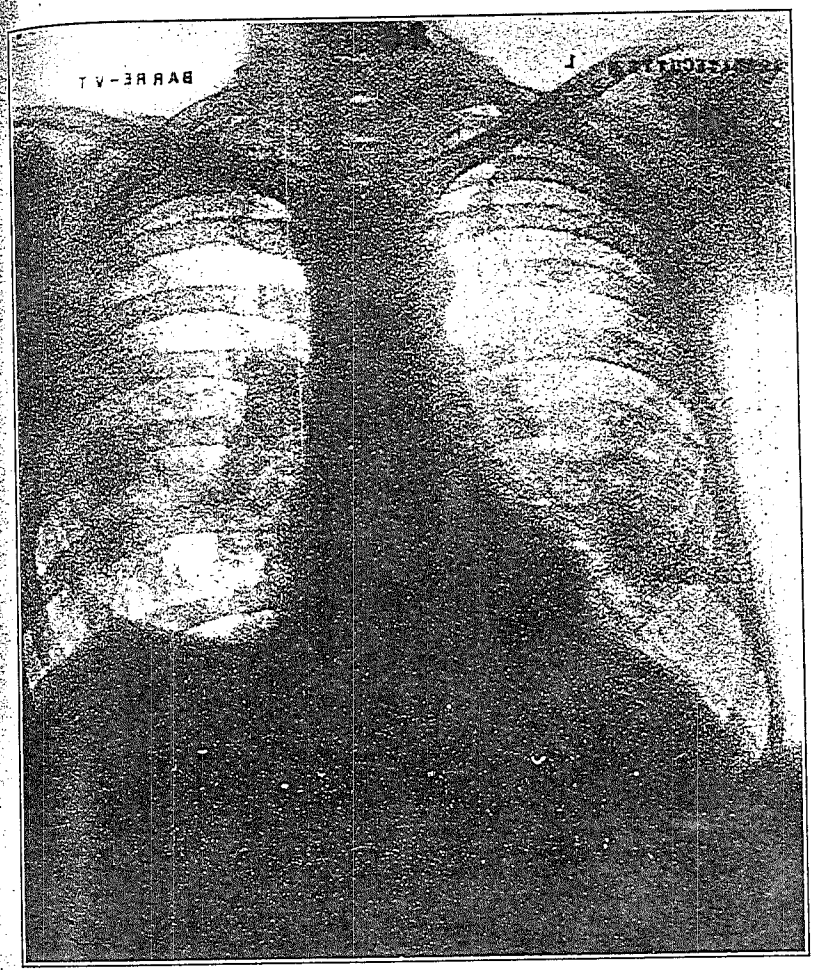
Examination: Height, 67 inches; weight, 135 pounds; impaired hearing, chronic rhinitis and pharyngitis; systolic blood pressure, 110; vital capacity, 2,500 cubic centimeters; chest expansion, 5 centimeters; chest showed evidence of silicosis of both lungs and an early tuberculous lesion in the right lung.



X ray 23.—Case 20. W. F., examined on April 21, 1924; Scotch, aged 39 years; married

Granite cutter, hand pneumatic tool for 20 years. Father dead, age and cause of death unknown. Mother died at age of 80 of heart trouble. Patient's health had generally been very good; habits good. No complaint at time of examination; felt well, ate and slept well, and worked regularly.

Height, 67½ inches; weight, 163 pounds; dental caries; blood pressure, 148 systolic; vital capacity, 3,800 cubic centimeters; chest showed evidence of silicosis.

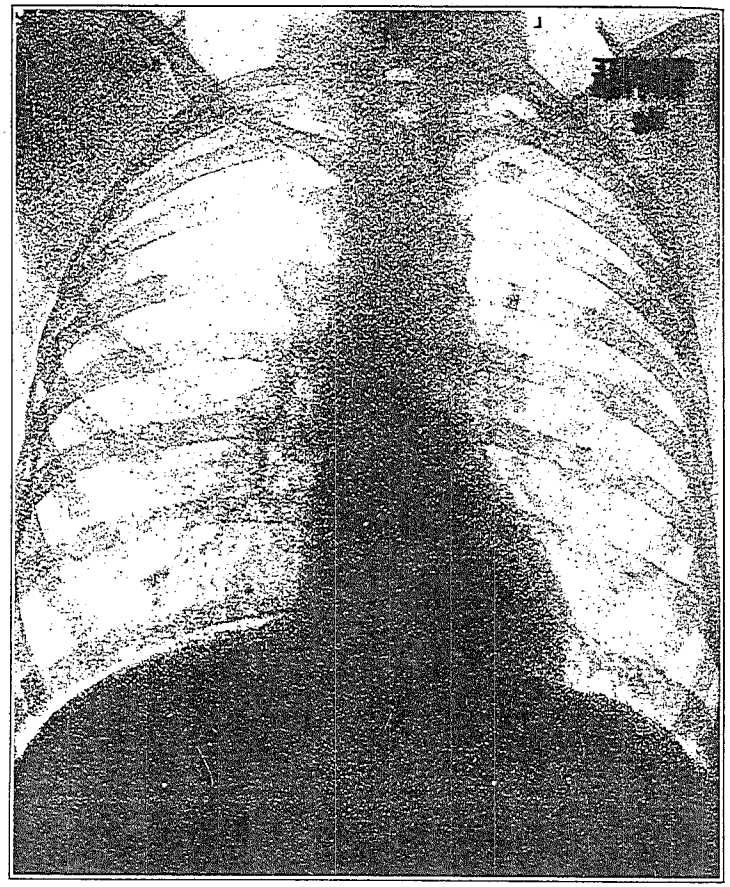


X ray 24.—Case 23. A. S., examined on June 5, 1924; Scotch, aged 49 years; married

He had been a granite cutter for 35 years and for 25 years had used the hand pneumatic tool. He had had pneumonia at the age of 13, bilateral (perhaps bronchial) and complicated by pleurisy with effusion. Apparently he made a good recovery. His habits were good, and he had always been very careful of his health. When examined, he had hoarseness, loss of voice, and pleurisy pains, and was greatly worried about his chest condition.

Height, 65 inches; weight, 158 pounds; had impaired hearing; chronic rhinitis and pharyngitis; blood pressure, 145, systolic; vital capacity, 3,000 cubic centimeters; chest expansion, 4 centimeters; varicose veins in legs; flat feet; chest showed evidence of silicosis and early tuberculosis.

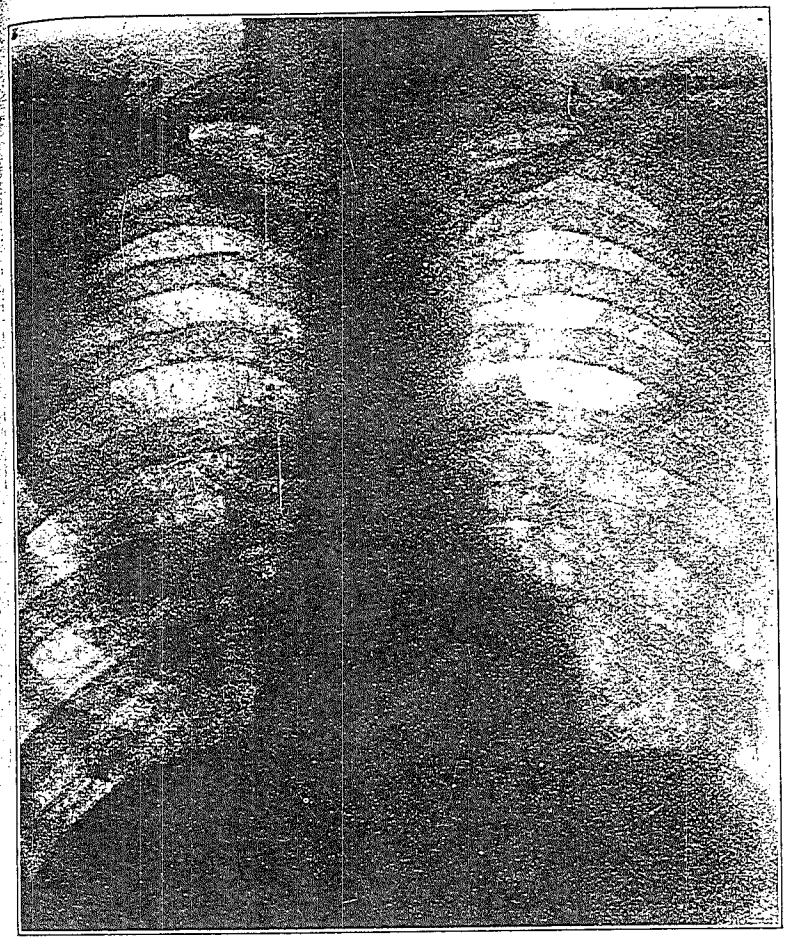
August 15, 1927, the patient was bedfast with tuberculosis.



X ray 25.—Case 110. A. R., examined on September 29, 1924; Scotch, aged 48 years; married

Granite cutter for 32 years; operated a surface-cutting machine for 24 years. His father died at the age of 71, of senility; his mother died at the age of 66, of heart disease. The patient had usually had very good health. At the time of this examination he felt weak and had a cough.

Height, 69 inches; weight, 149 pounds; small cyst on right eyelid; blindness of left eye, due to cataract (removed several years ago); impaired hearing; chronic rhinitis and pharyngitis; systolic blood pressure, 130; chest showed evidence of silicosis and early tuberculosis.



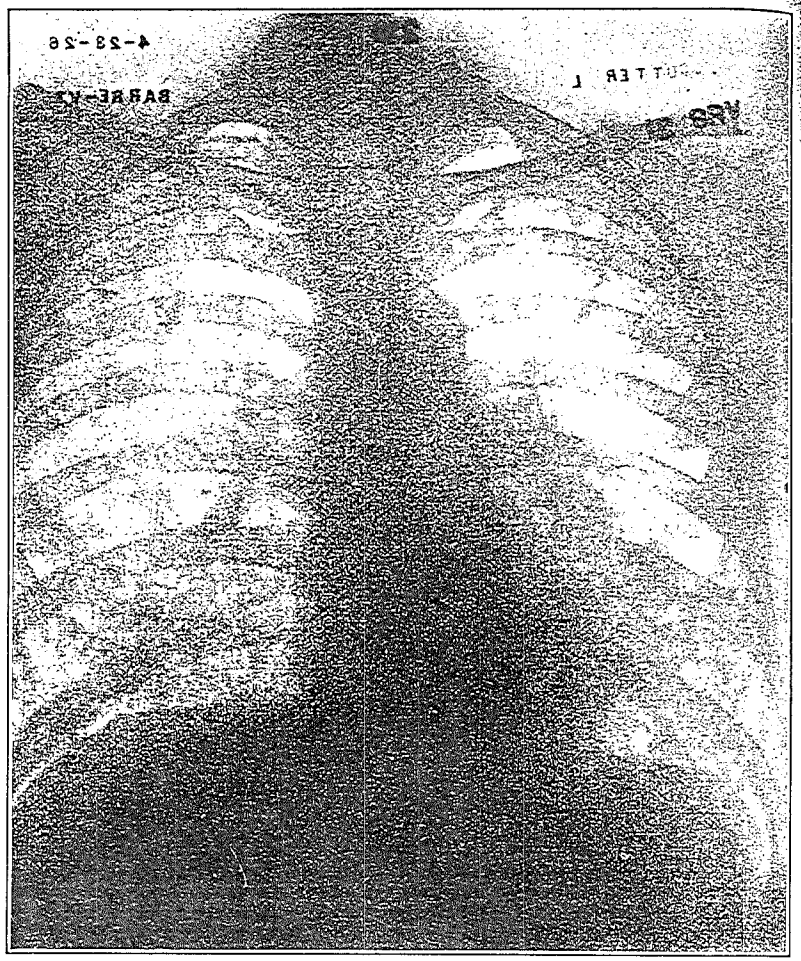
X ray 26.—Case 88. Z. L., examined on September 8, 1924; American (English stock), aged 59 years; married

Granite cutter, hand pneumatic tool, for 20 years. He had cut granite without the pneumatic tools for a long time previously. He had influenza and pneumonia in 1918, with a good recovery. At the time of this examination he complained of cold feet and hands.

Height, 71 inches; weight, 185 pounds; impaired vision and hearing, chronic rhinitis; blood pressure, 108, systolic; vital capacity, 3,100 cubic centimeters; chest expansion, 5 centimeters; varicose veins in both legs; chest showed evidence of definite silicosis.

Subsequent to this examination the patient had had an attack of pleurisy (no effusion); he complained also of fatigue and had lost some weight. In view of the above-mentioned symptoms and his age, tuberculosis in a latent stage was suspected. In June, 1925, he developed a small tumor in his mouth, apparently the joint result of friction of a denture against his cheek and the abrasive action of dust. He was treated with radium, and the tumor disappeared.

The patient was reexamined in August, 1927, and at that time had lost much weight and strength, had been having profuse pulmonary hemorrhages, and presented evidence of a tuberculous lesion in the base of the right lung.



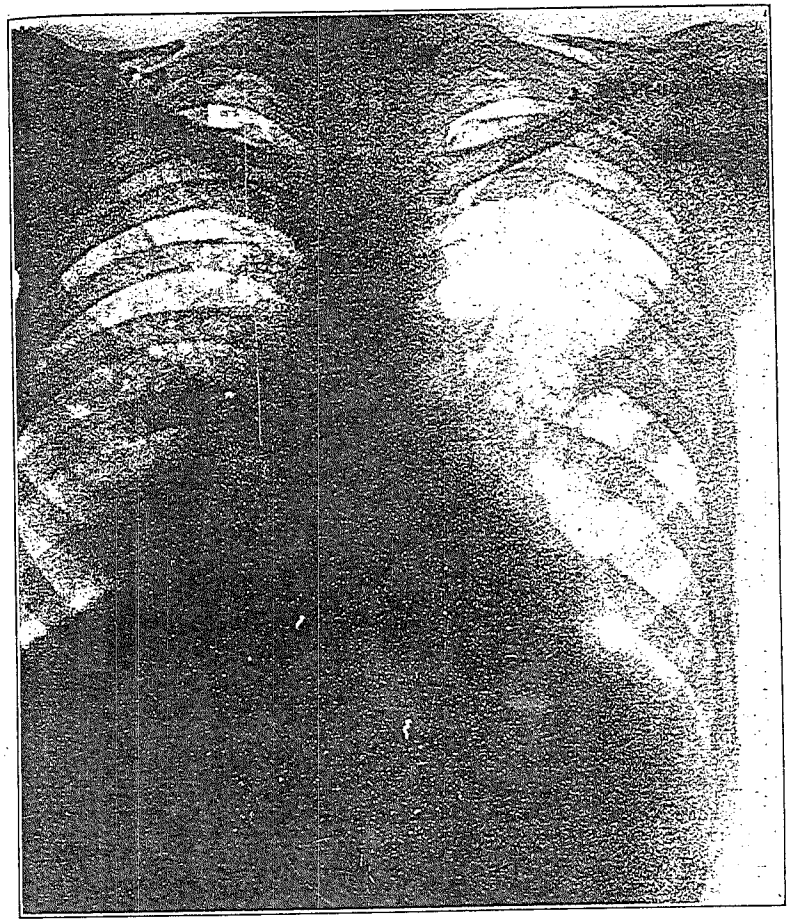
X ray 27.—Case 345. B. R., examined on August 4, 1925; Scotch, aged 47 years; married

Granite cutter, surface machine operator, for 30 years. He had pneumonia at the age of 40 and made good recovery; had influenza in 1918, good recovery; had attacks of tonsillitis occasionally for several years; was chronically constipated. He had lost 30 pounds in the last three years, which loss of weight he attributed to tonsillitis. At the time of this examination the patient felt well, though he had a dry cough; did not complain of dyspnœa.

Examination: Height, 68 inches; weight, 170 pounds; systolic blood pressure, 160; slight hardening of the radial and temporal arteries; chronic rhinitis and pharyngitis; vital capacity, 3,600 cubic centimeters; chest expansion, 5 centimeters, chest showed evidence of silicosis.

The patient returned for reexamination on April 23, 1926, complaining of pains in chest, severe cough, and profuse expectoration, loss of weight, afternoon rise in temperature, and night sweats. These symptoms followed an attack of influenza in January, 1926. Chest examination revealed evidence of a tuberculous lesion in the lower lobe of the left lung. Sputum contained tubercle bacilli.

The patient died in November, 1927.

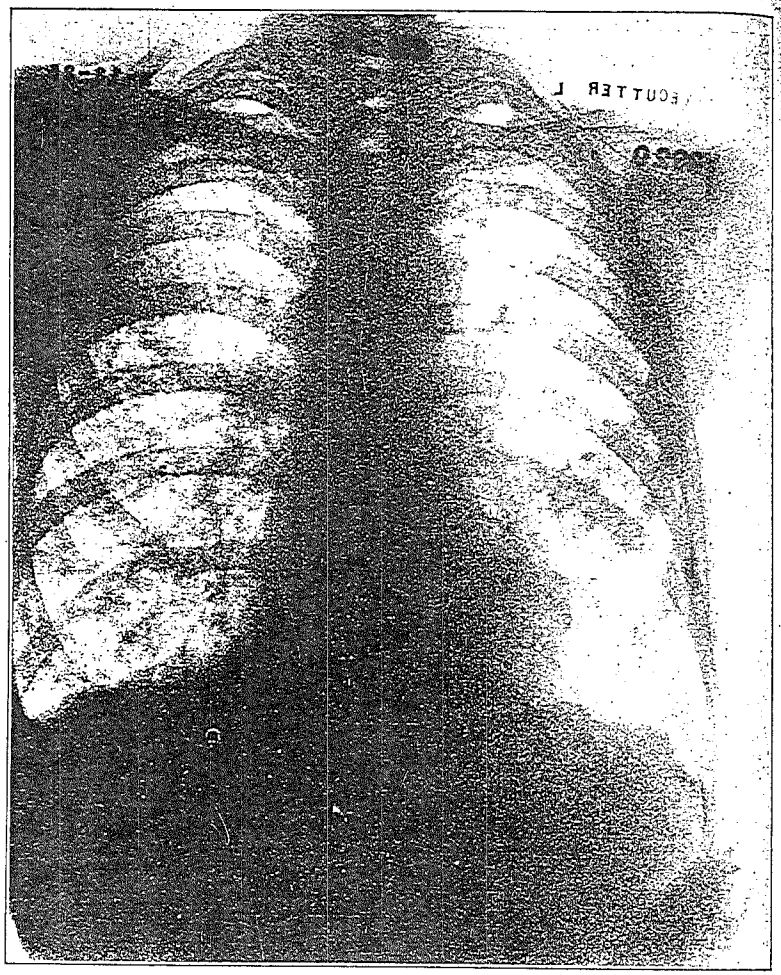


X ray 28.—Case 168. V. M., examined on January 12, 1925; Italian, aged 48 years; married

Granite cutter, hand pneumatic tool, for 29 years; had worked in limestone in Italy for four years. He had enjoyed good health, and seldom lost time from work. His recent illness began six months before this examination, with fatigue, loss of weight, weakness, and night sweats, and when examined he had, in addition to the above-mentioned symptoms, severe pleurisy pains, and blood expectoration. He had several profuse hemorrhages from the lungs subsequent to this examination.

Examination: Height, 67 inches; weight, 145 pounds; dental caries and pyorrhœa; chronic rhinitis and pharyngitis; varicose veins in legs, and lupus vulgaris on right forearm; systolic blood pressure, 120; vital capacity, 2,700 cubic centimeters; chest expansion, 3 centimeters; silicosis and tuberculosis; tuberculous lesion in the base of the right lung.

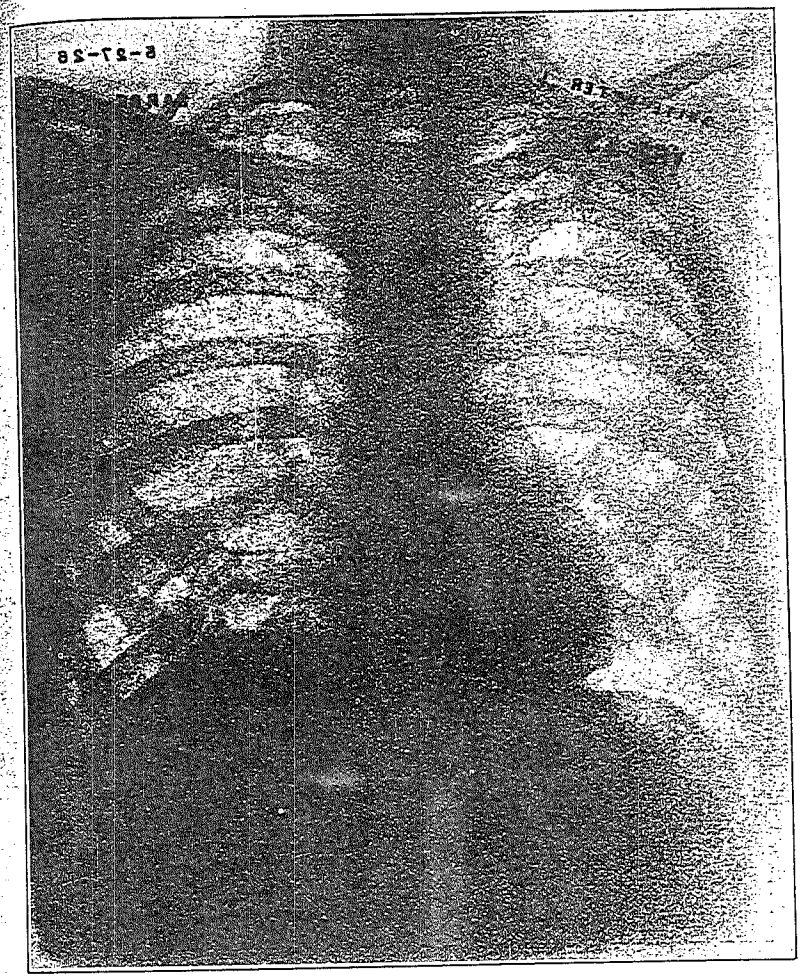
The patient died on October 11, 1925, of a massive hemorrhage from the lungs.



X ray 29.—Case 221. W. J., examined on March 13, 1925; Canadian (Swedish parentage), aged 42 years; married

Granite cutter, with hand pneumatic tool, for 20 years. Had been out of the industry for four years. His past health had been good; he had no history of any serious illnesses; his habits had been good. Complaints at the time of the examination: Cough and expectoration, loss of weight, fatigue, dyspnœa, fever.

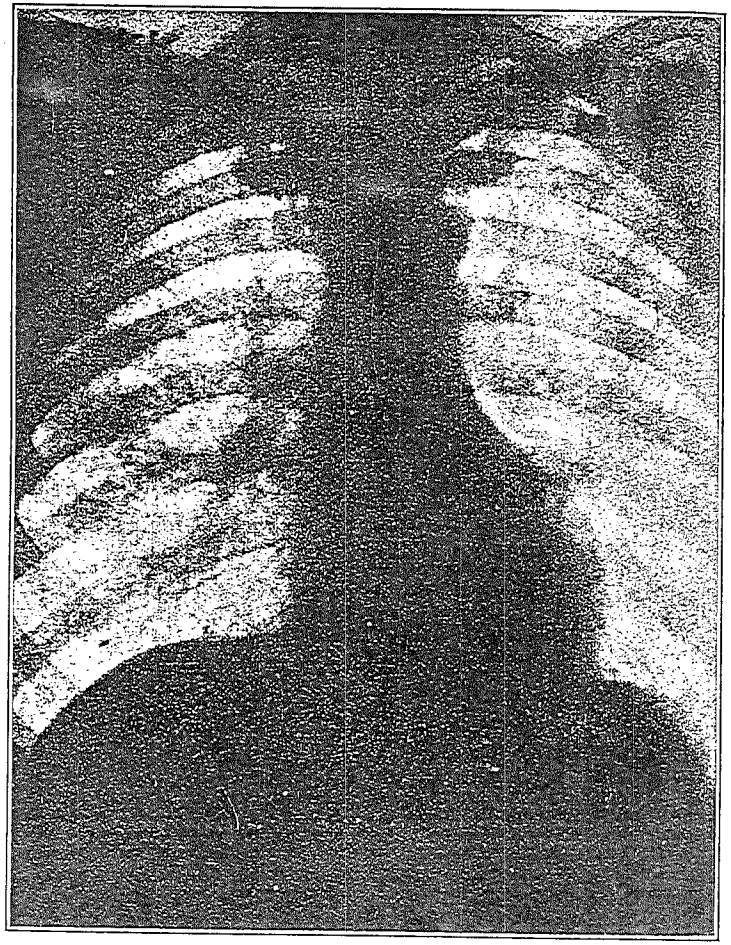
Examination: Height, 68 inches; weight, 133 pounds; impaired hearing; pyorrhœa; chronic rhinitis and pharyngitis; systolic blood pressure, 120; vital capacity, 2,100 cubic centimeters; silicosis and tuberculosis.



X ray 30.—Case 506. E. L., examined on May 26, 1926; Italian, aged 54 years; married

Granite cutter, with hand pneumatic tool, for 26 years; limestone cutter in Italy for a number of years before emigrating to this country. He had influenza in 1918; good recovery. Health had been good otherwise. At the time of this examination he was complaining of pains in chest, dyspnœa, cough and expectoration, fatigue, and loss of weight.

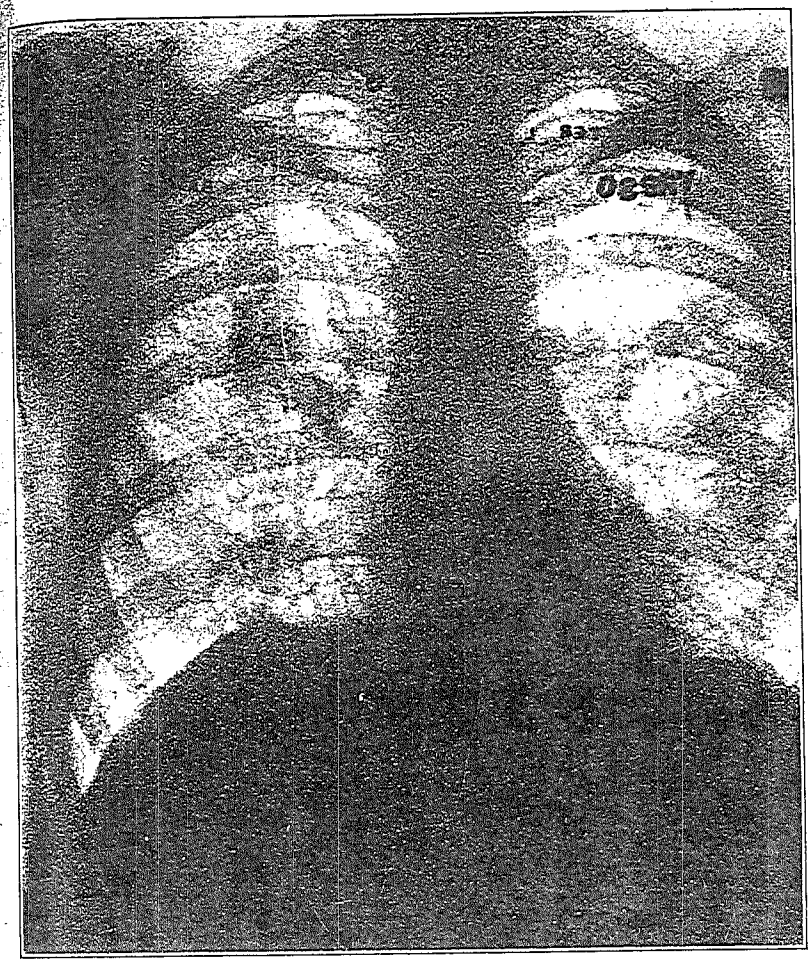
Examination: Height, 63 inches; weight, 117 pounds; chronic rhinitis and pharyngitis; pyorrhœa; systolic blood pressure, 140; chest expansion, 4 centimeters; vital capacity, 2,500 cubic centimeters; silicosis and tuberculosis.



X ray 31.—Case 310. W. C., examined on July 11, 1925; American, aged 52 years; married

Granite cutter for 34 years. Had previously worked as a laborer. He had pneumonia when a child, and rheumatic fever when 26 years old. His habits had been good, and his health had been fair, except that he had had pleurisy pains for several years, and at the time of this examination he was troubled with cough and expectoration, was rather neurasthenic, and complained of many minor ailments.

Examination: Height, 67 inches; weight, 131 pounds; early pterygium; loss of teeth; chronic pharyngitis; systolic blood pressure, 116; chest expansion, 4 centimeters; vital capacity, 3,200 cubic centimeters; silicosis and early tuberculosis; two specimens of sputum were negative for tubercle bacilli.

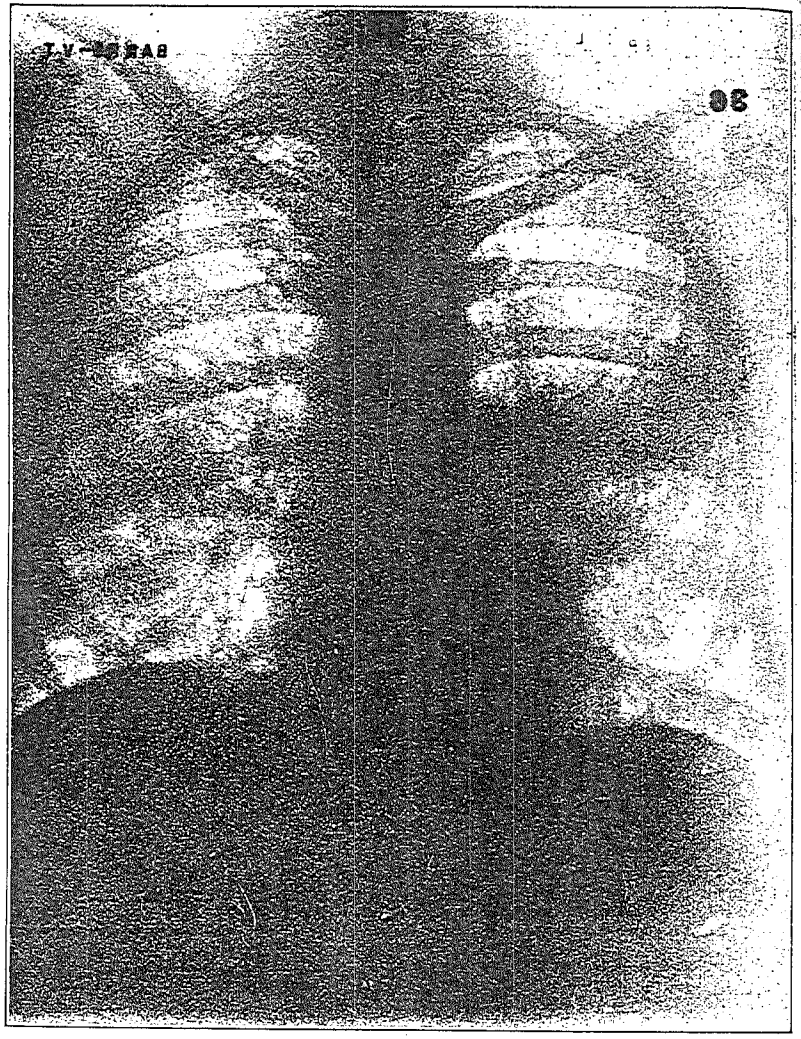


X ray 32.—Case 342. A. B., examined on July 29, 1925; Scotch, aged 47 years; married

Granite cutter with hand pneumatic tool for 30 years. This patient had cervical adenitis at the age of 7 years and had undergone an operation for abscessed appendix since he had reached adult age. His health had been good otherwise. He used alcoholics moderately.

His recent illness began a short time before this examination, with fatigue, pains in chest, and loss of weight; and at subsequent examinations he complained of the same symptoms, with addition of cough, expectoration, dyspnœa, and afternoon rise of temperature.

Examination: Height, 66 inches; weight, 147 pounds; impaired vision and hearing; chronic pharyngitis; upper teeth had been removed because of pyorrhœa and had been replaced with denture, and there were caries of the lower teeth; systolic blood pressure, 128; chest expansion, 4 centimeters; vital capacity, 3,800 cubic centimeters; chest showed evidence of moderate silicosis and early tuberculosis; abdominal hernia at site of incision of operation.



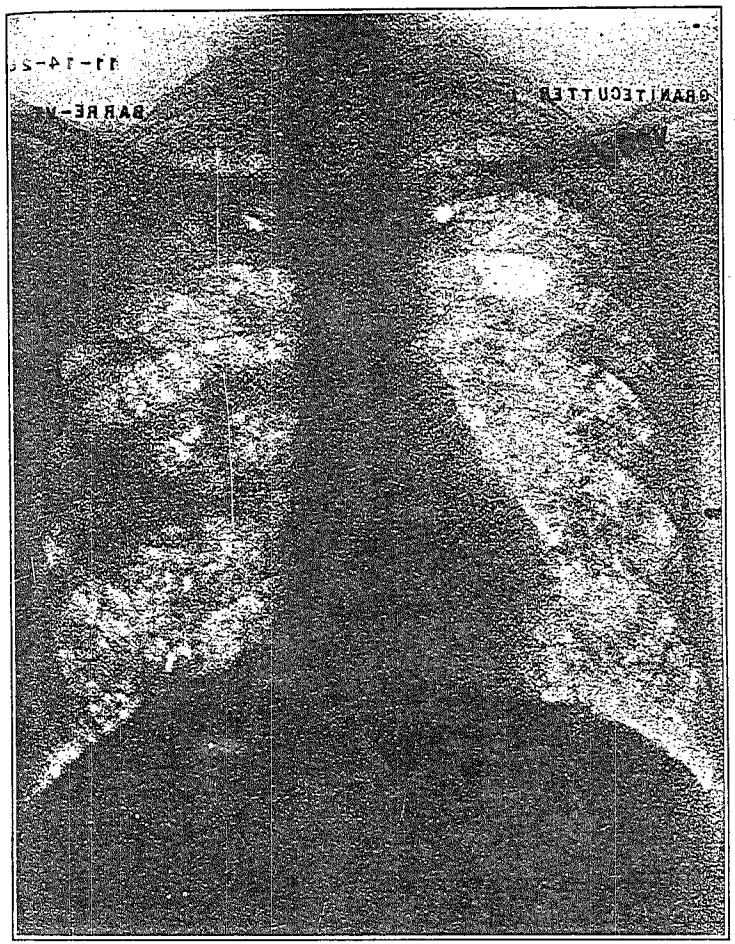
X ray 33.—Case 40. W. G., examined on July 14, 1924; Scotch, aged 50 years; married

He had cut granite for 30 years; for the five years just previous to this examination he had worked as a sand blaster and letterer. His father died at the age of 71 with apoplexy; and his mother died at age of 77 of bronchitis. The patient's previous health had been very good, except that for the past 18 years he had been suffering with pains in the chest.

He became ill in 1924, with a "bronchitis," and since that time he had had severe cough and profuse expectoration, pains in chest, dyspnœa, loss of weight and strength, fatigue, and afternoon rise in temperature.

Examination: Height, 64 inches; weight, 145 pounds; systolic blood pressure, 146; chest expansion, 4.5 centimeters; vital capacity, 1,900 cubic centimeters; chest examination showed evidence of silicosis and tuberculosis; sputum contained tubercle bacilli.

The patient died on December 4, 1925.

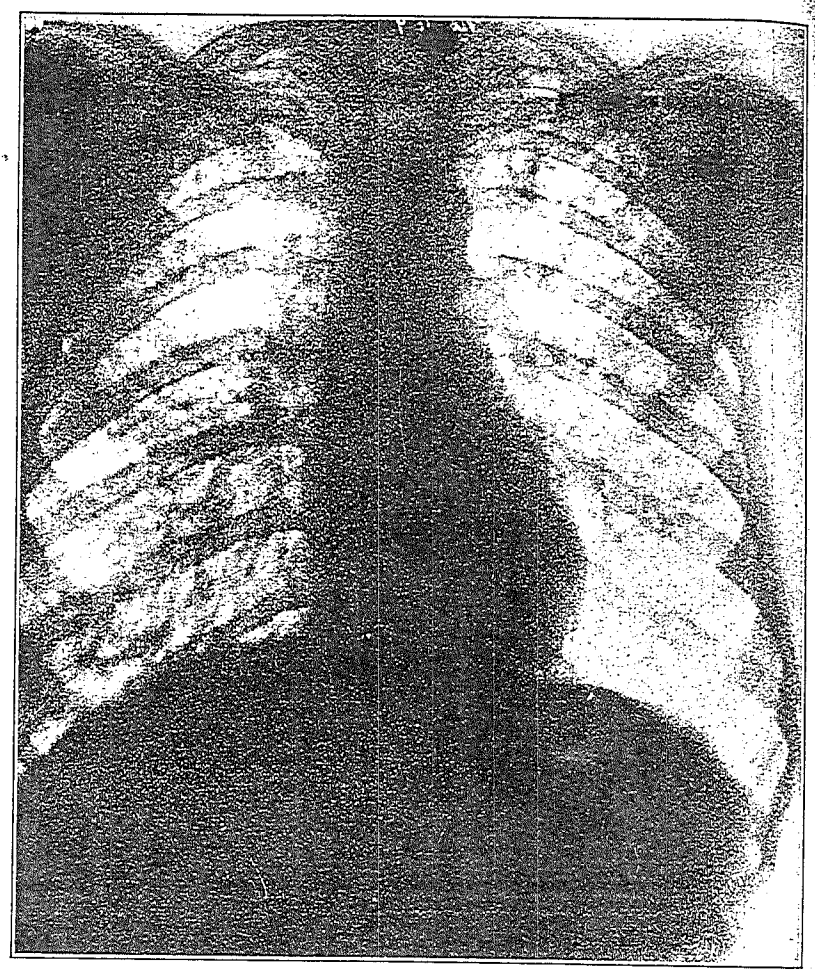


X ray 34.—Case 405. J. B., examined on November 14, 1925; Scotch, aged 55 years; married

Granite cutter for 37 years, 23 years with hand pneumatic tool. Father dead; age and cause of death unknown to patient. Mother died at age of 75 of senility. The patient's health had been very good, except that he had infected teeth and rheumatism; the latter ailment was relieved when the infected teeth were removed. At the time of the examination he was troubled with cough and expectoration, had pains in the chest, was losing weight, and suffered with marked dyspnœa. (He was very reluctant to give a history of his symptoms.)

Examination: Height, 69 inches; weight, 130 pounds; impaired vision, chronic rhinitis and pharyngitis; systolic blood pressure, 140; vital capacity, 3,000 cubic centimeters; chest expansion, 4 centimeters; chest examination revealed evidence of silicosis and tuberculosis.

The patient died in December, 1926.

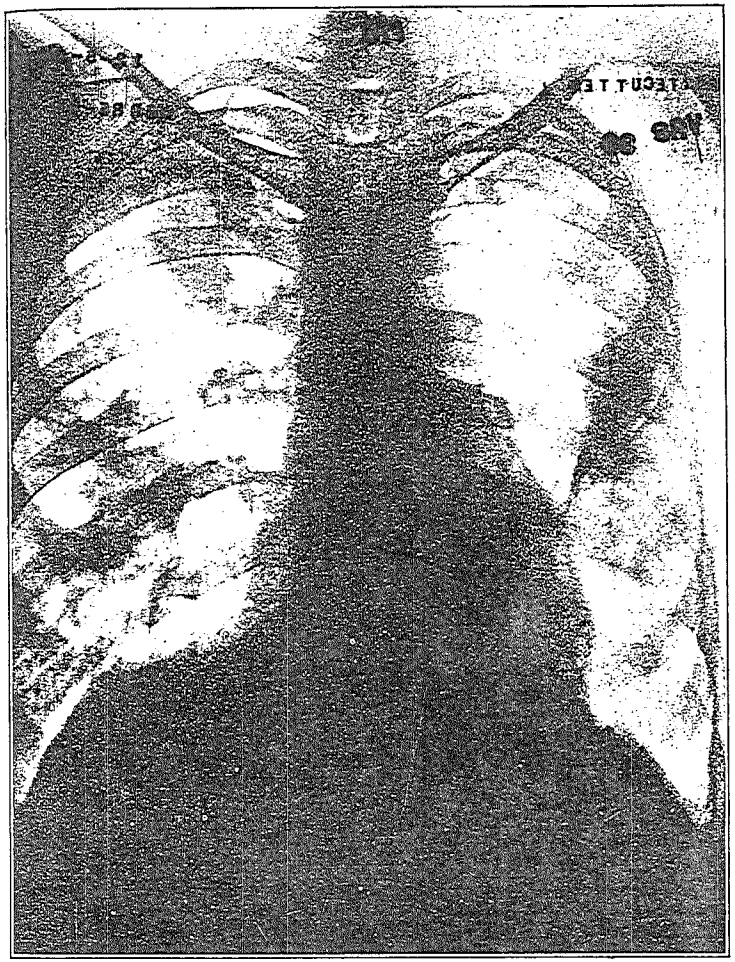


X ray 35.—Case 152. J. G., examined December 22, 1924; Italian, aged 39 years; married

He had cut granite with hand pneumatic tool for 27 years. His past health had been very good; habits good. At time of this examination he complained of cough, expectoration, pleurisy, loss of weight, dyspnœa, and frequent colds; he was reluctant to state his symptoms.

Examination: Height, 68 inches; weight, 142 pounds; impaired hearing; teeth removed because of caries and pyorrhœa, and replaced by dentures. Chronic rhinitis and pharyngitis; systolic blood pressure, 140; vital capacity, 3,200 cubic centimeters; chest showed evidence of silicosis and of early tuberculosis; tuberculous lesion in the lower lobe of the right lung.

Patient returned to Italy and the outcome of his illness is not known.

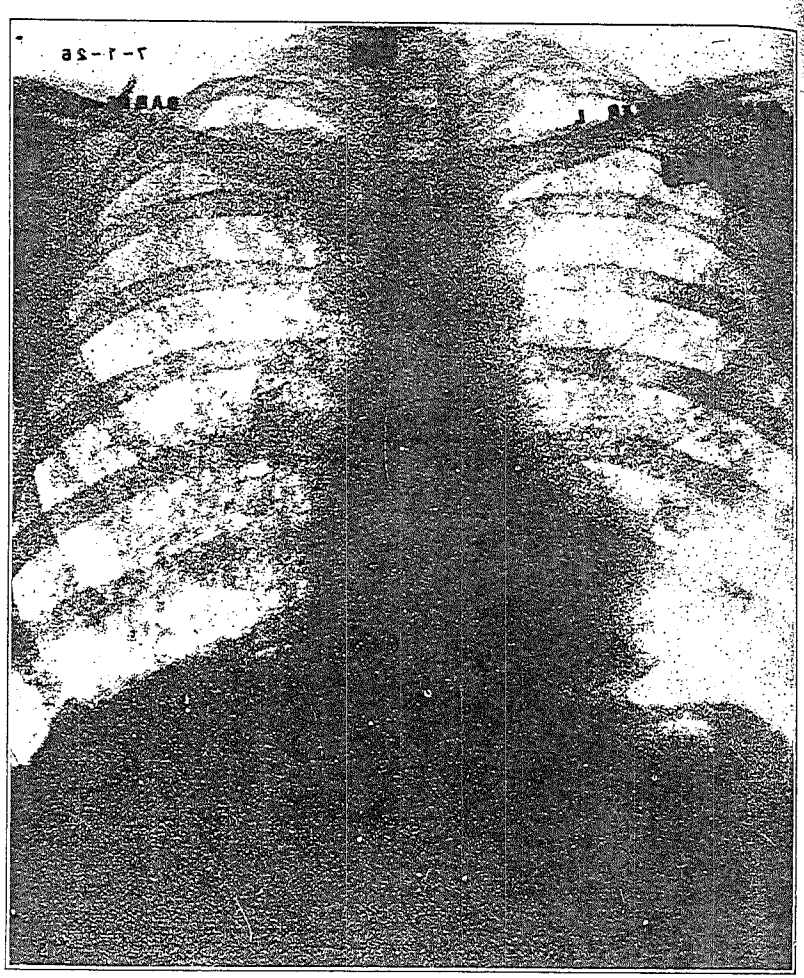


X ray 36.—Case 417. P. C., examined on December 1, 1925; Irish, aged 59 years; married

Granite cutter, using both pneumatic tool and surface machine, for 39 years. His health had been good until a few years ago; after that time he said he had "bronchial trouble" and severe dyspnœa (evidently symptoms of advanced silicosis). At the time of the examination he complained of severe dyspnœa, cough and expectoration, pains in chest, loss of weight, fatigue and fever.

Examination: Height, 65 inches; weight, 130 pounds; impaired hearing; chronic rhinitis and pharyngitis; loss of teeth; systolic blood pressure, 116; chest expansion, 3 centimeters; vital capacity, 2,000 cubic centimeters; silicosis and tuberculosis.

The patient died about February 1, 1926.

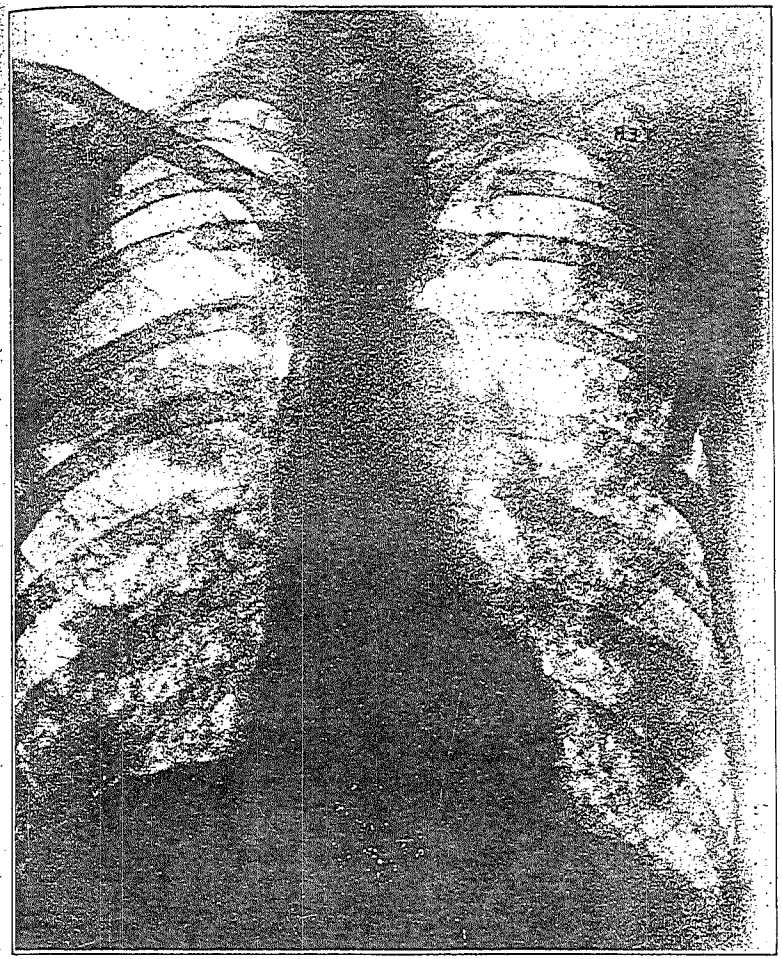


X ray 37.—Case 300. C. C., examined on June 30, 1925; Swedish, aged 47 years; married

Granite cutter, surface machine operator, for 25 years. He had previously worked on a farm in Sweden. He was reluctant to give his history and an account of his illness. He said that his health had usually been very good, but that he had been dyspnœic for several years. His recent illness began on June 2, and he quit working two days later. The illness was of the nature of grippe. At the time of the examination he had a productive cough, pains in chest, marked dyspnœa, loss of strength, fatigue, night sweats, and fever in afternoons, and had lost 24 pounds in the preceding four weeks.

Examination: Height, 68 inches; weight, 148 pounds; pterygium on right eye; impaired hearing; dental caries, pyorrhœa; chronic pharyngitis; systolic blood pressure, 116; vital capacity, 2,400 cubic centimeters; chest examination revealed evidence of silicosis and advanced tuberculosis; sputum contained tubercle bacilli.

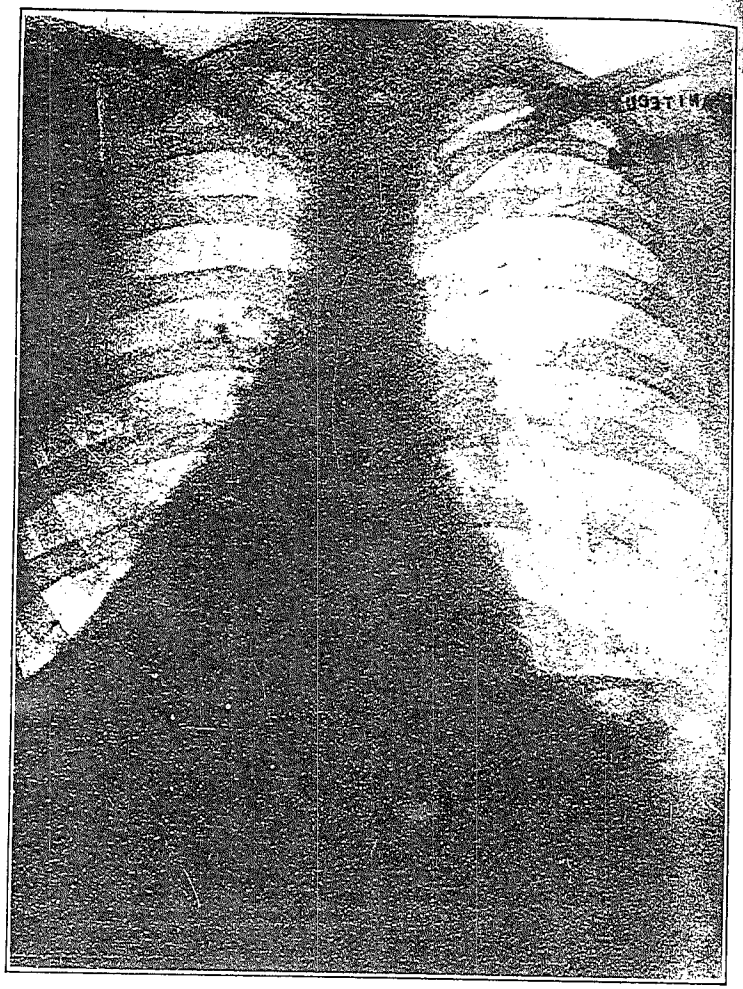
This patient refused to come later at intervals for examination, but the writer saw him sitting in the park frequently and it was very evident that his disease was progressing rapidly. When he left for his home in Sweden, he was very emaciated and weak and apparently had but a short time to live. No news of his death was available, but he probably died soon after reaching home.



X ray 38.—Case 437. S. R., examined on January 2, 1926; American (English stock), aged 47 years; married

Granite cutter, with hand pneumatic tool, for 30 years; previously lived on a farm. His father died at the age of 45, of diphtheria; his mother died at the age of 83, of apoplexy. A brother, who was a granite cutter, died of tuberculosis. The patient had usually had good health, but had been dyspnœic for several years. When examined the patient had a cold, coughed, and expectorated, and complained of loss of weight and severe dyspnœa, which had bothered him for a long time. He was reluctant to give a very detailed history of his illness. It was apparent that he had lost much weight and that he tired easily.

Height, 71 inches; weight, 139 pounds; impaired vision in left eye—the result of an industrial accident; impaired hearing; pterygium, right eye; complete dentures (patient had pyorrhœa before having teeth removed); systolic blood pressure, 120; vital capacity, 3,700 cubic centimeters; chest expansion, 5 centimeters; chest examination revealed evidence of silicosis and early tuberculosis, with lesion in the right lung and possible early extensions into the left lung.

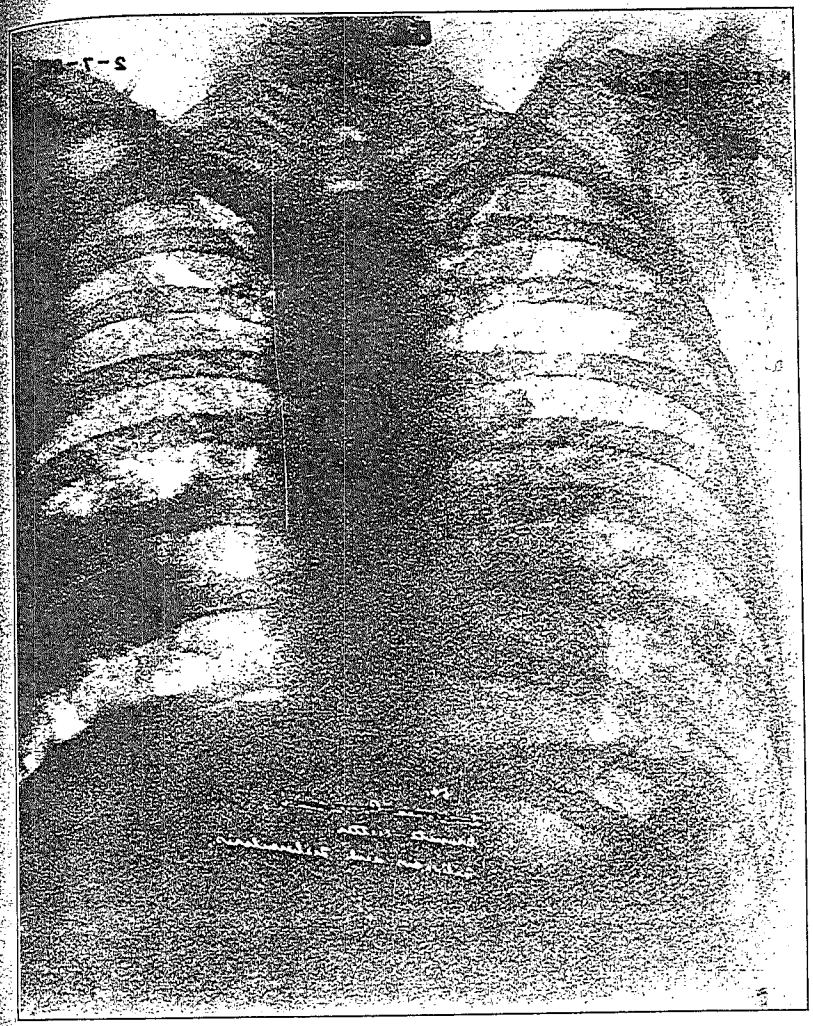


X ray 39.—Case 470. P. B., examined on March 15, 1926; French (Canadian), aged 36 years; married

Granite cutter for 14 years, but had recently been a manufacturer. His father died at the age of 77; his mother, at age of 67, of acute indigestion. The patient had influenza in 1918, in France; and pneumonia following anæsthesia and operation for appendicitis, 17 years before this examination. At the time of examination he complained of frequent colds which persisted for a long time, cough and expectoration, and occasional pains in the chest.

Examination: Height, 66 inches; weight, 142 pounds; chronic rhinitis and pharyngitis; systolic blood pressure, 140; vital capacity, 3,300 cubic centimeters; chest showed evidence of silicosis and tuberculosis; lesion in the base of the right lung; sputum contained tubercle bacilli.

A child of this patient died of tuberculous meningitis in March, 1926, soon after this examination was made.



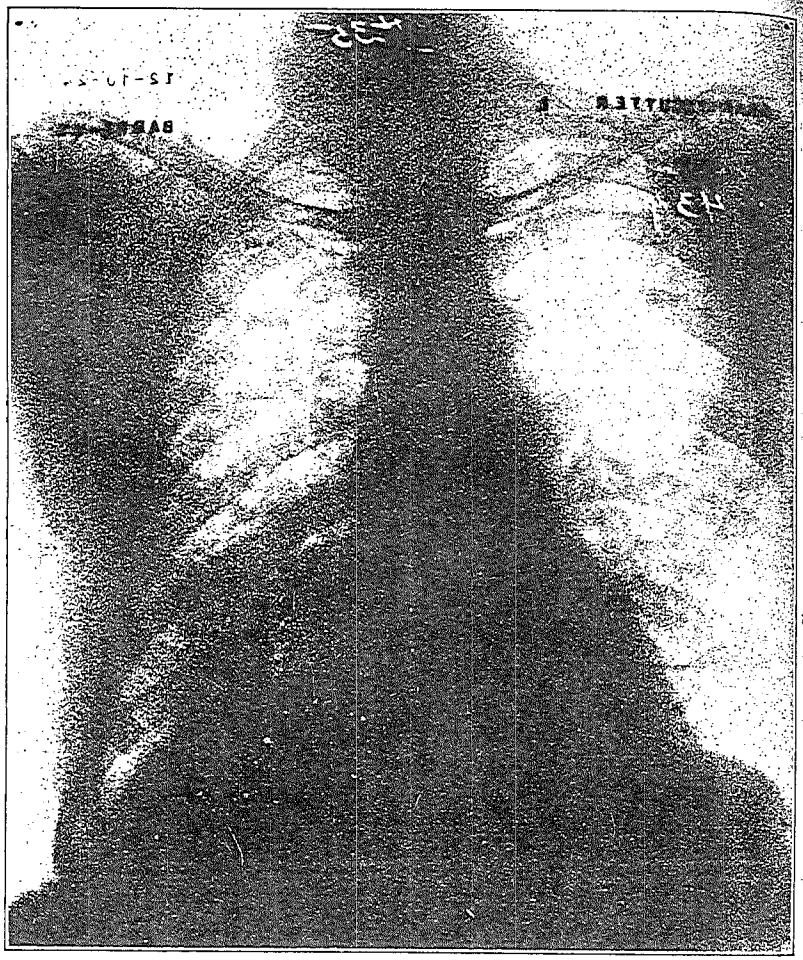
X ray 40.—Case 174. D. C., examined on February 3, 1925; Italian, aged 46 years; single

Granite cutter, surface machine operator for two years; he had previously cut with the hand pneumatic tool for 16 years. He was a marble cutter in Italy for two years before coming to the United States. His health had usually been good; he had no history of any serious illnesses; his habits were good.

Just before the time of this examination he had a hemorrhage from the lungs. His physician stated that the patient had had a pulmonary hemorrhage two years earlier. He had been losing weight and strength and had a cough and expectoration. He was very reluctant to give any details about himself and his illness.

Examination: Height, 66 inches; weight, 147 pounds; chronic rhinitis; dental caries; systolic blood pressure, 118; vital capacity, 2,300 cubic centimeters; chest examination revealed evidence of silicosis and tuberculosis; the tuberculous lesion was in the base of the right lung. The patient would not comply with request for sputum specimen.

He died of pneumonia on June 22, 1925, after an illness of three days.

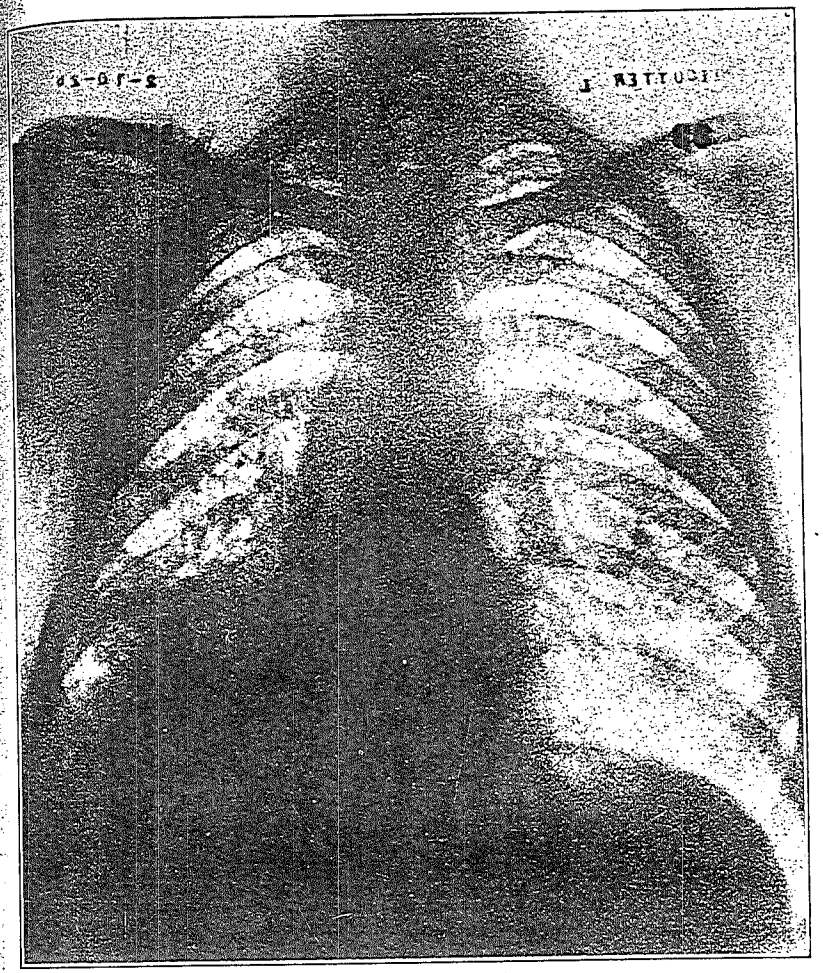


X ray 41.—Case 141. G. R., examined on December 9, 1924; Italian, aged 56 years; married

Granite cutter, hand pneumatic tool, for 31 years; marble cutter previously. His health had usually been good. Three years before this examination he had bronchitis, so-called, and had had a cough and expectoration since that time, and also pleurisy pains and dyspnœa. His illness he said was a continuation of the "bronchitis" which he had had three years before. He was rather dyspnœic, and tired easily, and had pains in the chest, cough and expectoration, afternoon rise in temperature, loss of weight and strength.

Examination: Height, 65 inches; weight, 171 pounds; pterygium on each eye; chronic rhinitis and pharyngitis; systolic blood pressure, 144; chest expansion, 4 centimeters; silicosis, and a tuberculous lesion in the base of the right lung; sputum contained tubercle bacilli.

The patient died of pneumonia, on July 24, 1925.



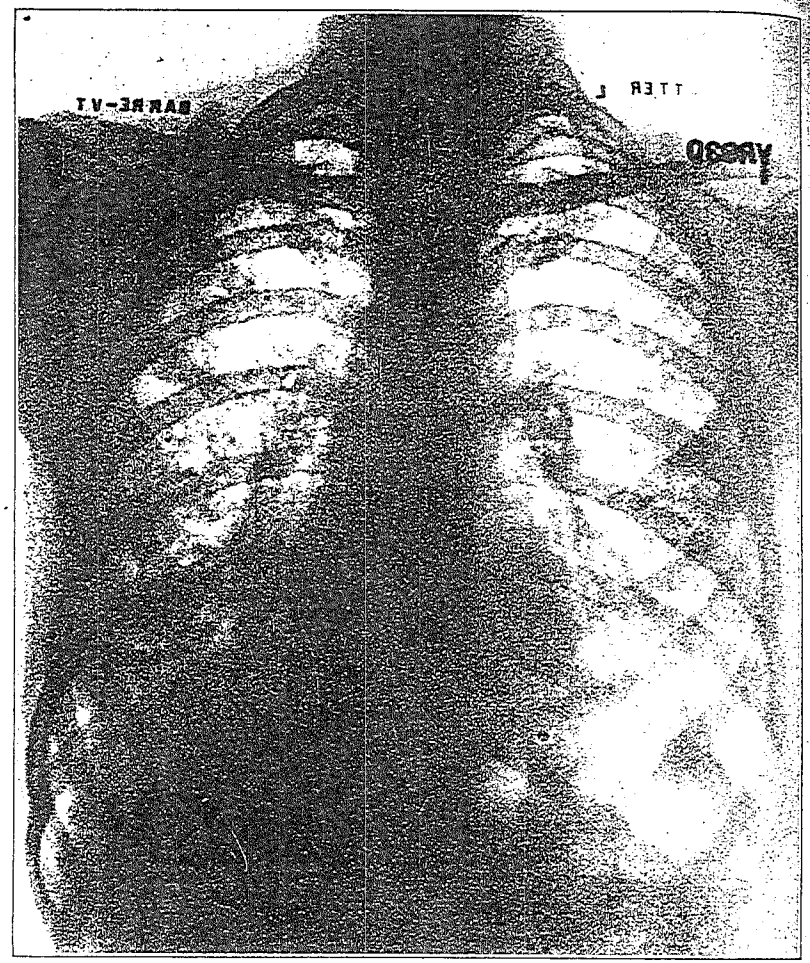
X ray 42.—Case 175. J. McP., examined on February 4, 1925; Scotch, aged 50 years; divorced

Granite cutter, hand pneumatic tool, for 33 years; tool boy in granite shed for five years. His father died at the age of 65, of a chronic chest condition (exact nature of disease not known to patient); his mother died at the age of 84, of senility. The patient had typhoid fever at the age of 15; 20 years before the time of this examination he met with an industrial accident which resulted in loss of sight in his right eye. His health had been good otherwise. Patient had used alcoholics excessively at intervals for a number of years, and had kept rather irregular hours.

He was taken ill several months before the examination, with cough and expectoration, pains in chest, and dyspnœa; later he began to lose weight, and to have an afternoon rise in temperature and profuse night sweats. These symptoms had continued. He had also had hemoptysis at intervals.

Examination: Height, 65 inches; weight, 128 pounds; total blindness in right eye; dental caries and pyorrhœa; chronic rhinitis and pharyngitis; systolic blood pressure, 110; chest expansion, 5 centimeters; vital capacity, 3,000 cubic centimeters; silicosis and tuberculosis; tuberculous lesion in the base of right lung; sputum contained tubercle bacilli.

The patient died on March 8, 1927.



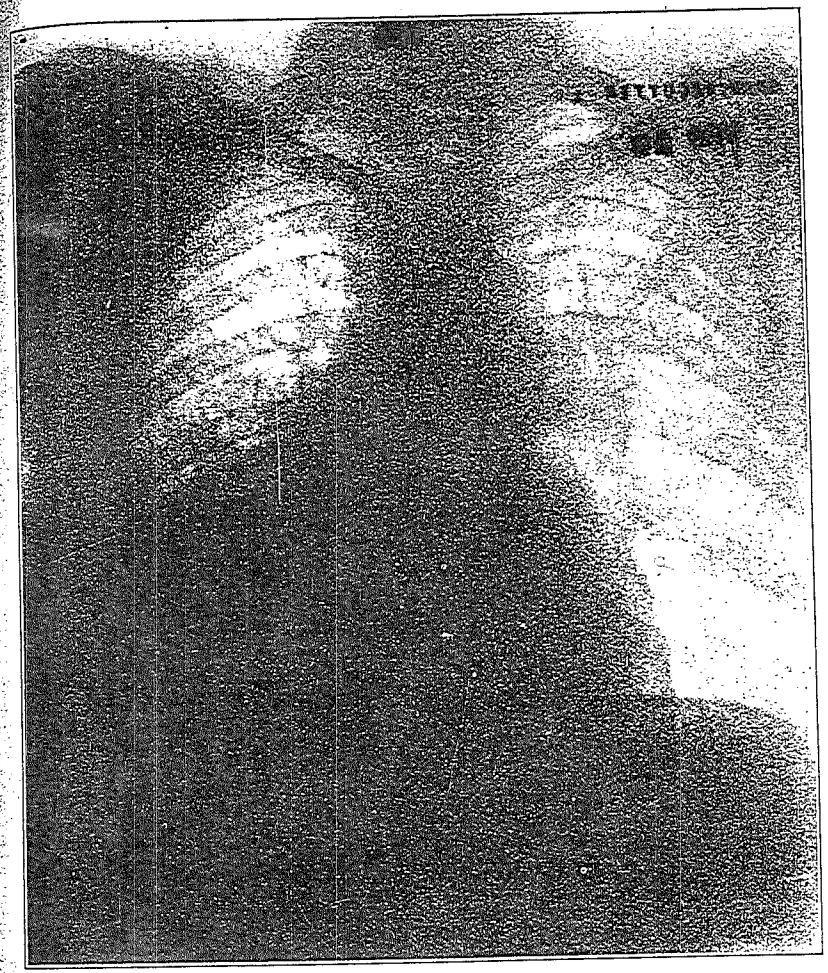
X ray 43.—Case 195. M. P., examined on February 19, 1925; Italian, aged 45 years; married

Granite cutter, hand pneumatic tool, for 32 years. His father died at the age of 57 of bronchitis; his mother died at the age of 71, cause of death unknown to patient. The patient's health had been good, except for an occasional attack of rheumatism, which did not disable him from work. His habits were good.

The first manifestations of his present illness were a disturbance of digestion and a "cold." He did not stop work until two months after he began to feel ill. At the time of this examination he had a severe cough, with profuse expectoration, had lost weight, and suffered from fatigue, afternoon rise of temperature, dyspnœa, and night sweats.

Examination: Height, 66 inches; weight, 130 pounds; chronic rhinitis; dental caries; systolic blood pressure, 118; silicosis and tuberculosis; tuberculous lesion in the base of the right lung; sputum contained tubercle bacilli.

The patient died on July 8, 1926.

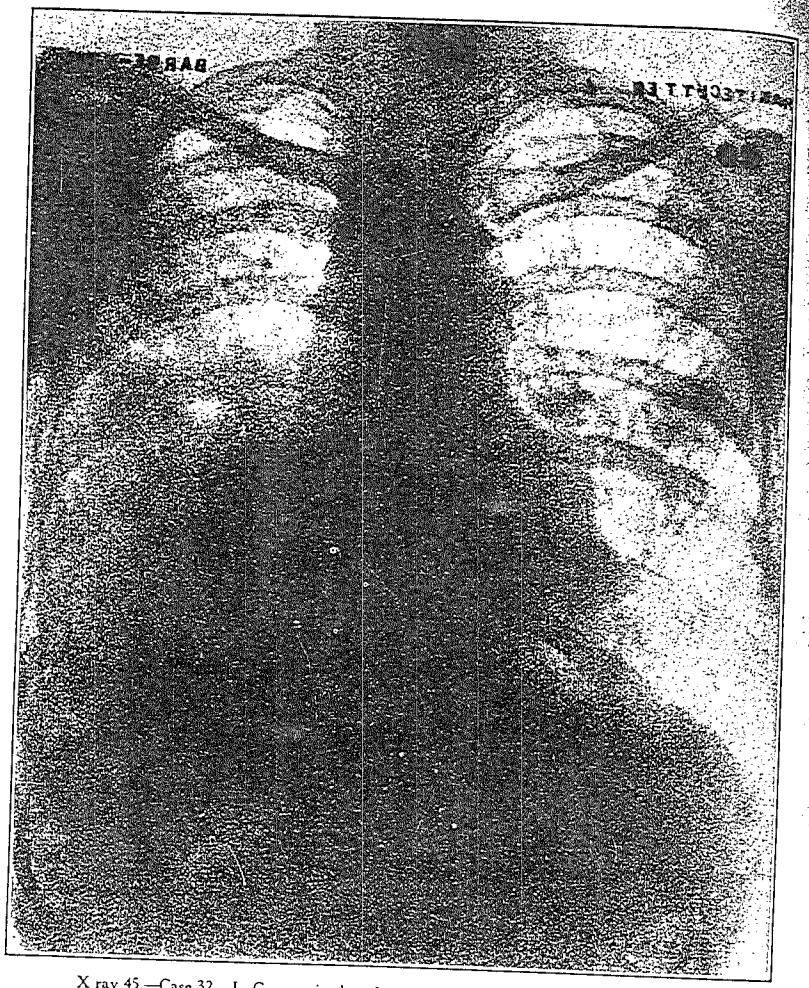


X ray 44.—Case 108. P. H., examined on September 26, 1925; Swedish, aged 44 years; married

The patient was a granite cutter for 22 years and had been a manufacturer for the two years preceding this examination. Before his apprenticeship in the granite industry, he worked in a cotton mill. His father died at the age of 62, of meningitis; his mother, aged 75, was living and well. He had typhoid fever in 1902, with good recovery. His health was good otherwise until two years before this examination, when he developed a perirectal abscess. Incision was made, but a fistula still persisted. He had complained of fatigue and dyspnœa since that time. He also developed interstitial keratitis (luetic) about the same time. When examined he complained of cough and expectoration, night sweats, dyspnœa. He had hemorrhages from the lungs later.

Examination: Height, 69 inches; weight, 194 pounds; interstitial keratitis; dental caries and pyorrhœa; systolic blood pressure, 132; anal fistula; chest showed evidence of silicosis and tuberculosis; sputum contained tubercle bacilli; tuberculous lesion in the base of the right lung; cavitation present.

The patient died on September 12, 1926.

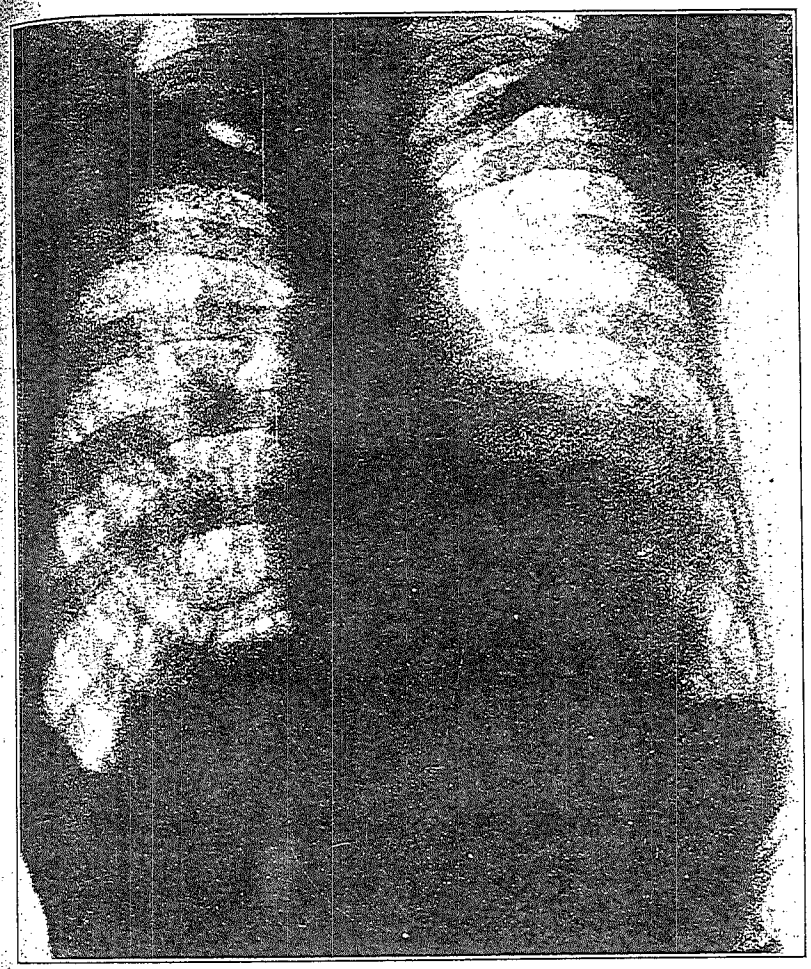


X ray 45.—Case 32. L. G., examined on June 13, 1924; Italian, aged 48 years; married

Granite cutter, hand pneumatic tool, for 24 years. He had cut marble in Italy for a few years before coming to this country. Father died at age of 23, of septicemia; mother living, aged 96 years. Brother was a granite cutter; he returned to Italy and died of tuberculosis. The patient's health had generally been good; he had recently operated a small manufacturing firm, and worked very hard. He had been ill for about a year with cough, expectoration, loss of weight and strength, severe pleurisy pains, and dyspnœa. These symptoms had persisted at time of examination, and he was quite dyspnœic and was having slight hemorrhages from the lungs occasionally.

Height, 69 inches; weight, 151 pounds; dental caries; systolic blood pressure, 104; chest revealed evidence of silicosis and a tuberculous lesion in the right base; cavitation present.

The patient died on May 20, 1926.

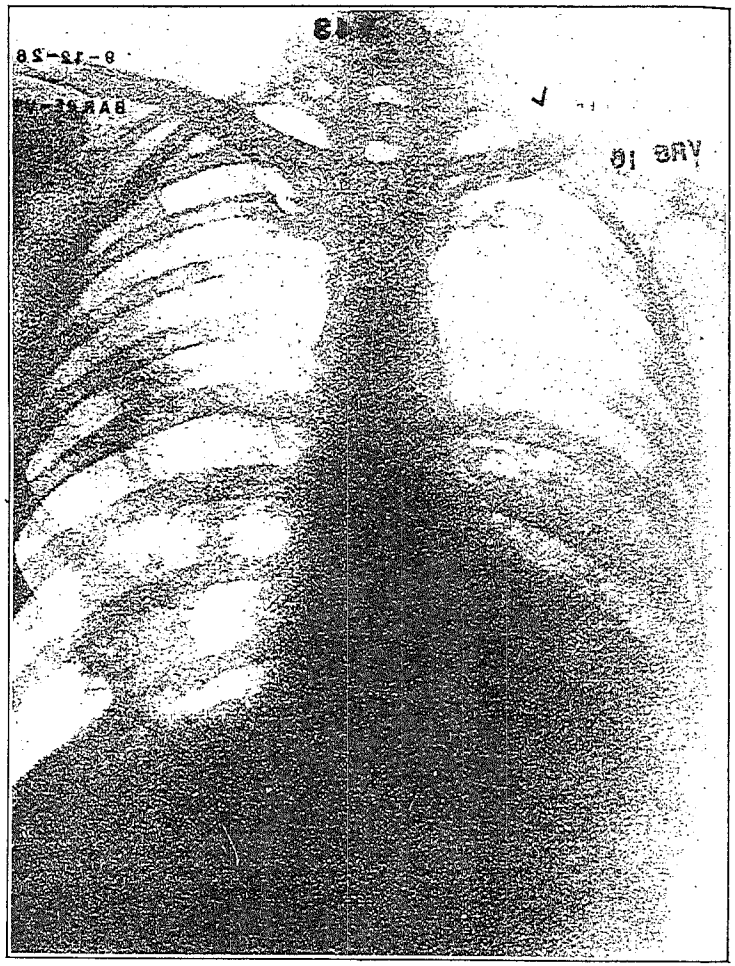


X ray 46.—Case 194. C. T., examined on February 18, 1925; Italian, aged 56 years; married

Granite cutter, with hand pneumatic tool, for 29 years; foreman in granite plant for the preceding five years. Health and habits had been good. At time of this examination he was complaining of fatigue, severe cough and profuse expectoration, pains in chest, and marked dyspnœa.

Examination: Height, 66 inches; weight, 123 pounds; impaired hearing; chronic rhinitis and pharyngitis; systolic blood pressure, 120; chest expansion, 3 centimeters; vital capacity, 2,300 cubic centimeters; chest showed evidence of silicosis and of tuberculosis.

The patient died on March 1, 1927.

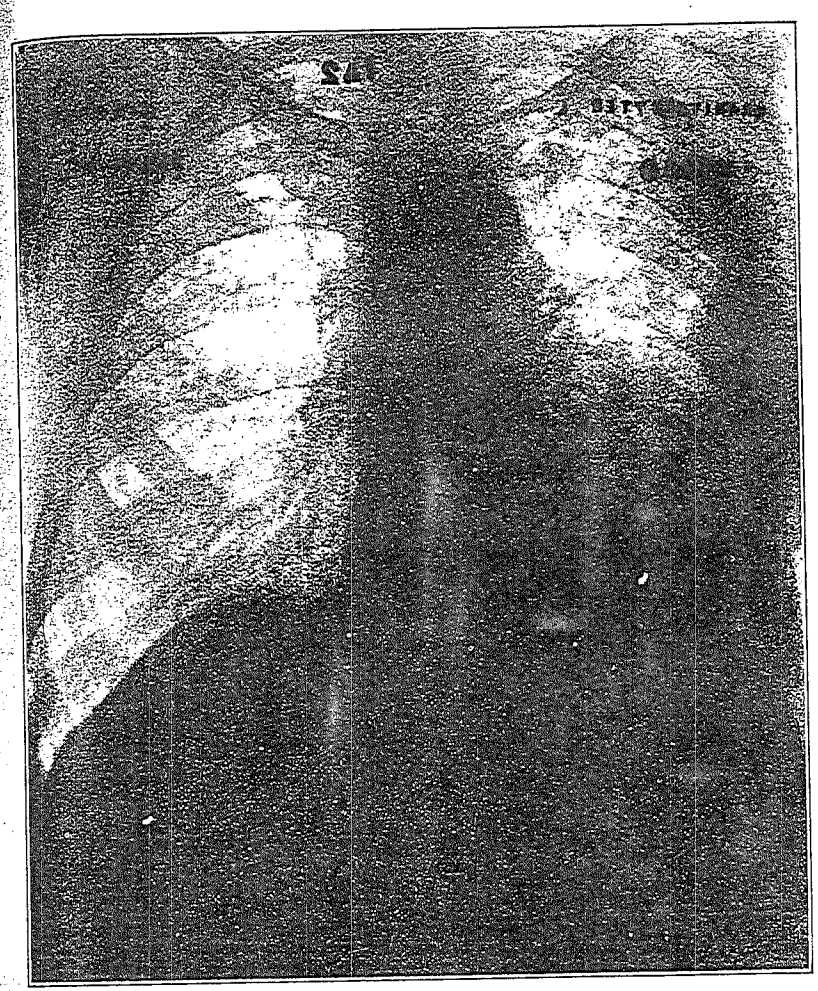


X ray 47.—Case 11. H. F., examined on May 5, 1924; Canadian (French), aged 37 years; married

Granite cutter, surface machine operator, for 15 years. Had not been feeling well for a while before the examination; complained of fatigue, loss of weight, and cough with slight expectoration. Physical examination at this time revealed evidence of silicosis and of a latent tuberculosis. The patient was advised to change his occupation, which he did. He returned to the granite industry in less than a year afterwards and worked as a manufacturer.

The patient returned in September, 1926, for reexamination. At this time he complained of loss of weight, fatigue, night sweats, severe pleurisy pains, dyspnœa, cough and expectoration, and afternoon rise in temperature.

Examination: Height, 65 inches; weight, 115 pounds; dental caries; vital capacity, 1,400 cubic centimeters; chest expansion, 4 centimeters; evidence of a tuberculous lesion in the base of the left lung, with an extension into the base of the right lung..



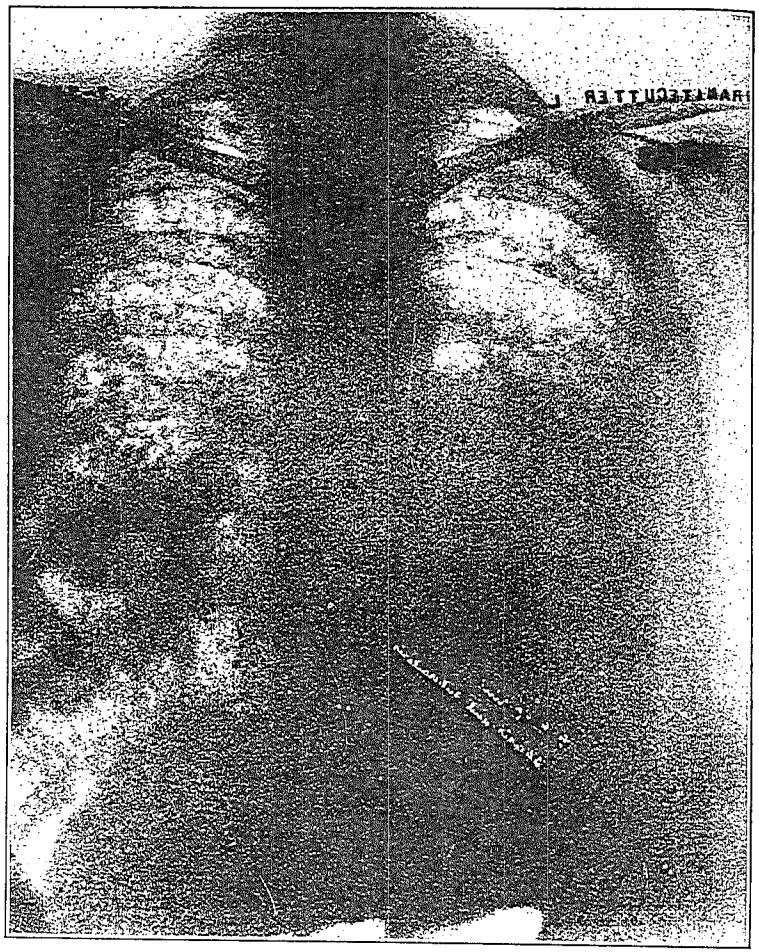
X ray 48.—Case 46. A. C., examined on September 22, 1925; Scotch, aged 60 years; married

Granite cutter, hand pneumatic tool, for 28 years. Had not worked for the past two years. He had cervical adenitis when a child. Two years before this examination developed tuberculosis of the left elbow, and had his arm amputated. At the same time incisions were made in the right inguinal glands, which were tuberculous, and they had not healed. While in the hospital, he had hemoptysis, cough and expectoration. When he returned home, he performed light work until the time of this examination.

The patient had a hemorrhage from the lungs on the day of the examination; he complained of loss of weight, cough and expectoration, fatigue, afternoon rise in temperature, dyspnœa.

Examination: Height, 67 inches; weight, 139 pounds; teeth replaced by dentures (he had had caries and pyorrhœa); tuberculous adenitis, right inguinal glands; systolic blood pressure, 150; silicosis and tuberculosis; tuberculous lesion in the base of the left lung; sputum contained tubercle bacilli.

The patient had several profuse hemorrhages after this examination. He lost much weight, and before his death, on April 25, 1926, he was the picture of a typical case of advanced tuberculosis.



X ray 49.—Case 301. G. C., examined on July 2, 1925; Italian, aged 50 years; divorced

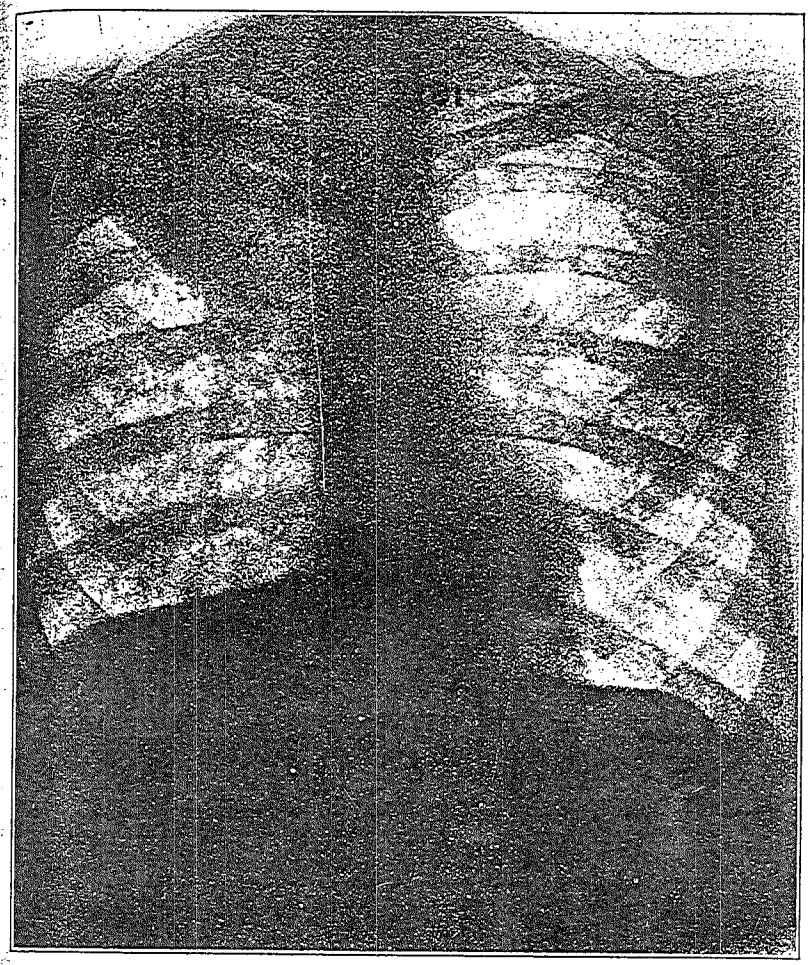
Granite cutter, hand pneumatic tool, 32 years; had cut marble in Italy for seven years. His recent illness began on June 26, 1925, with severe dyspnœa, which had grown worse; when examined, he could not walk more than a few steps before resting. He had a slight cough and marked acceleration of pulse, which was incident to the dyspnœa and his anxiety.

Examination: Height, 68 inches; weight, 162 pounds; impaired hearing; dental caries and pyorrhœa; chronic pharyngitis; systolic blood pressure, 146; chest expansion, 2 centimeters; chest presents evidence of consolidation in the left lung, below the fourth rib, anteriorly, and in the axilla and the angle of the scapula.

The patient remained in the same condition for some time, with extreme dyspnœa, no fever, accelerated pulse, anxiety, and slight cough which was nonproductive.

The patient was visited on January 13, 1926. His weight was apparently the same; he now had a productive cough, and the severe dyspnœa was still present. This examination revealed evidence of consolidation, with the addition of breath sounds and numerous râles after expiration and cough; sputum contained tubercle bacilli.

The patient returned to Italy, and it is not known whether he is still living.

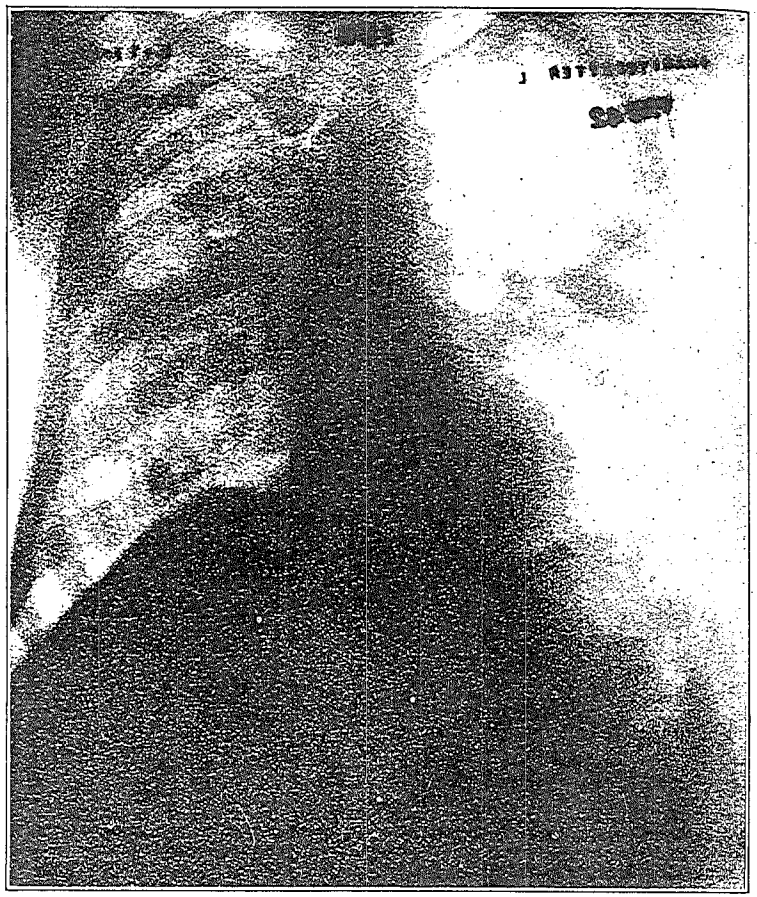


X ray 50.—Case 418. E. F., examined on December 2, 1925; Scotch, aged 46 years; married

Granite cutter, with hand pneumatic tool, for 22 years; had cut granite for a time in Scotland before emigrating to the United States. Had had influenza several times; health good otherwise. His illness had begun in September, 1925, with fatigue, dyspnœa, cough, expectoration, pains in chest, and afternoon fever, with loss of weight and strength.

Examination: Height, 67 inches; weight, 150 pounds; teeth had been removed because of caries and pyorrhœa, and had been replaced by dentures; chronic rhinitis and pharyngitis; silicosis and tuberculosis; sputum contained tubercle bacilli.

Patient had had subsequently several severe hemorrhages from the lungs. He died in February, 1927.

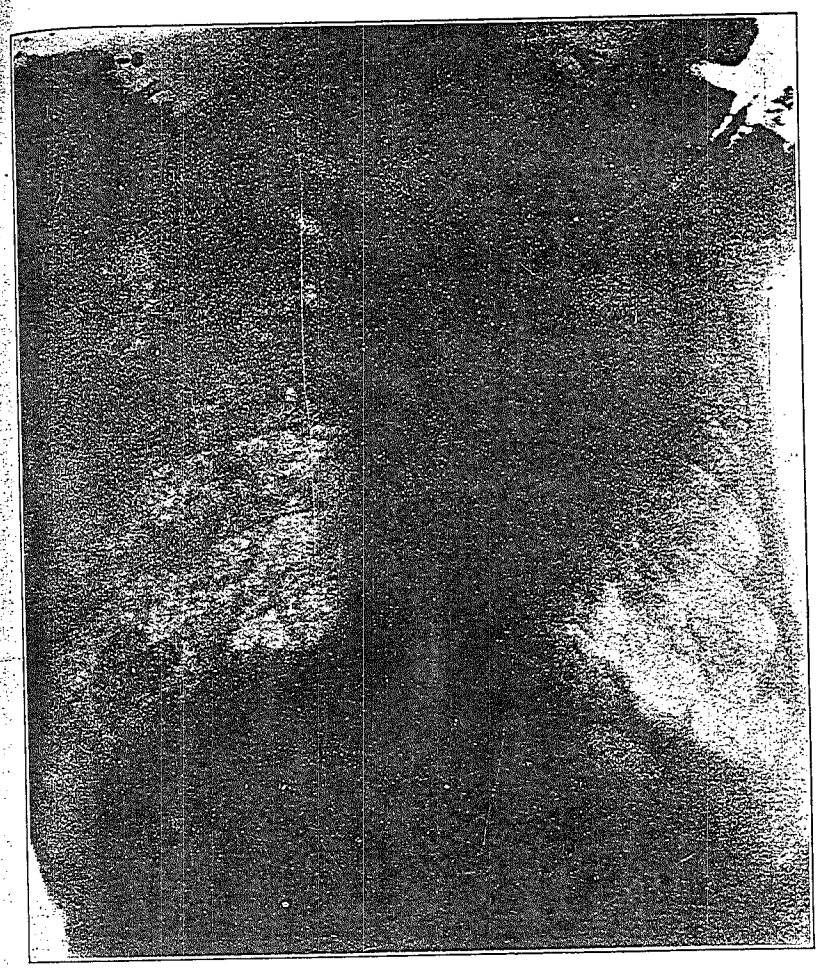


X ray 51.—Case 242. A. M., examined on April 8, 1925; Scotch, aged 55 years; married

This patient had cut granite for 40 years, using the hand pneumatic tool for the major portion of this time. His past health had been good, and his habits were good. His illness began a month before this examination, with fatigue and a marked increase in dyspnœa; a few days later he had a hemorrhage from the lungs and raised a small amount of blood on each of several days following. Since that time he had had pleurisy pains, and afternoon fever. During the year before the examination he had had a productive cough.

Examination: Height, 70 inches; weight, 152 pounds; impaired hearing; chronic pharyngitis; silicosis and tuberculosis; cavitation in the right upper lobe.

The patient died on March 29, 1926.



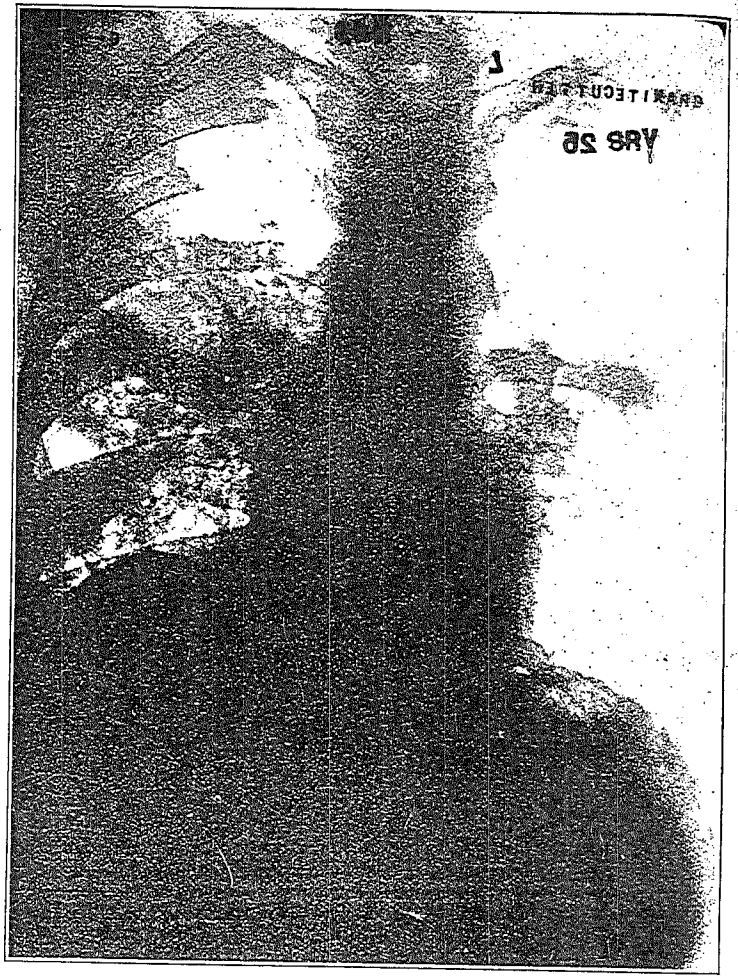
X ray 52.—Case 265. T. N., examined on May 1, 1925; English, aged 59 years; married

Granite cutter, surface machine operator, for 38 years. Previously worked on farm in England. His father died at the age of 65; cause of death unknown. His mother died at the age of 54, of cancer. The patient had typhoid fever at the age of 28, and made a good recovery. He sustained a slight injury to one of his feet, seven years ago. He had "bronchitis" one year before this examination, during which illness he had severe cough and expectoration, dyspnœa, and pains in chest, and lost 15 pounds in weight. He had been dyspnœeic for several years and had grown worse progressively; when examined it was difficult for him to get up the hill to his home, or to climb stairways.

Examination: Height, 69 inches; weight, 144 pounds; impaired hearing; chronic rhinitis and pharyngitis; systolic blood pressure, 116; loss of teeth and replacement with dentures; vital capacity, 3,000 cubic centimeters; chest examination revealed evidence of advanced silicosis and advanced tuberculosis, with cavitation in the left lung; tubercle bacilli present in the sputum.

Seen on July 23, 1926, patient was very dyspnœeic and was unable to walk up the hill to his home; he had had several small hemorrhages from the lungs; he was having afternoon rise in temperature and night sweats.

The patient died on December 12, 1926.

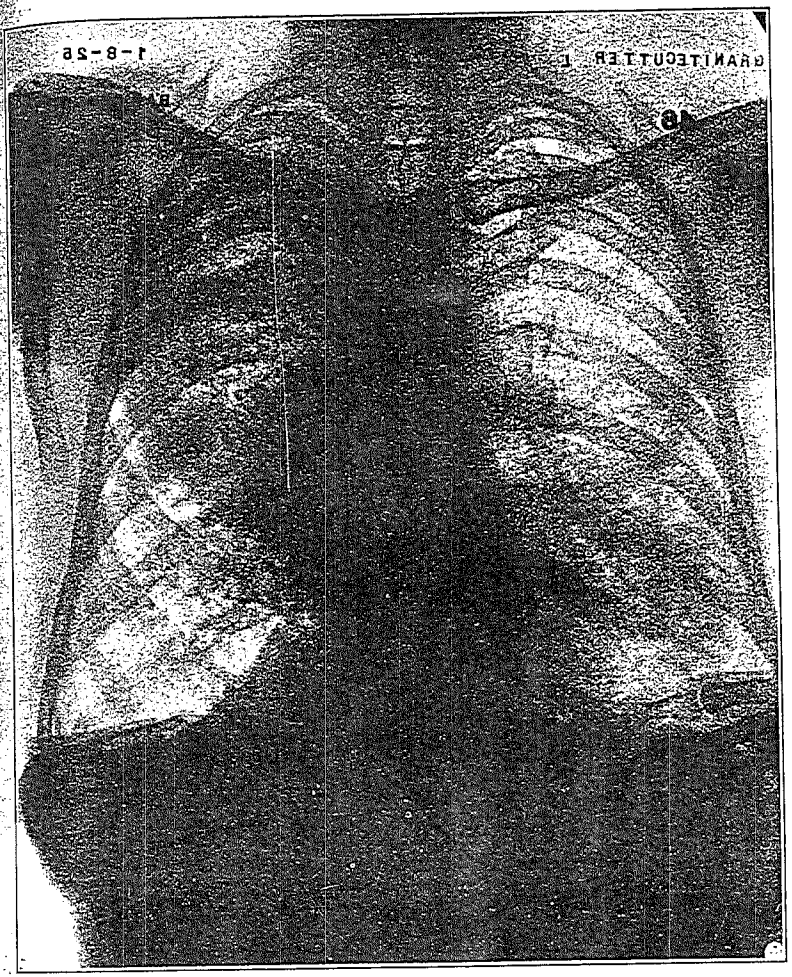


X ray 53.—Case 539. S. A., examined on October 1, 1926; Italian, aged 44 years; married

Granite cutter with hand pneumatic tool for 26 years. His health had been good until two years before this examination, when he had a tuberculous abscess on his neck (gland). He became ill two months before this examination, with pains in his chest, dyspnœa, cough and expectoration, night sweats, loss of weight, fatigue, and occasional expectoration of blood. These symptoms had continued, and he was having a marked rise of temperature in the afternoons.

Examination: Height, 67 inches; weight, 142 pounds; chest showed evidence of silicosis and tuberculosis; tubercle bacilli were present in the sputum; the tuberculous lesion was located in the base of the right lung.

The patient died on March 28, 1927.



X ray 54.—Case 156. P. C., examined on December 27, 1924; Italian, aged 59 years; single

Granite cutter for 26 years, cutting by hand, but exposed to the general atmosphere of the plant where pneumatic tools were used. He had cut marble in Italy several years before coming to the United States. His health and habits had been good.

Complaints at time of examination: Severe dyspnœa, which had partially incapacitated him for some time; pains in chest; loss of weight and strength; fatigue; fever; and night sweats.

Examination: Height, 64 inches; weight, 110 pounds; impaired vision and hearing; chronic rhinitis and pharyngitis; pyorrhœa and dental caries; systolic blood pressure, 128; chest expansion, 3 centimeters; vital capacity, 2,000 cubic centimeters; silicosis and tuberculosis; sputum contained tubercle bacilli.

The patient died on June 29, 1926.



X ray 55.—Case 272. L. R., examined on May 20, 1925; Italian, aged 54 years; married

Granite cutter, hand pneumatic tool, for 40 years. His father died at the age of 50, his death resulting from an accident; his mother was living. The patient had influenza and pneumonia in 1918 and was ill for two months. He had pneumonia again two years before this examination and was ill for five months. He had had severe dyspnœa since that illness. His health had been good otherwise; his habits were good. At the time of this examination he complained of severe dyspnœa, which was so marked that he was unable to exercise much in damp weather.

Examination: Height, 65 inches; weight, 131 pounds; impaired hearing, chronic rhinitis and pharyngitis; teeth badly worn; systolic blood pressure, 116; vital capacity, 2,200 cubic centimeters; chest expansion, 2 centimeters; left inguinal hernia; chest examination revealed evidence of advanced silicosis and a latent tuberculous condition.

In July, 1926, the patient became ill and soon afterwards was admitted to a hospital for the tuberculous. He died of tuberculosis on April 19, 1927.

CASE HISTORIES AND X RAYS

The X rays (with accompanying case histories) are presented in this section in the order of increasing severity.

The first cases are those with beginning tuberculosis.

Case No. 503 had evidence on physical examination of an early tuberculous process in the lower right lung. There were a few clinical signs of the disease.

Case No. 20 showed evidence of a latent tuberculous lesion in the right apex. However, he had no clinical evidence of it.

Cases Nos. 23, 88, and 345 were observed before the onset of tuberculosis and the X-ray prints shown herein were made when the disease (tuberculosis) was in its incipiency.

Case No. 11 was also examined two years prior to the time he became an active case of tuberculosis.

The age (60 years) of *Case No. 46* and the fact that he had scrofula in his childhood are interesting facts in this case. The tuberculous complications are also interesting.

Owing to the interest attaching to the presence of pulmonary tuberculosis among granite cutters, the detailed histories are given for a number of workers with the disease on whom X rays were not obtained or where the X rays were necessarily omitted because of lack of space.

Case No. 31.—O. C.: Examined on June 13, 1924. Italian, aged 52 years; married.

Granite cutter for 23 years, using hand pneumatic tool. His health had usually been very good. His final illness began in July, 1923, with loss of weight, cough, and expectoration. At the time of this examination he had the above symptoms and, in addition, fatigue, fever, night sweats, bloody expectoration, dyspnœa, and insomnia.

Examination: Height, 70 inches; weight, 165 pounds; pterygium on each eye; dental caries and pyorrhœa; systolic blood pressure, 130; chest expansion, 2 centimeters; vital capacity, 2,300 cubic centimeters; left inguinal hernia; silicosis, and tuberculosis.

The patient died on May 28, 1925.

Case No. 511.—W. B.: Examined on May 31, 1926. English, aged 59 years; widower.

Granite cutter for 43 years, using hand pneumatic tools for the greater part of this time. His health had usually been good; his habits were good. An industrial accident injured his left eye several years before the time of this examination, a fragment of flying stone driving a piece of his eyeglass into the cornea. Recovery was good, with but little loss of function.

He complained of having had a hemorrhage from the lungs three days before, and since that time he had expectorated blood-streaked sputum. He had had a cough for several months and had been gradually failing in health, according to the statement of his son. Patient was reluctant to complain of any symptoms.

Examination: Height, 67 inches; weight, about 135 pounds; impaired hearing; loss of teeth from caries and pyorrhœa; chronic pharyngitis; systolic blood

pressure, 130; gastroptosis, silicosis, and tuberculosis. Tuberculous lesion was in the base of the right lung. Sputum contained tubercle bacilli.

The patient died in December, 1927.

Case No. 284.—S. L.: Examined on June 11, 1925. French-Canadian, aged 54 years; married.

Granite polisher for 28 years, working in plant with granite cutters and exposed to the dust of the general atmosphere. Quarryman for 14 years before his employment in the granite sheds. Two of his children have died of tuberculosis.

The patient had had pneumonia five years before the date of this examination, and had had cough and expectoration since that time. He had herpes zoster one year before the examination and was ill for two months.

Complaints when examined: Loss in weight of 30 pounds in the past year; fatigue, dyspnœa, pains in chest, cough and expectoration, night sweats, gastric disturbances.

Examination: Height, 67 inches; weight, about 135 pounds; impaired hearing, dental caries; systolic blood pressure, 138; left inguinal hernia; silicosis and tuberculosis (cavity formation). Sputum contained tubercle bacilli.

The patient died on November 14, 1925.

Case No. 139.—A. M.: Examined on December 6, 1924. Scotch, aged 56 years; married.

Granite cutter for 40 years, using hand pneumatic tool. Past health had been good, except that he had had pleurisy at intervals; no history of an effusion. He complained of pains in the chest, loss of weight and strength, dyspnœa, cough and expectoration, fever, and night sweats.

Examination: Height, 65 inches; weight, 130 pounds; impaired hearing; silicosis and tuberculosis. Tuberculous lesion in the lower lobe of the right lung; evidence of cavitation.

The patient died on April 12, 1926.

Case No. 483.—A. C.: Examined on May 5, 1926. Italian, aged 46 years; married.

Granite cutter with hand pneumatic tool for 26 years. His past health had been good. His illness began several months before, and at the time of this examination he complained of loss of weight, dyspnœa, fatigue, fever, night sweats, cough and expectoration, and pains in chest. He was quite ill.

Examination: Silicosis and tuberculosis.

The patient died on June 16, 1926.

Case No. 399.—E. V.: Examined on October 6, 1925. Italian, aged 47 years; married.

Granite cutter for 25 years, with hand pneumatic tool; marble cutter for a few years before coming to the United States. His health had been good, and his habits were good. His illness began two weeks before this examination, with fever and pains in the chest. He had had dyspnœa for some time, and had recently developed a cough, with expectoration. Subsequently to this examination he had several profuse pulmonary hemorrhages.

Examination: Height, 68 inches; weight, 189 pounds; chronic rhinitis and pharyngitis; systolic blood pressure, 116; vital capacity, 2,700 cubic centimeters. Silicosis and tuberculosis. Tuberculous lesion in the base of the right lung. Sputum contained tubercle bacilli.

The patient died in January, 1927.

Case No. 79.—G. B.: Examined on August 29, 1924. Italian, aged 37 years; single.

Granite cutter, hand pneumatic tool for 17 years. His health had usually been very good. He served in the United States Army during the World War—

domestic service. He became ill two years before this examination, with disturbed digestion, losing about 9 pounds in weight, and soon afterwards he had a pulmonary hemorrhage; he suffered from dyspnoea, night sweats, and afternoon temperature. Since that time he had been hospitalized in a sanatorium for early cases of tuberculosis.

At the time of this examination he complained of loss of weight and strength, fever in afternoons, cough and expectoration, dyspnoea, and occasional severe pulmonary hemorrhages.

Examination: Height, 69 inches; weight, 149 pounds; chest showed evidence of silicosis and advanced tuberculosis.

Sputum contained tubercle bacilli.

Treatment did not alter the course of the disease, and the patient died on March 4, 1926.

Case No. 81.—B. G.: Examined on September 3, 1924. Swiss (Italian), aged 47 years; married.

Granite cutter with hand pneumatic tool for 32 years. His health had been good. He used alcoholics excessively. His illness followed an acute alcoholism which almost amounted to delirium tremens. He had not been well before this, but was able to work. He had been dyspnoeic for a long time. The examination revealed evidence of silicosis and early tuberculosis. He rested for a while and then returned to work and was able to get along a few months. He quit work, and in June, 1925, was visited and found to be quite emaciated and suffering from a severe cough and profuse expectoration, night sweats, marked dyspnoea, and severe pleurisy pains. He had had hemoptysis. Tubercle bacilli had been found in his sputum on February 1, 1925. His chest showed evidence of advanced tuberculosis and silicosis.

The patient died on July 3, 1925.

Case No. 381.—J. F.: Examined on August 30, 1925. Scotch, aged 40 years; married.

Granite cutter, hand pneumatic tool, for 24 years. His health had generally been good; habits good; athletic tendencies—played much golf during summer months. He had had for a long time a very marked phthisiophobia and had frequently refused to have an examination. When he became ill, this idiosyncrasy disappeared, and he thought that he had bronchitis and would recover very soon.

At the time of this examination he had cough and expectoration and had had several severe pulmonary hemorrhages. He had lost much weight and strength, and had severe pleurisy pains and marked dyspnoea.

Examination (at patient's home): Chest revealed evidence of silicosis and advanced tuberculosis. Subsequent to the examination the patient had several severe pulmonary hemorrhages, declined rapidly, and died on October 30, 1925, 91 days after he stopped work.

Absences from work during the study, for reasons other than illness, 27 days.

Case No. 293.—H. P.: Examined on June 29, 1925. American (English stock), aged 56 years; married.

This patient had worked in the granite plants at various jobs for 28 years, mostly as a granite lumper. His father died at the age of 49 of cancer; his mother died at the age of 34 of tuberculosis. The patient's health had usually been very good.

Complaints when examined: Cough and profuse expectoration, dyspnoea, marked fatigue, and rapid loss of weight. Patient was reluctant to give a detailed history of his illness. Apparently he had all the symptoms common to an advancing case of tuberculosis. His hoarseness was such as might indicate a tuberculous infiltration of the larynx.

Examination: Height, 70 inches; weight, 125 pounds; partial deafness; chronic pharyngitis; loss of teeth; systolic blood pressure, 116; chest expansion, 4 centimeters; vital capacity, 2,200 cubic centimeters. Chest showed evidence of silicosis and tuberculosis. Tuberculous lesion in the base of the left lung. Sputum contained tubercle bacilli.

The patient died on May 9, 1926.

Case No. 491.—W. N.: Examined on May 14, 1926. American (French-Canadian parentage), aged 45 years; married.

Granite cutter for 24 years, operating a surface-cutting machine. Health and habits had been good. He had been dyspnœic for a long time prior to the illness from which he was suffering at the time of this examination. He had a pulmonary hemorrhage in January, 1926, and had not been well since that time. Later he developed a severe cough, with expectoration, and had fever and night sweats, with rapid loss of weight and strength, dyspnœa growing much worse.

Examination: Height, 67 inches; weight, 113 pounds; impaired hearing; chronic rhinitis and pharyngitis; loss of teeth; systolic blood pressure, 142; vital capacity, 2,100 cubic centimeters; silicosis and tuberculosis. Sputum contained tubercle bacilli.

The patient died on November 28, 1926.

Case No. 176.—J. R.: Examined on February 6, 1925. Italian, aged 46 years; married.

Granite cutter, using hand pneumatic tool, for 30 years. A marble cutter previously for a short time in Italy. He had an abscess in the right hypochondriac region nine years before this examination and he had an operation for gallstones a year later; a third year later he had an operation for appendicitis (three anæsthetics). Health had been good otherwise.

His final illness began in December, 1924, and he stopped working in January, 1925. He had loss of weight, fatigue, and interference with digestion, pains in chest, cough and expectoration, and dyspnœa.

Examination: Height, 66 inches; weight, 126 pounds; impaired hearing; dental caries and pyorrhea; chronic rhinitis and pharyngitis; systolic blood pressure, 120; vital capacity, 3,000 cubic centimeters; tenderness over abdomen, due perhaps to adhesions; silicosis and tuberculosis. Sputum contained tubercle bacilli.

The patient died on November 17, 1925.

Case No. 116.—C. B.: Examined on October 1, 1924. Italian, aged 52 years; married.

Granite cutter with hand pneumatic tool for 35 years. Marble cutter in Italy a short time before coming to the United States. The patient had septicemia following a wound on finger (industrial accident), and an abscess in the right axilla. Subsequently he had an operation for appendicitis and a hemorrhoidectomy. Health had been good otherwise.

The patient's final illness began in September, 1924, with pains in chest, dyspnœa, cough and expectoration. These symptoms persisted, and at the time of this examination he also suffered from fatigue and a morbid fear of tuberculosis. Subsequent to this examination the patient had severe pleurisy, with rapid loss of weight and marked depression.

Examination: Height, 67 inches; weight, 190 pounds; right inguinal hernia; silicosis and tuberculosis. Sputum contained tubercle bacilli.

The patient died on April 20, 1925.

Case No. 315.—B. M.: Examined on July 17, 1925. Italian, aged 48 years; widower.

Granite cutter with hand pneumatic tool for 27 years; marble cutter in Italy a few years previously. Patient had influenza in 1918, and bronchitis two years before; health had been good otherwise. At the time of this examination he complained of marked fatigue, cough and expectoration, loss of weight, dyspnœa, fever, and weakness.

Examination: Height, 64 inches; weight, 118 pounds; pterygium on left eye; dental caries and pyorrhea; chronic pharyngitis; systolic blood pressure, 112; temperature range, 37° to 38° C.; pulse, 88 to 108; silicosis and tuberculosis; sputum contained tubercle bacilli.

Patient's condition declined rapidly, and he died on September 14, 1925.

Case No. 281.—G. Z.: Examined on June 1, 1925. Italian, aged 39 years; married.

Granite cutter, using hand pneumatic tool, for 17 years. Health had been good; habits were good. Complaints when examined: Cough, which had persisted for five months; expectoration—the substance raised being at times blood-streaked; hoarseness; dyspnœa; and loss of weight. Patient was reluctant to describe symptoms of his illness.

Examination: Height, 62 inches; weight, 107 pounds; chronic pharyngitis; systolic blood pressure, 124; chest expansion, 5 centimeters; vital capacity, 2,000 cubic centimeters. Chest showed evidence of silicosis and tuberculosis. Tuberculous lesion in the lower lobe of left lung. Sputum contained tubercle bacilli.

The patient died on October 19, 1925, of massive pulmonary hemorrhage. He had several hemorrhages from the lungs during the five and one-half months from the time of this examination until his death.

Case No. 126.—J. L.: Examined on November 18, 1924. Italian, aged 38 years; single.

Granite cutter for 25 years, using hand pneumatic tool.

This patient's previous health had been good. He had used alcohol to excess for several years. He complained of marked fatigue, loss of weight, cough and expectoration, dyspnœa, and pains in chest.

Examination: Height, 68 inches; weight, 148 pounds; dental caries; chronic rhinitis and pharyngitis; systolic blood pressure, 120; vital capacity, 2,100 cubic centimeters. Silicosis and tuberculosis. Tuberculous lesion in the lower lobe of the left lung. Sputum contained tubercle bacilli.

Patient died on November 4, 1925.

Case No. 61.—P. C.: Examined on August 11, 1924. Italian, aged 50 years; married.

Granite cutter for 23 years, using a hand pneumatic tool; marble cutter in Italy a few years before coming to the United States. His past health had been good; habits good. He had been ill for about a year before this examination. He complained of severe dyspnœa, cough and expectoration, pains in chest, hemoptysis, night sweats, fever, and rapid loss of weight and strength.

Examination: Silicosis and far advanced tuberculosis.

The patient died on September 10, 1924.

Case No. 128.—G. C.: Examined on November 21, 1924. Italian, aged 51 years; married.

Granite cutter with hand pneumatic tool for 31 years. He had good habits and his health had been good until about a year before the time of this examination, when he had a hemorrhage from the lungs. Since that time he had had pains in chest, loss of weight and strength, fatigue, dyspnœa, night sweats, and fever in the afternoons. He had worked at intervals after illness began. During the two days just prior to examination the patient had been very nervous and fretful, and had had severe headaches, insomnia, and projectile vomiting.

His physician has stated that later the patient became unconscious and remained so until his death.

Examination revealed silicosis, tuberculosis of the lungs, and tuberculous meningitis. Tuberculous lesion in the lower lobe of the left lung.

The patient died on November 24, 1924.

Case No. 447.—W. J.: Examined on January 21, 1926. English, aged 54 years; married.

Granite cutter with hand pneumatic tool for 30 years; a quarryman for 4 years previously.

The patient had pneumonia at age of 49 and was ill for 2 months. Lost vision in left eye in consequence of industrial accident 12 years before date of examination. Health good otherwise. Habits good.

His illness began in August, 1925, with fatigue and dyspnœa, afternoon rise in temperature, pleurisy pains, loss of weight, cough and expectoration. These symptoms had persisted, and the patient had lost much weight and strength.

Examination: Height, 69 inches; weight, 149 pounds; loss of vision in left eye; chronic rhinitis and pharyngitis; systolic blood pressure, 128; vital capacity, 2,000 cubic centimeters; inguinal hernia, left side; silicosis and tuberculosis. Sputum contained tubercle bacilli.

Patient died.

Case No. 187.—D. P.: Examined on February 11, 1925; Italian, aged 40 years; married.

Granite cutter for 21 years, using the hand pneumatic tool. His mother and father died of heart disease at the ages of 70 and 67, respectively. Patient's health had usually been good. He had an attack of pleurisy in the autumn of 1924, while visiting in Italy, and had not been well since that time. At time of this examination he was complaining of cough and expectoration, loss of weight and strength, afternoon fever, dyspnœa, and pains in chest.

Examination: Height, 66 inches; weight, 152 pounds; chronic rhinitis and pharyngitis; systolic blood pressure, 140; chest expansion, 4 centimeters; vital capacity, 3,500 cubic centimeters. Chest examination revealed evidence of silicosis and a tuberculous lesion in the base of the right lung. Sputum contained tubercle bacilli.

Case No. 445.—P. C.: Examined on January 15, 1926. Italian, aged 50 years; widower.

Granite cutter with hand pneumatic tool for 21 years; marble cutter in Italy for 7 years before coming to the United States. He was very ill at the time of the examination, having had several severe hemorrhages from the lungs, and a detailed history was not taken. He stated that he had not been well for a year and had stopped work in the previous November because of severe dyspnœa, pleurisy, and weakness.

The hospital record of temperature showed a range of from 38° to 41° C. and a pulse range of 100 to 120. Chest showed evidence of silicosis and tuberculosis. Sputum contained tubercle bacilli.

The patient died on January 17, 1926.

Case No. 140.—C. R.: Examined on December 18, 1924. Italian, aged 44 years; married.

Granite cutter with hand pneumatic tool for 24 years. He had cut marble for a short time before coming to the United States. His health had been good, and his habits were good.

Complaints when examined: Fatigue and weakness, cough and expectoration, pleurisy, severe dyspnœa.

Examination: Height, 68 inches; weight, 140 pounds; impaired hearing; dental caries and pyorrhœa; silicosis and tuberculosis. Tuberculous lesion in the lower lobe of the right lung.

The patient died on July 23, 1925.

Case No. 56.—C. W.: Examined on July 6, 1924. American, aged 51 years; married.

Granite cutter 32 years with surfacing machine. He had malaria during the Spanish-American War and influenza in 1918, but good recovery from both diseases. His health had been good otherwise. He complained of fatigue, cough, and expectoration, nervousness, fever, night sweats, and pains in the chest.

Examination: Height, 71 inches; weight, 185 pounds; impaired vision and hearing; chronic rhinitis and pharyngitis; dental caries and pyorrhoea; inguinal hernia; vital capital, 2,700 cubic centimeters; silicosis and tuberculosis. Tuberculous lesion in the lower lobe of the right lung.

The patient's condition rapidly declined, and he became very much emaciated. He died on December 31, 1925.

Case No. 477.—M. L.: Examined on April 24, 1926. American (Canadian-French and Irish stock); aged 46 years; single.

Granite cutter, using hand pneumatic tool, for 20 years. His health had been very good and his habits were good. He had been ill for over a year before this examination. He complained of loss of weight and strength, fatigue and weakness, cough and expectoration, pains in chest, and severe dyspnœa.

Examination (in patient's home): He was rather emaciated and was quite ill. His fingers were clubbed. His chest showed evidence of silicosis and advanced tuberculosis, with cavitation in the left upper lobe. His sputum contained tubercle bacilli.

The patient died on August 4, 1926.

Case No. 455.—H. B.: Examined on February 8, 1926. Scotch, aged 60 years; married.

Granite cutter for 30 years, with hand pneumatic tool. His past health had been good. His illness began a year before this examination, with pleurisy and severe dyspnoea. He had been dyspnoeic for several years previously.

Complaints at time of examination: Cough and expectoration, pleurisy, dyspnoea, loss of weight and strength, fever, night sweats, and weakness.

Examination: Height, 57 inches; weight, 120 pounds; impaired hearing, loss of teeth, silicosis and tuberculosis. Sputum contained tubercle bacilli.

Subsequent to this examination the patent had severe hemorrhages from the lungs.

Patient died.

Case No. 70.—F. S.: Examined on August 18, 1924. Italian, aged 48 years; married.

Granite cutter for 22 years, with hand pneumatic tool; marble cutter several years in Italy before coming to the United States. He had influenza in 1918 and was not well afterwards. He returned to work and worked at intervals until 1922, when he gave up entirely. At the time of examination he complained of cough and expectoration, emaciation, fever, night sweats, severe dyspnoea, pains in chest, and anorhexia. Subsequent to the examination he had pulmonary hemorrhages and declined rapidly.

Examination (at patient's home): Silicosis and tuberculosis.

The patient died on September 15, 1924.

Case No. 382.—L. V.: Examined on August 31, 1925. Italian, aged 38 years; single.

Granite cutter with hand pneumatic tool for 16 years. Previously, marble cutter for 4 years. He had tonsillitis and rheumatism. Health good, otherwise; habits had been good.

Complaints at time of examination: Severe cough and expectoration; pains in chest; dyspnœa; loss of 20 pounds in weight in preceding few months; afternoon rise in temperature.

Examination: Height, 65 inches; weight, 120 pounds; impaired hearing; dental caries; silicosis and tuberculosis. Sputum contained tubercle bacilli.

The patient died on June 4, 1926.

Case No. 154.—J. J.: Examined on December 26, 1924. Swedish, aged 62 years; married.

Granite cutter, hand pneumatic tool, for 33 years. His health had usually been good; he had influenza in mild form in 1918, and was operated on for hydrocele three years before this examination. Habits good.

His recent illness had come on gradually. Three weeks before this examination the patient was obliged to stop work because of dyspnœa (he had been very dyspnœic for several years). He had a severe cough and expectorated profusely; he suffered from pleurisy and occasional night sweats.

Examination: Height, 71 inches; weight, 175 pounds; impaired hearing; chronic rhinitis and pharyngitis; systolic blood pressure, 110; chest expansion, 4 centimeters; vital capacity, 3,000 cubic centimeters. Chest showed evidence of emphysema, silicosis, and tuberculosis. Sputum contained tubercle bacilli.

The patient died of broncho-pneumonia in June, 1925.

Case No. 36.—J. T: Examined on July 9, 1924. Scotch, aged 48 years; married.

Granite cutter, with hand pneumatic tool, for 32 years. Health had usually been very good. He became ill two years before this examination with a hemorrhage from the lungs and had not worked regularly since that time. A month before this examination he had another pulmonary hemorrhage. He complained also of cough and expectoration, pains in chest, night sweats, fever, fatigue, and loss of weight.

Examination: Height, 67 inches; weight, 150 pounds; impaired hearing, dental caries, and pyorrhea; chronic pharyngitis; systolic blood pressure, 106; chest expansion, 3 centimeters; vital capacity, 2,000 cubic centimeters; silicosis and tuberculosis—tuberculous lesion in the base of the right lung. Sputum contained tubercle bacilli.

The patient died on June 4, 1925.

Case No. 409.—F. P.: Examined on November 23, 1925, American (Danish parents), aged 50 years; married.

Granite cutter, surface-machine operator, for 28 years. He had appendicitis and an operation at the age of 29 years, making a good recovery; and had pneumonia at the age of 35 years, and was ill for several months. His health had been good since that time.

His recent illness began about six weeks before this examination, with fatigue, increase in dyspnœa, pains in chest, digestive disturbance, and slight cough and expectoration. A week before the examination he had a pulmonary hemorrhage of about 300 cubic centimeters while at work, and the next day he had another hemorrhage, losing about the same amount of blood. Blood-streaked sputum for several days afterwards.

Examination: Height, 72 inches; weight, 169 pounds; impaired hearing, dental caries, and pyorrhœa; chronic rhinitis and pharyngitis; silicosis and tuberculosis.

The patient died in Europe.

Case No. 60.—A. R.: Examined on August 11, 1924. Italian, aged 51 years; married.

Granite cutter for 25 years; marble cutter for several years previously in Italy. He had been ill for about a year before this examination. His health had been good until June, 1923. His illness began with fatigue, dyspnœa, cough and expectoration, pulmonary hemorrhages, loss of weight, severe pleurisy pains, fever, and night sweats. These symptoms had persisted, and at this examination the patient presented the picture of an advanced case of tuberculosis.

Examination: Height, 66 inches; weight, 120 pounds; dental caries; impaired hearing; chronic pharyngitis; systolic blood pressure, 110; silicosis and tuberculosis. Sputum contained tubercle bacilli.

The patient died on December 26, 1924.

Case No. 366.—J. E.: Examined on August 12, 1925. Scotch, aged 56 years; married.

Granite cutter, with hand pneumatic tool, for 24 years, foreman 12 years, superintendent 6 years. Total time in the industry, 42 years. Exposure to dangerous amount of dust for 36 years. He had pneumonia 3 years before this examination and had had severe dyspnœa ever since. He had previously been dyspnœic. He lost much weight in the 2 years preceding this examination. He had influenza in 1918 and had had frequent colds in the last several years.

Complaints: Dyspnœa, cough and expectoration, fatigue and weakness, emaciation, anorhexia, fever in afternoons, and night sweats.

Examination: Height, 66 inches; weight, 128 pounds; partial deafness; chronic pharyngitis; tuberculous ulcer in nose; loss of teeth; systolic blood pressure, 104; vital capacity, 1,000 cubic centimeters; silicosis and advanced tuberculosis. Sputum contained tubercle bacilli.

The patient died on September 10, 1925.

Case No. 65.—F. G.: Examined on August 12, 1924. Italian; aged 56 years; married.

Granite cutter, with hand pneumatic tool, for 30 years. His health and habits had been good. He became ill in February, 1924, with influenza and did not fully recover. He had a persistent cough and expectoration. Later he developed a peri-rectal abscess and was treated in the hospital. He spent some time in southern California, where he improved; but when he returned he was still unable to resume his trade. He had had dyspnoea, which grew worse. His symptoms continued, and he gradually lost weight and strength.

Examination: Height, 69 inches; partial deafness; dental caries; systolic blood pressure, 140; vital capacity, 2,600 cubic centimeters; silicosis and tuberculosis. Sputum contained tubercle bacilli.

The patient died on April 11, 1925.

Case No. 50.—W. L.: Examined on July 23, 1924. Scotch; aged 58 years; widower.

Granite cutter, surface machine operator, for 36 years. His past health had been good until 2 years before the examination, and since that time it had gradually declined. He was treated in the city hospital in May, 1922, for pleurisy with effusion.

At the time of the examination the patient complained of severe dyspnoea, cough and expectoration, loss of weight and strength, marked fatigue, and pains in the chest.

Examination: Impaired hearing; loss of teeth; varicose veins; systolic blood pressure, 106; silicosis and advanced tuberculosis.

The patient died on September 20, 1924.

Case No. 482.—C. M.: Examined on May 5, 1926. Italian, aged 47 years; married.

Granite cutter with hand-pneumatic tool for 24 years. Previously he cut marble in Italy for a few years. His health and habits had been good. He became ill in July, 1925, complaining of fatigue, impaired digestion, marked dyspnœa, loss of weight, fever, and night sweats. He quit working on August 1, and his condition gradually grew worse.

Examination was made at the patient's home and was not so general as the examinations made at office. Chest showed evidence of silicosis and tuberculosis, and sputum contained tubercle bacilli.

The patient died on October 30, 1926.

Case No. 521.—O. H.: Examined on June 24, 1926. Finlander, aged 43 years; single.

Granite cutter with hand pneumatic tool for 18 years. He had had influenza four years before this examination; his health had been good otherwise. He used alcoholics excessively for several years.

Complaints: Cough and expectoration, pleurisy pains, severe dyspnœa, of two years' duration, night sweats, fever, and fatigue. Lost 20 pounds in weight within a few months prior to this examination.

Examination: Height, 64 inches; weight, 130 pounds; chronic rhinitis and pharyngitis; systolic blood pressure, 118; chest expansion, 3.5 centimeters; vital capacity, 1,900 cubic centimeters; silicosis and tuberculosis. Sputum contained tubercle bacilli.

The patient died on February 22, 1927.

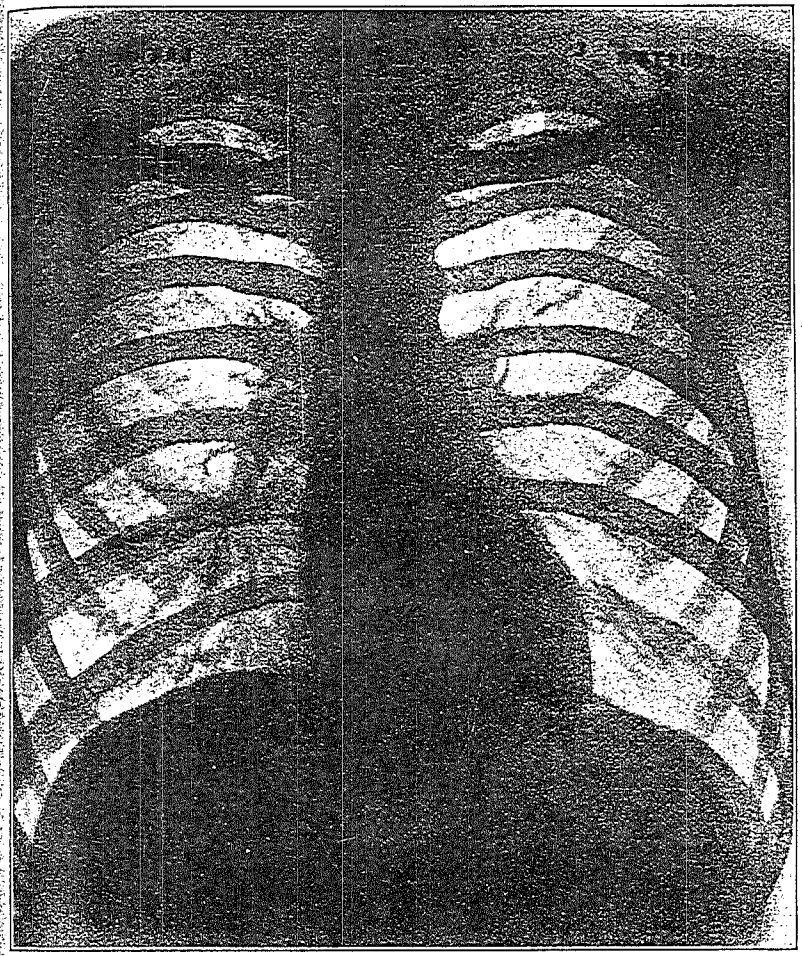
Case No. 148.—E. F.: Examined on December 18, 1924. Italian, aged 42 years; single.

Granite cutter with hand-pneumatic tool for 20 years. Marble cutter for six years before coming to the United States. His previous habits had been good. He stopped working a month before this examination.

Complaints at time of examination: Fatigue, cough and expectoration, pains in chest, nervousness, and loss of weight.

Examination: Slight dental caries; chronic rhinitis and pharyngitis; chronic tonsillitis; gastroptosis; systolic blood pressure, 140; vital capacity, 2,000 cubic centimeters; silicosis and tuberculosis—tuberculous lesions in the lower lobes of each lung.

The patient returned to Italy, and it is not known whether he is still living, but the probability is that he has died.



X ray 56.—Case 62. J. P., examined on August 11, 1924. American (Italian parentage), aged 24 years; single

Granite cutter two years; marble cutter four years previously. Father died at age of 40, of tuberculosis; he was a granite cutter. Mother died at age of 40, of influenza; two brothers died of tuberculosis. Patient had influenza in 1918, with a good recovery; health had been good otherwise.

Height, 66½ inches; weight, 136 pounds; chronic rhinitis and pharyngitis; blood pressure, 140, systolic (blood pressure fell 10 points later); chest expansion, 6 centimeters; chest showed evidence of a moderately advanced silicosis.

VII. DEVELOPMENT OF CONCURRENT SILICOSIS AND TUBERCULOSIS

The cases shown as concurrent silicosis and tuberculosis are either sons of granite cutters who died of silicosis and tuberculosis or are persons who have had a definite history of prolonged exposure to tuberculosis. Among these cases are some who gave a history of intimate contact with tuberculosis prior to industrial life and others who were exposed to granite dust and tuberculosis at the same time. It is apparent from the following case histories and X rays that fibrosis of the lungs develops more rapidly where there is both exposure to dust and a tuberculous infection present than where a simple silicosis develops or where an uncomplicated tuberculous lesion exists.

The first case presented is one of suspected tuberculosis, the patient's father and brother having died of tuberculosis and silicosis. During the time this observation was made the patient was also living with a relative (Case No. 195) who had tuberculosis and silicosis. This case had been exposed to granite dust for only two years. The extent to which the fibrosis had developed at the time of examination was quite out of proportion to the length of exposure.

Case No. 498 is similar to case No. 62. Although he was not a cutter, he was exposed to the dust in a general plant atmosphere, which is about one-half the amount to which case No. 62 was exposed. The father of this case has been ill for some time with tuberculosis. The amount of pathology indicated in the X ray seems to be in excess for the amount of exposure.

Case No. 22 presents evidence on physical examination and in the X ray of a latent tuberculosis. During the course of the study he was disabled from pleurisy (dry). His father had silicosis and tuberculosis and died at the age of 48 years. There is a tuberculous lesion indicated in the X ray in the right apex. The extent of silicosis seems in excess to the length of exposure to dust.

The previous cases in this section have had a latent tuberculous infection. The subsequent ones have active disease. The tuberculosis in these cases is different from that which the cutters develop at a later age, inasmuch as the principal cases shown herein have apical lesions and are prone to run a more chronic course, as in cases outside of the industry. No X rays are given for these cases; the case histories are given herewith.

Case No. 389.—H. R.: Examined on September 28, 1925. American (English stock), aged 25 years, single. Granite cutter six years with hand pneumatic tool.

Father was a granite cutter and died of tuberculosis at age of 48. Mother living and well. Sister had had tuberculous peritonitis for several years.

Patient's health had been good; habits good. He had been taken ill a week before this examination, when he had a profuse hemorrhage from the lungs; had had four hemorrhages since that time. He was reluctant to complain of anything referable to tuberculosis. He coughed and expectorated and had afternoon fever (as evidenced by hospital records).

Examination: Height, 71 inches; weight, 157 pounds; chronic pharyngitis, early silicosis and tuberculosis. Tuberculous lesion in the right apex. Sputum contained tubercle bacilli.

Case No. 292.—H. P.: Examined on June 29, 1925. American (English stock), aged 26 years, married. Lumper and tool carrier for a year.

Father was ill and died of tuberculosis during our study.

Examination: Height, 70 inches; weight 113 pounds; chronic rhinitis and pharyngitis; chest expansion, 2 centimeters; vital capacity, 2,000 cubic centimeters.

This patient had early tuberculosis, right apex; he was treated later at the State sanitorium.

Case No. 143.—A. B.: Examined on December 11, 1924. Italian, aged 35 years; single. Granite cutter for 13 years, using hand pneumatic tool. Had cut marble previously.

Father died at age 74 of an accident; mother died of pneumonia. One brother, a granite cutter, died of tuberculosis.

Patient had blindness in left eye due to an industrial accident—a piece of steel struck him in the eye. He had influenza in 1918. Otherwise he has had good health.

At the time of examination he complained of loss of weight and strength, weakness, cough, and expectoration.

Examination: Blindness in left eye; chronic rhinitis and pharyngitis; systolic blood pressure, 124; vital capacity, 3,300 cubic centimeters. Chest reveals evidence of silicosis and an early tuberculosis.

Patient's condition declined, and he wished to return to his home in Italy. He had a profuse pulmonary hemorrhage on the way, and died on December 2, 1925.

Case No. 97.—M. J.: Examined on September 16, 1924. American, aged 27 years; married. Granite cutter with hand pneumatic tool for two years; was a tool boy for one year. Has been out of the granite industry for 10 years.

Father was a granite cutter and died of tuberculosis at age of 47. Mother living and well.

Patient's health was generally good; habits were good. Had had tuberculosis for several years and presented most of the characteristics of a case of low toxicity of several years' standing.

Systolic blood pressure, 120; vital capacity, 2,500 cubic centimeters; chest showed evidence of a tuberculous condition of long standing. Cavitation and much fibrosis in evidence. Sputum contained tubercle bacilli.

Case No. 411.—J. B.: Examined November 24, 1925, American (Canadian-French), aged 27 years; married.

Draftsman; had been former granite cutter, with hand pneumatic tool for four years; exposed to granite dust four years.

Father was a granite cutter; died at age of 47 of pulmonary tuberculosis. Mother living.

Had pneumonia at age 10 and 13; was ill a month each time. Served in United States Army two years; received a shrapnel wound in right side of chest, scar of which extends from level of third dorsal spine downwards and laterally to angle of scapula. Three months ago he expectorated blood; also, one month ago, and again, to-day. Feels well other than from worrying over his condition.

Chest reveals (by X ray) the presence of a small piece of shrapnel in the upper lateral portion of right lung; evidence of an early tuberculous process in right apex; vital capacity, 3,200 cubic centimeters; chronic pharyngitis.

Patient died of pulmonary hemorrhage, July, 1928.

VIII. COURSE OF SILICOSIS AMONG WORKERS NO LONGER EXPOSED TO SILICA DUST

DISCUSSION OF LITERATURE

In the study of silicosis one of the most important questions which has arisen is the health history of those individuals who have worked in the granite industry for a number of years and then left, to find occupations in other trades where there was no further dust exposure. It was possible during the course of the study at Barre to observe 24 such cases. Eighteen of the case histories are given in this section.

The latency of silicosis has been referred to by other investigators. The South African workers found that "a steady fall over a period of years in dust concentration is not associated with the corresponding fall in the silicosis incidence."[52] Dr. Watkins-Pitchford also records cases of miners who had been exposed to dust for a long period of time, apparently sufficient to develop silicosis, but who went into the war apparently not silicotic. He asserted that such cases were liable to develop tuberculosis. Doctor Pancoast presents a case of advanced pneumonoconiosis in a quartz miner who had been exposed to dust for eight years. He had been out of the mining industry for 10 years, yet the X ray showed extensive pneumonoconiosis with irregularities of diaphragm, and by fluoroscope he found the diaphragm restricted on each side. There was, perhaps, a tuberculous infection intervening at the time.[53]

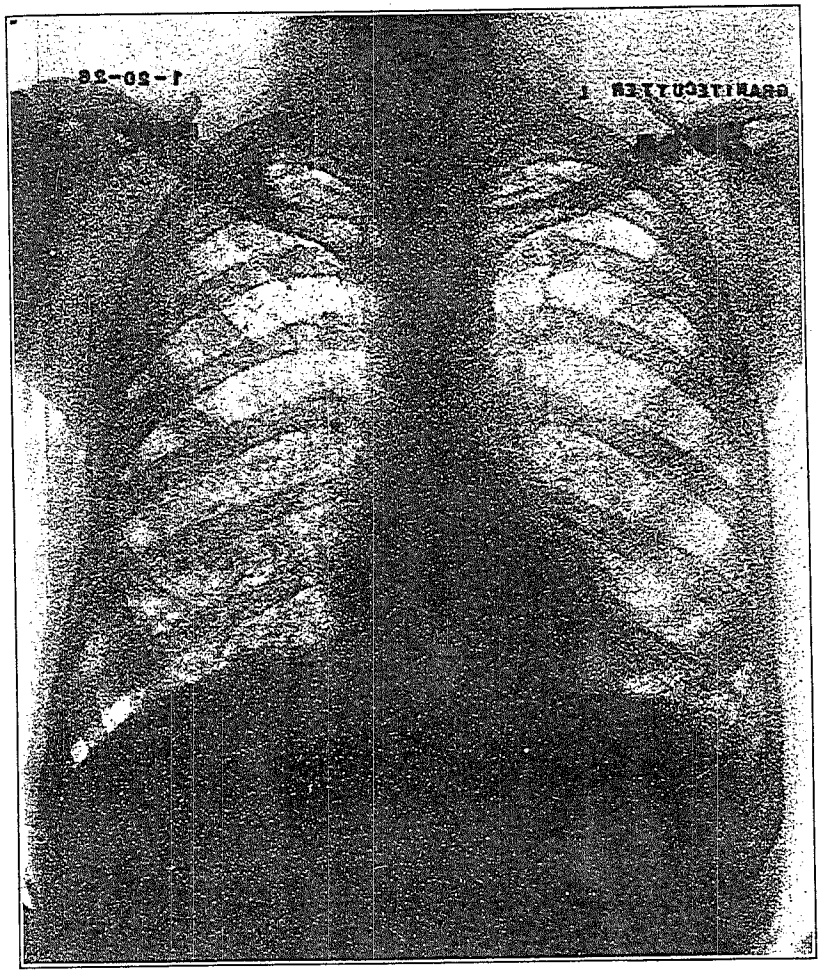
Britton [54] reports two cases of workers who had been exposed to dust between seven and eight years. They changed occupations and had been away from siliceous dust for eight and nine years. They developed pulmonary symptoms and were found to be suffering from silicosis and tuberculosis. Tattersall [55] also observed cases of latent silicosis in his studies: "Some of the men (rock drillers), moreover, had changed their occupation for various reasons quite apart from health, but in due course the inevitable dyspnoea came on. One man, for instance, worked eight years regularly with rock drills, from 1906 to 1914, then joined the Army, was passed as A–1; but in spite of his open-air life, dyspnoea came on in 1918, and from then until his death six years later his illness was a typical case of silicosis."

[52] South African Institute Medical Research, Annual Report Year Ending 1925.

[53] Pancoast, Henry K.: Röentgenological Studies and Other Fibrosing Conditions of the Lungs. Analysis of Clinical Medicine, July, 1923.

[54] Britton, James A., M. D.: Silicosis, a Modern Factory Hazard. Jour. Ind. Hygiene, September, 1924.

[55] Tattersall, Norman, M. D.: The Occurrence and Clinical Manifestations of Silicosis Among Hard Ground Workers in Coal Mines. Jour. Ind. Hygiene, November, 1926.

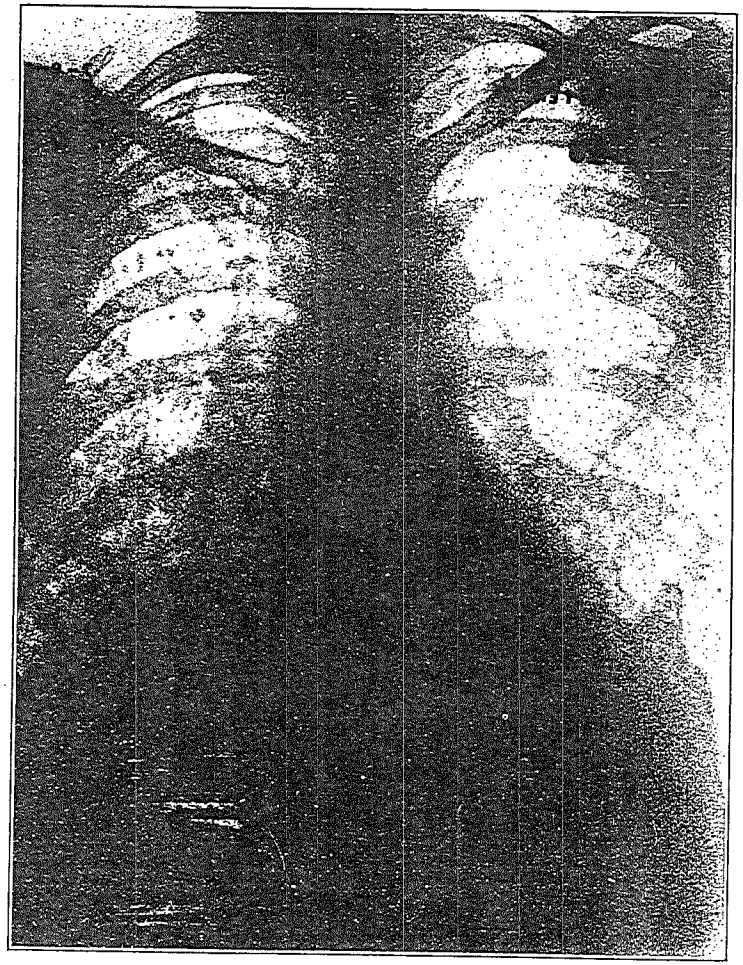


X ray 61.—Case 112. C. B. C., examined on September 29, 1924; Italian, aged 47 years; married

Granite cutter, hand pneumatic tool, for 26 years. Had cut marble for several years in Italy before coming to the United States. Salesman, four years. His health had generally been very good; habits good.

At the time of this examination the patient complained of dyspnœa, which was worse on exertion. He also had a slight cough, but made no reference to it.

Height, 63 inches; weight, 141 pounds; impaired vision in each eye, and a pterygium on left eye; impaired hearing; chronic rhinitis and pharyngitis; blood pressure, 126, systolic; chest expansion, 6 centimeters; chest showed evidence of silicosis.

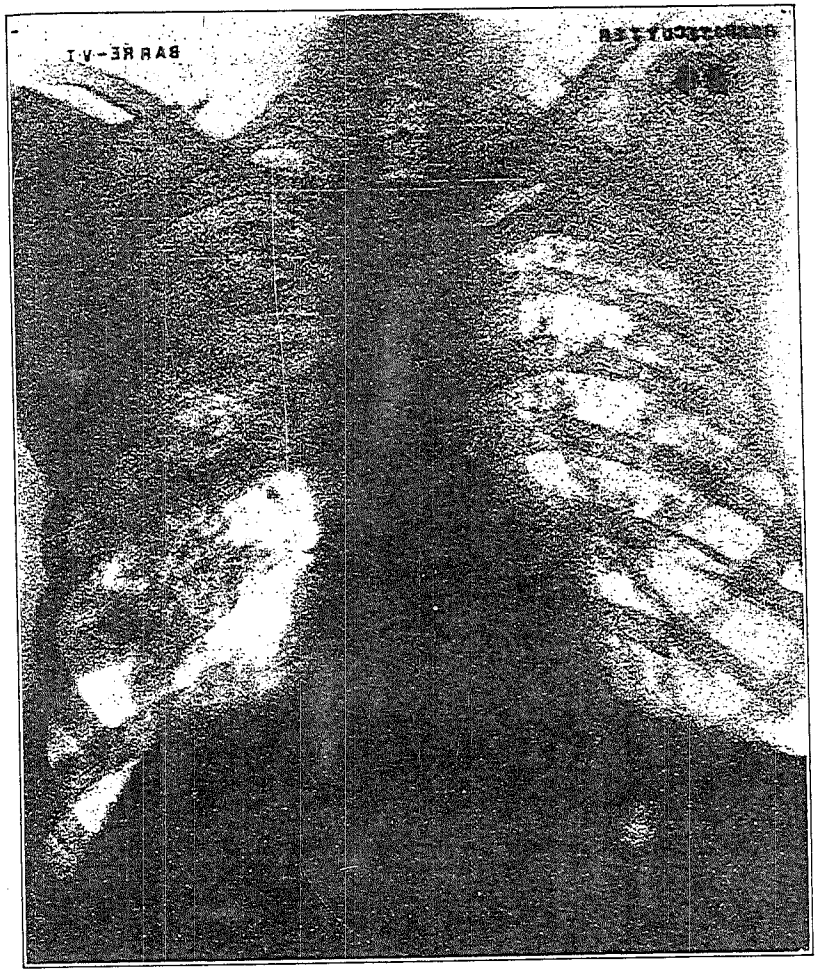


X ray 62.—Case 299. W. F., examined on June 30, 1925; American (Irish parentage), aged 64 years; married

Granite cutter with hand pneumatic tool for 26 years. Night watchman at hospital for the insane for the past 13 years. His health and habits had been good, but he had been dyspnœic for several years, and his dyspnœa had become more severe in the past two or three years. He also complained of cough and expectoration at night and in the morning, and of slight indigestion.

Examination: Height, 72 inches; weight, 184 pounds; impaired hearing; chronic rhinitis and pharyngitis; dental caries and pyorrhœa; systolic blood pressure, 160; vital capacity, 2,300 cubic centimeters: silicosis.

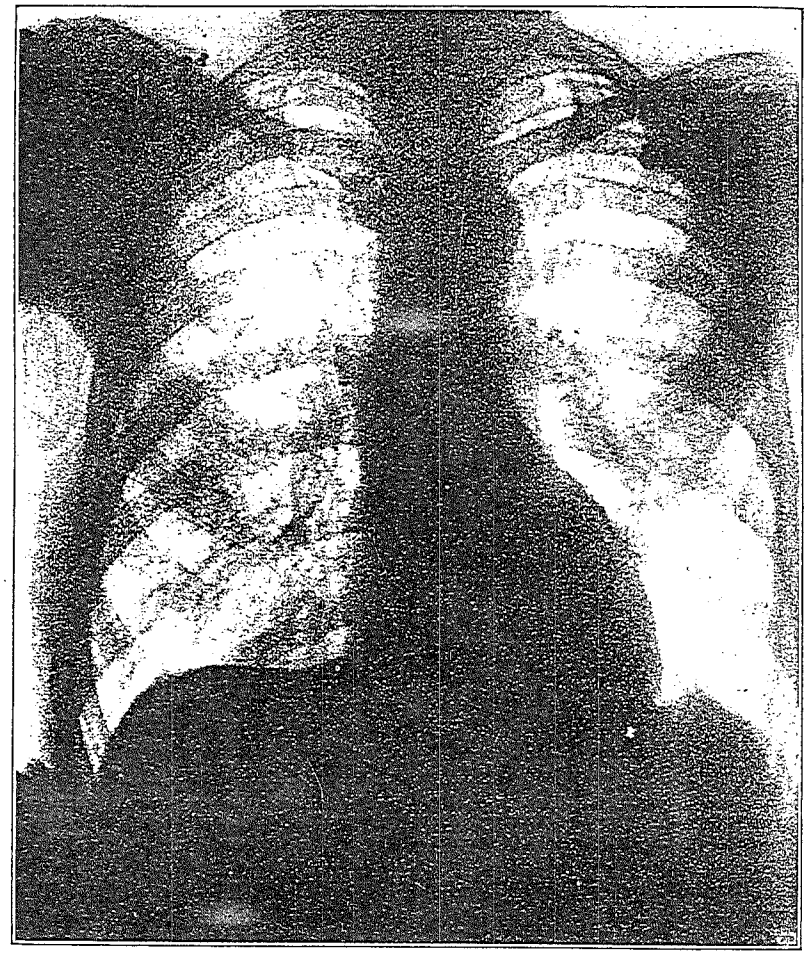
The patient was observed at intervals for over two years after this examination, and his condition remained about the same with the exception of an increase in dyspnœa.



X ray 63.—Case 18. C. A., examined May 25, 1924; Italian, aged 50 years; married

Granite cutter for 25 years, but had not worked at the trade for the 11 years preceding examination, during which time he had been living on a farm. His health had been good; habits very good. At the time of this examination he complained of dyspnœa and fatigue. He had been dyspnœic for several years, but his dyspnœa had not been of such severity as to incapacitate him. He did not cough nor expectorate, and ate and slept well. He was afraid of breaking down with tuberculosis. Anxiety constituted about as great a disability as any other of which he complained.

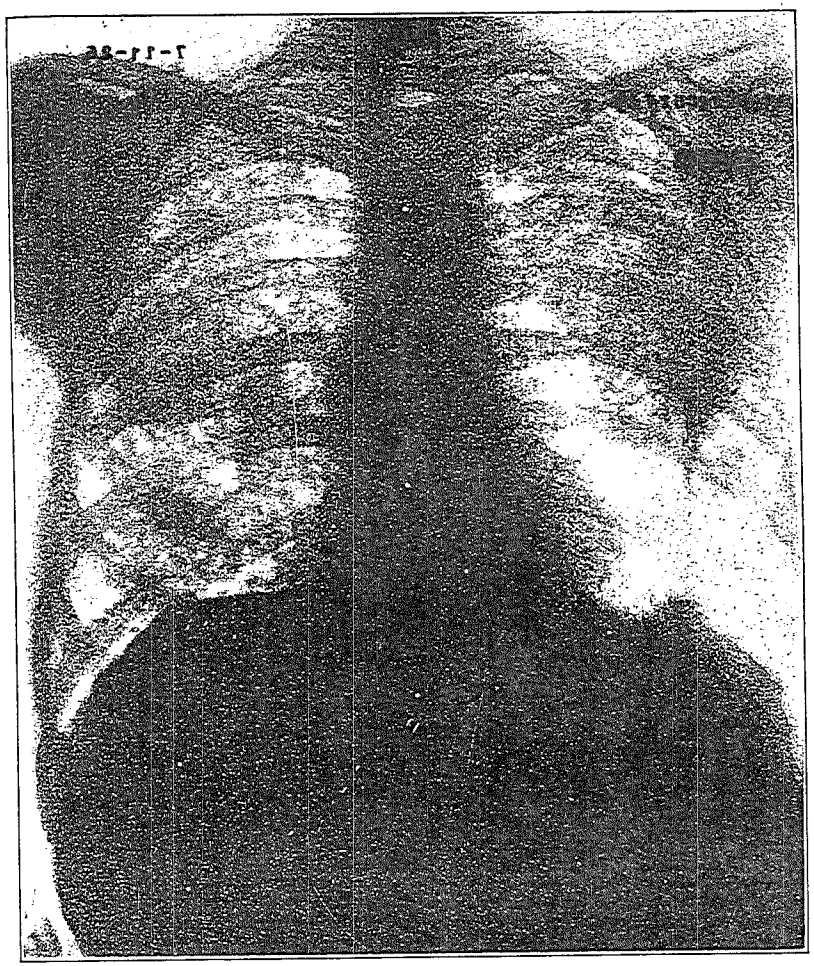
Examination: Height, 65 inches; weight, 160 pounds; impaired hearing; teeth badly worn; systolic blood pressure, 100; vital capacity, 3,100 cubic centimeters; abdominal hernia; advanced silicosis and suspected latent tuberculosis.



X ray 64.—Case 432. C. L. B., examined December 15, 1925; Scotch, aged 54 years; married

Granite cutter with hand pneumatic tool for 25 years; janitor and fireman for the five years preceding this examination. Complaint at time of examination: Dyspnœa and cough.

Examination: Impaired hearing, chronic pharyngitis, chronic arthritis; systolic blood pressure, 170; vital capacity, 2,800 cubic centimeters; silicosis.



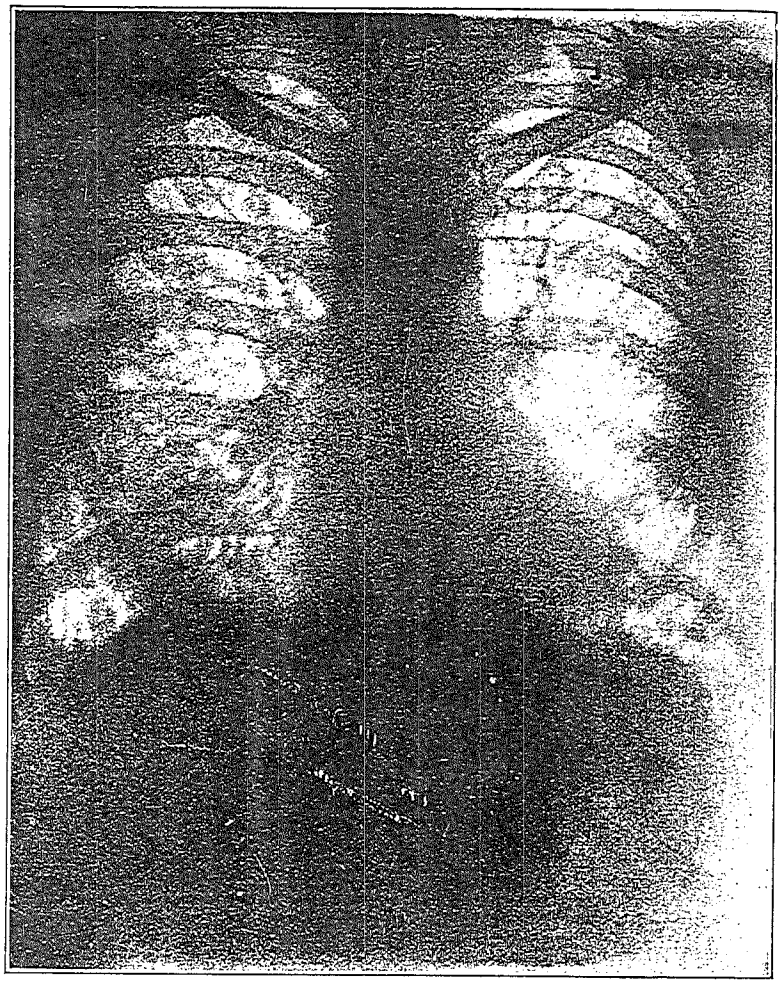
X ray 65.—Case 309. N. V., examined on July 10, 1925; English, aged 51 years; married

Granite cutter for 28 years but for three years just prior to this examination he had been working as a janitor at a school building. He had had appendicitis and an operation for it 20 years before, and influenza in 1918, and he had not felt well since.

Complaint when examined: Severe dyspnœa, which almost entirely incapacitated him at times; occasional pains in chest; severe cough during the winter months; slight expectoration.

Examination: Height, 66 inches; weight, 148 pounds; dental caries and pyorrhœa; chronic pharyngitis; systolic blood pressure, 128; chest expansion, 3.5 centimeters; vital capacity, 1,800 cubic centimeters; advanced silicosis.

Patient died of silicosis and tuberculosis three years after examination.



X ray 66.—Case 296. J. E., Scotch, aged 46 years; married

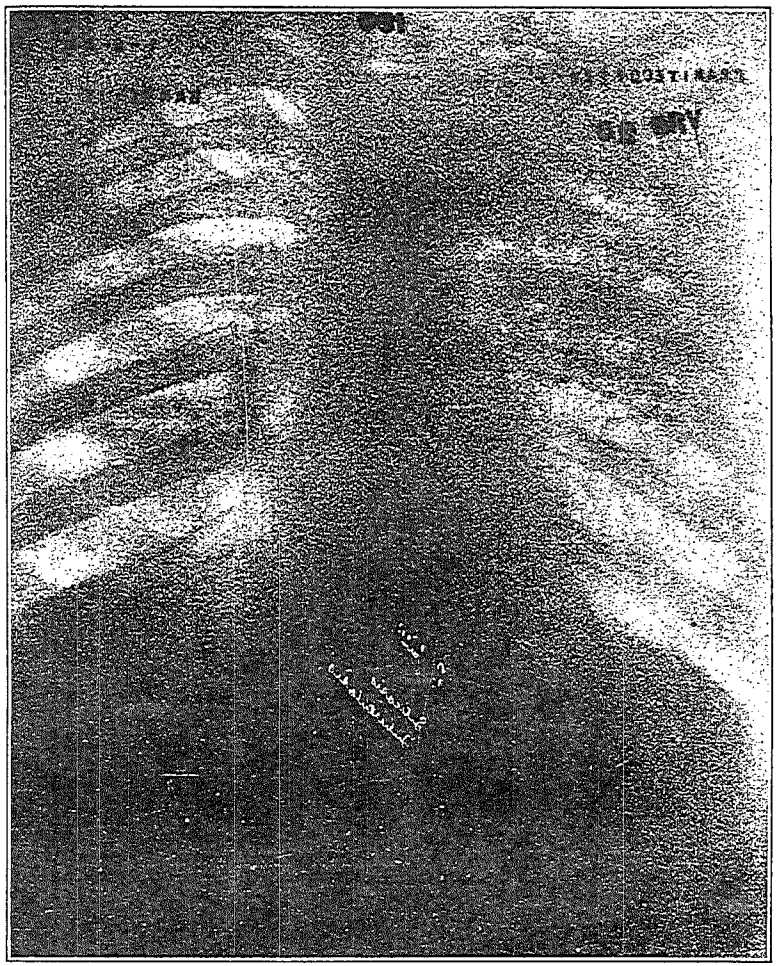
Granite cutter with hand pneumatic tool for 12 years. Foreman for 5 years, and superintendent of a granite plant for 10 years. The last occupation was not in a dusty atmosphere. Father was a granite cutter and died of tuberculosis. Patient had his left foot amputated, the result of an industrial accident. He had influenza in 1918, and had good health otherwise.

Complaints at time of examination: Cough and expectoration; loss of weight; hemoptysis; pleurisy pains; and frequent colds which seemed to persist.

Examination: Height, 68 inches; weight, 154 pounds; chronic pharyngitis; systolic blood pressure, 160; vital capacity, 2,500 cubic centimeters; silicosis and tuberculosis; tuberculous lesion in the base of the right lung.

Subsequent to this examination the patient had severe pulmonary hemorrhages.

Patient died.

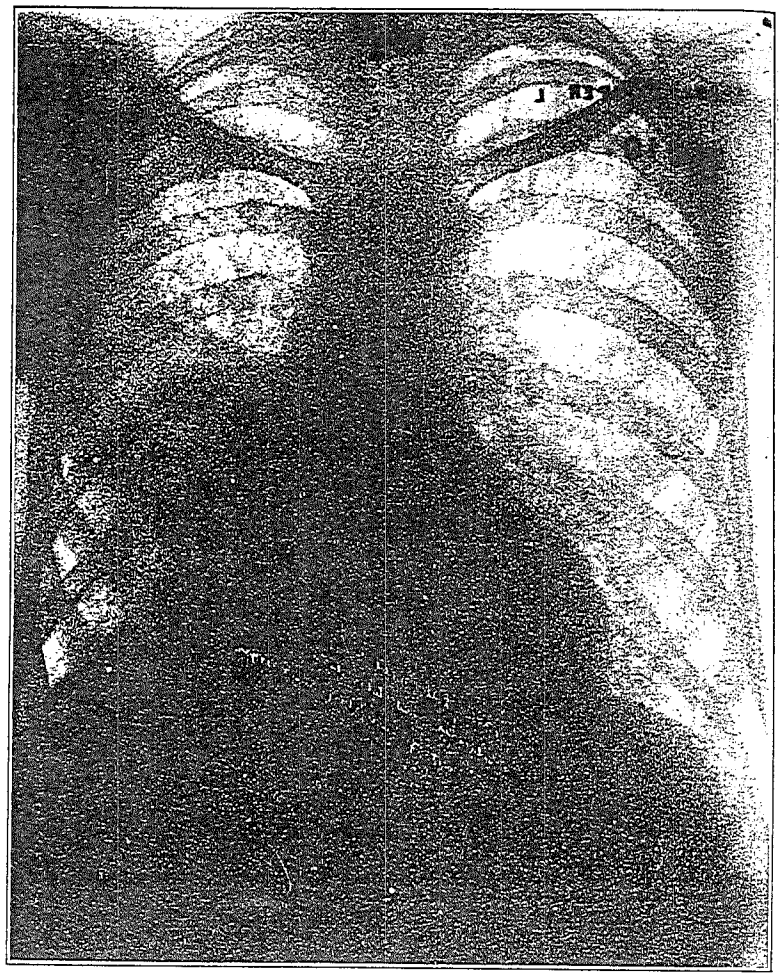


X ray 67.—Case 443. B. G., examined on January 8, 1926; Italian

Street cleaner 6 years, granite cutter with hand pneumatic tool previously for 23 years.

Examination: Height, 68 inches; weight, 162 pounds; blindness right eye; dental caries; pyorrhœa; chronic rhino-pharyngitis; systolic blood pressure, 130; vital capacity, 3,500 cubic centimeters; silicosis and tuberculosis; sputum contained tubercle bacilli.

Patient died July 26, 1926.

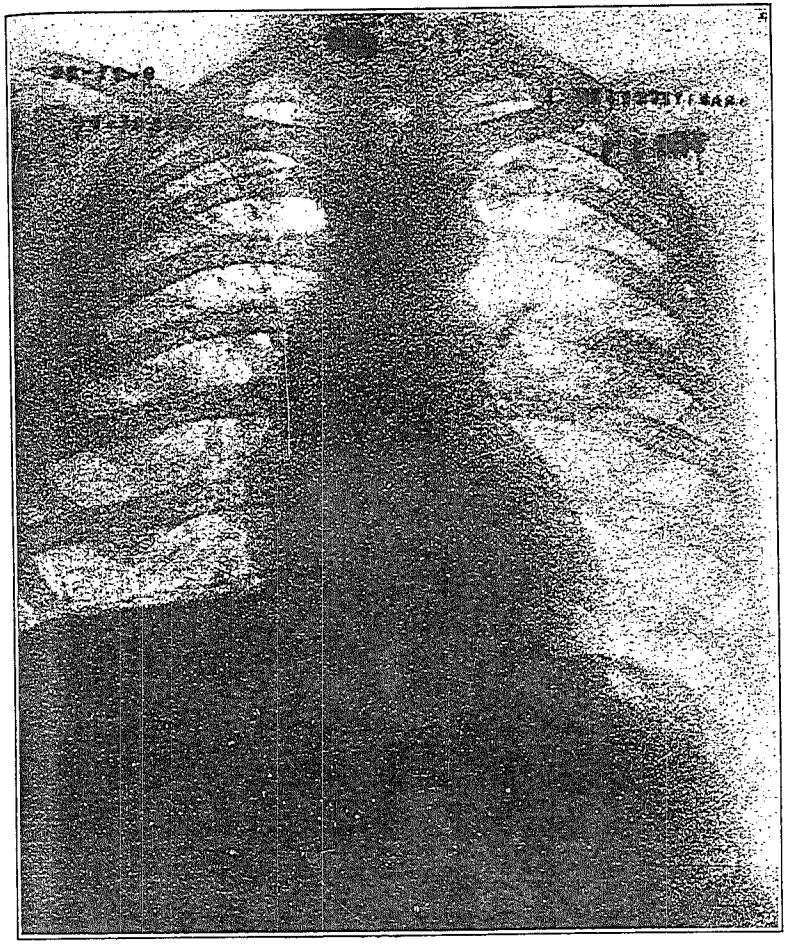


X ray 68.—Case 339. L. H., examined on July 28, 1925; American, aged 55 years; married

Granite cutter for 17 years. Then he spent 15 years on a farm and returned to his old trade of stone cutting about a year prior to this examination.

Patient had pneumonia 16 years ago, and a slow convalescence. He changed occupations and enjoyed good health excepting that he had influenza during the 1918 epidemic. Patient complained of dyspnœa; his respiratory rate was 36 per minute five minutes after he had climbed one flight of stairs. At the end of the examination, the respiratory rate was 18 per minute. He also complained of cough and expectoration, pains in chest, and fatigue.

Examination: Height, 72 inches; weight, 125 pounds (patient is of large stature); chronic rhinitis and pharyngitis; systolic blood pressure, 130; vital capacity, 2,300 cubic centimeters; silicosis and early tuberculosis.

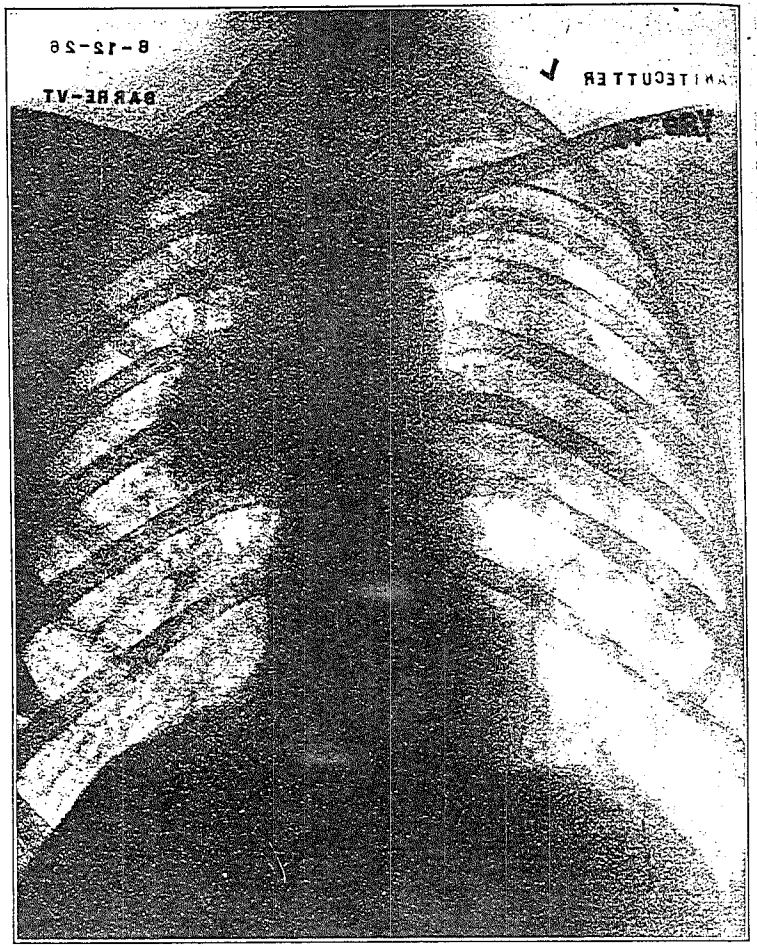


X ray 69.—Case 387. A. C., Italian, aged 42 years; married

Granite cutter with a hand pneumatic tool for 14 years; he had not worked at his trade for four years prior to this examination.

Complaints at time of examination: Cough and expectoration, pains in chest, fever, night sweats, and hoarseness. Anxiety over his condition.

Examination: Height, 63 inches; weight, 153 pounds; chronic rhinitis and pharyngitis; silicosis and tuberculosis; sputum contained tubercle bacilli.



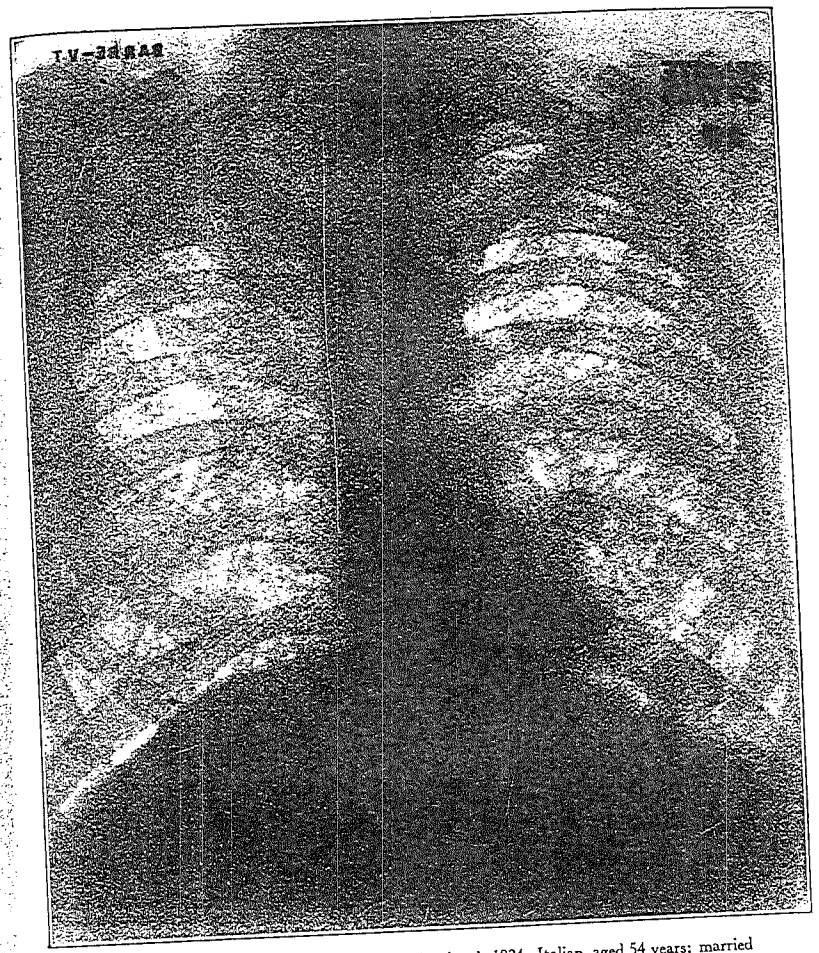
X ray 70.—Case 322. W. C., examined on July 21, 1925; Scotch, aged 45 years; divorced

Granite cutter for 10 years, but had not been cutting granite for the 10 years preceding examination and had not been exposed to granite dust during that period. He had had pneumonia in 1911 and was ill for three weeks; he was ill with this disease again in 1924, and again made a good recovery. Health had been good otherwise. He had used alcoholics excessively for the preceding five years and had kept irregular hours. Illness at the time of this examination began several months ago with dyspnœa, tired feeling, and a cough. He had several pulmonary hemorrhages last January and had hemoptysis at several intervals since that time. He had also lost weight, and was having night sweats, pains in chest, and an increase of dyspnœa.

Examination: Height, 66 inches; weight, 143 pounds; dental caries and pyorrhœa; systolic blood pressure, 112; vital capacity, 3,600 cubic centimeters; left inguinal hernia; silicosis and tuberculosis; sputum contained tubercle bacilli.

August, 1927, he was very emaciated, with all the outward appearances of a far advanced case of tuberculosis.

Patient died December, 1927.



X ray 71.—Case 117. J. C., examined on October 1, 1924; Italian, aged 54 years; married

He had cut granite for 20 years, using a hand pneumatic tool, and had cut marble in Italy for four years before coming to this country. He had not cut granite for the eight years just prior to the examination, having become a manufacturer. His father died at the age of 70, his death resulting from an accident; his mother died at the age of 78, of asthma and complications. The patient had usually enjoyed very good health; he had no history of any serious illnesses.

His recent illness began about two years before the examination, with a chronic throat condition; and on consulting a physician, he was referred to a chest specialist for examination. At that time he had a productive cough, pains in chest, dyspnœa, and loss of weight and strength, and occasionally expectorated blood. These symptoms had gradually become worse; and he was troubled in addition, with night sweats, hemorrhages from the lungs, and severe dyspnœa.

Examination: Height, 68 inches; weight, 176 pounds; impaired hearing; chronic rhinitis and pharyngitis; blood pressure, 142, systolic; chest expansion, 4 centimeters; inguinal hernia; chest showed evidence of an advanced tuberculosis, with cavitation in the upper right lobe, superimposed on a generalized silicosis; sputum contained tubercle bacilli.

The patient's condition gradually declined; he had several severe pulmonary hemorrhages, and died on September 21, 1926.

RESULTS

An attempt has been made to summarize briefly the more important data in the case histories in the following table.

TABLE 69.—*Summary of cutters, groups A and B, previously exposed to granite dust, but later employed in nondusty trades*

Case No.	Age	Years in granite	Occupation since leaving granite	Years in such occupation	Comment
112	47	26	Salesman	4	Silicosis.
299	64	26	Night watchman	13	Do.
18	50	25	Employed on farm	11	Advanced silicosis and suspected latent tuberculosis.
432	54	25	Janitor and fireman	5	Silicosis.
309	51	28	Janitor	3	Advanced silicosis and tuberculosis.[2]
296	46	17	Superintendent	10	Silicosis and tuberculosis.[2]
443	49	23	Street cleaner	6	Do.[2]
339	55	[1]18	Employed on farm	15	Silicosis and early tuberculosis.
387	42	14	Secretary	4	Silicosis and tuberculosis.
322	45	10	Salesman	10	Silicosis and advanced tuberculosis.[2]
117	54	20	Manufacturer	8	Do.[2]
540	51	28	Shipping clerk	6	Silicosis and tuberculosis.[2]
58	52	14	Farmer	20	Silicosis and extensive tuberculosis in both lungs.[2]
132	52	21	Chauffeur	7	Silicosis and tuberculosis.[2]
289	60	39	City clerk	4	Do.[2]
42	45	27	Insurance agent	4	Silicosis and tuberculous pneumonia.[2]
440	43	26	Farmer	3	Silicosis and tuberculosis.[2]
379	62	12	....do	20+	Do.[2]

[1] Total years in granite. Returned to industry 1 year before examination.
[2] Died of silicosis and tuberculosis.

The examining physician after considering the patients' histories, consulting their physicians, and studying the cases, was of the opinion that they had grown progressively worse in a similar manner as had the cases who remained in the industry.

CASE HISTORIES AND X RAYS

The following are cases of latent silicosis and tuberculosis. Tuberculosis in these cases was not different from that in other granite cutters who had been in the industry a number of years.

Case No. 339 left the industry and lived on a farm in Oregon for 15 years. He was very dyspnoeic for several years. He returned to the East and again took up his old trade. With the silicosis already existing, he was unable to make an adjustment to working again in a dusty atmosphere, consequently he was ill for a greater part of the year which he had tried to spend in the industry just prior to this examination.

CASE HISTORIES WITHOUT X RAYS

Case No. 540.—F. G.: American, aged 51 years; married.

Granite cutter with hand pneumatic tool for 15 years. Foreman in a granite plant 12 years and superintendent for 1 year; shipping clerk in an implement factory for 6 years prior to this examination.

Patient had typhoid fever at age 20 and had malaria during the Spanish-American War. Health had been good otherwise. Had been dyspnoeic for several years prior to this examination. In February, 1926, he had influenza and has not been well since that time. At time of this examination he complained of severe dyspnoea, cough and expectoration, loss of weight, fatigue, pains in chest, and hoarseness.

Examination: Height, 67 inches; weight, 185 pounds; impaired hearing, chronic rhinitis and pharyngitis; systolic blood pressure, 100; silicosis and tuberculosis; varicose veins in right leg.

Patient died.

Case No. 58.—D. R.: Examined August 7, 1924; American, aged 52 years; married.

Farmer for 20 years; previously he had cut granite with hand pneumatic tool for 14 years. No history of tuberculosis in family. Health and habits have been good.

Four years previous to this examination patient began to have dyspnoea, fatigue, cough, and expectoration, and later he had loss of weight and strength, pains in chest, night sweats, and fever. These symptoms have persisted and become augmented and at present the patient presents the picture of a case of advanced tuberculosis.

Examination: Height, 69 inches; weight, 120 pounds; silicosis and extensive tuberculosis in both lungs.

Patient died May 27, 1925.

This case is interesting because of the fact that he was not intimately exposed to tuberculosis, and had been out of the granite industry and developed the disease at about 50 years of age.

Case No. 132.—L. R.: Examined November 26, 1924; Italian, aged 52 years; married.

Patient has been a chauffeur for about seven years. He cut granite for 21 years previously, and had cut marble a few years before coming to the United States.

Patient's health had been good except for an occasional attack of rheumatism. He had not been well for about two years previous to this examination. At time of examination he complained of cough and expectoration, dyspnoea, loss of weight, weakness, fever and night sweats, pains in chest.

Examination: Height, 64 inches; weight, 104 pounds; impaired hearing and vision, dental caries and pyorrhoea, systolic blood pressure, 150; vital capacity, 300 cubic centimeters (questionable as to whether this low value really represents the man's actual vital capacity); congenital ichthyosis, silicosis, and tuberculosis.

Patient died May 25, 1925.

Case No. 289.—J. S.: Examined June 27, 1925; Scotch, aged 60 years; married.

Granite cutter for 39 years, but has not worked at this trade for the past 4 years. Health and habits have been good.

Patient has been very dyspnoeic for several years, but for the three years previous to this examination he has been greatly incapacitated on this account, being unable to walk a block without stopping to rest. When met on the street he was unable to speak until he had rested. At time of examination patient also complained of pains in chest, weakness, fatigue, cough and expectoration, and insomnia.

Examination (at patient's home): Partial deafness, loss of teeth, silicosis, and tuberculosis. Tuberculous lesion in the base of the right lung.

Patient died August 25, 1925.

Case No. 42.—J. B.: Examined July 15, 1924; Italian, aged 45 years; married.

Granite cutter for 27 years, using hand pneumatic tool; insurance agent for past 4 years. Health and habits have been good.

Illness began in January, 1924, following an attack of influenza; he had blood-streaked sputum, dyspnœa, cough and expectoration, indigestion, and pains in chest. He went to a sanatorium for tuberculosis and remained several months. While home on leave he developed a severe pleurisy, had fever, and became quite ill.

Examination: Impaired hearing, dental caries, pleural friction rub, silicosis, and tuberculous pneumonia.

Patient died July 24, 1924.

Case No. 440.—W. D.: Examined January 7, 1926; Scotch, aged 43 years; married.

Farmer for 3 years; previously a granite cutter for 26 years. Health has been good.

Patient complained of pains in chest, cough and expectoration, loss of weight, fatigue, fever and night sweats, and dyspnoea.

Examination: Height, 68 inches; weight, 130 pounds; impaired hearing, chronic rhinitis and pharyngitis, silicosis and tuberculosis. Cavitation in the right apex. Sputum contained tubercle bacilli.

Patient died June 6, 1926.

Case No. 379.—P. K.: American (Irish parents), aged 62 years; widower.

Patient cut granite for 12 years but had subsequently worked on a farm for over 20 years. Health and habits had been good.

Complaints at time of examination: Cough and expectoration, loss of weight, fatigue, severe dyspnoea, and fever in afternoons.

Examination: Silicosis and tuberculosis. Sputum contained tubercle bacilli.

Patient died of tuberculosis May 19, 1926.

IX. HISTORY OF TUBERCULOSIS AMONG MEMBERS OF GRANITE CUTTERS' FAMILIES

The question of the contagiousness of "granite cutters' consumption" has been raised from time to time by various investigators. The study of the cases of tuberculosis in members of the granite cutters' families in the present survey has been approached from two angles—first, study of the nature of the tuberculosis which developed among certain male members of the family who have entered the granite-cutting industry after intimate contact with cases of tuberculosis among granite cutters in the same family (see p. 129); and, second, tuberculosis among members of the family who were too young to have trades or who worked in dust-free occupations.

In the discussion of the latter cases there are several points which should be borne in mind: First is the fact that granite cutters make good wages, have comfortable homes, and, as a rule, wholesome food. They are above the average industrial worker in habits and hygienic living, all of which are conducive to a lower incidence of tuberculosis. We might expect a lower incidence in the family since, as a rule, cutters do not develop tuberculosis at an age when contact with their children is intimate. It is not presumed that the few cases which are given here will settle the question of the contagiousness of the granite cutters' consumption either in a positive or negative way, as it has not been possible in this study to determine the incidence of tuberculosis among the granite cutters' families compared to families in other occupational groups of a similar social status. All the cases recorded in this section, however, were in households where a granite cutter lived or had lived who had a definite case of tuberculosis.

Case No. 390.—M. R.: Examined on March 18, 1925. American, female, aged 22 years; single.

Her father was a granite cutter and died of tuberculosis at the age of 48. Her brother has pulmonary tuberculosis. The patient has tuberculous peritonitis and a quiescent tuberculous condition of the lungs.

Case No. 529.—M. B.: Examined on August 9, 1926. American (parents, Austrian), aged 10 years; single.

His father was a granite cutter and had tuberculosis (sputum positive); and was one of the cases observed in the study. The patient has early pulmonary tuberculosis and tuberculous peritonitis.

Case No. 530.—L. C.: Examined on August 12, 1926. American (Italian parentage), female, aged 8 years; schoolgirl.

Diagnosis: Tuberculous meningitis. The patient died after 10 days' illness.

This girl was the niece of V. P., Case No. 465, who resided at her home while he was ill with tuberculosis and silicosis.

Case No. 537.—I. R.: Examined on July 15, 1926. American (Italian parents), female, aged 26 years; single.

Her father was a granite cutter and died of tuberculosis at the age of 50. Her stepfather also died of this same disease. The patient had had tuberculosis for several years and had been treated in the State sanatorium. Activity of the disease was questionable at the time of this examination.

Case No. 391.—P. P.: Examined on March 15, 1925. American (Italian parents), aged 30 years; widower.

His father was a granite cutter and died of tuberculosis.

The patient had advanced tuberculosis, a pneumothorax and tuberculous laryngitis.

He died a few weeks after this examination.

Case No. 514.—J. R.: Examined on June 7, 1926. American (Italian parents), aged 17 years; schoolboy.

His father was a granite cutter, and died of pulmonary tuberculosis and silicosis. His mother is living and well. The patient has tuberculous peritonitis.

Case No. 392.—F. B.: Examined on September 16, 1924. American, female, aged 19 years; telephone operator. Her father was a granite cutter, and died of tuberculosis.

The patient had pulmonary tuberculosis, and died six months after examination.

Case No. 538.—E. G.: Examined on April 1, 1926. American (Italian parentage), female, aged 17 years; single.

Her father was a granite cutter, and died of tuberculosis while the study was in progress. The patient presented positive evidence of a latent tuberculous lesion in the apex of the right lung.

X. A PATHOLOGICAL STUDY OF EIGHT LUNGS FROM EMPLOYEES IN THE GRANITE INDUSTRY

By LEROY U. GARDNER, M. D.
Director and Pathologist

Saranac laboratory for the study of tuberculosis, Saranac Lake, N. Y.

It was difficult to obtain permission to perform autopsies on granite cutters, as the place where the study was made was a small city and the people were quite unaccustomed to such procedures. During the course of this study Doctor Russell was able to perform six autopsies, this being made possible through the courtesy of Dr. William McFarland, Dr. J. H. Woodruff, and Dr. R. E. Avery. Dr. D. C. Jarvis permitted the use of three[56] specimens he had had for some time, and Doctors Whitney and Kent, of the State board of health, gave one specimen.

Physical examinations were made on three of these cases before death and the reports are included herein.

Of these cases death resulted from a combination of tuberculosis and silicosis in 5 instances; from suicidal drowning in 2 cases; from a tumor (lymphoblastoma) in 1; and from broncho-pneumonia in 1 (the excluded case). The known ages of the silicotic and tuberculous cases varied from 41 to 63 years. The duration of exposure to granite dust as far as was known varied from 9 to 28 years, but no history was obtained in one instance. Some degree of silicosis was found in 7 of the 8 cases considered; it was very early in 1, moderately advanced in 3, and far advanced in 3.

There follow the protocols of the gross and microscopic examinations of these lungs.

CASE 452

HISTORY

Age, 22; American, English stock. Occupation, granite cutter (apprentice), using hand pneumatic tool for two and one-half years.

Paternal grandmother died of cancer. Father and mother living and well; also three brothers living and well.

Patient at 1 year of age had adenitis of the cervical lymph glands and they drained for about one year. He also had influenza in 1918 (age 15) and was severely ill. He had erysipelas in the region

[56] One of which was finally discarded.

of the right eye in May, 1921. Patient also complained of rheumatism a year ago and consulted a physician, who treated him for tonsillitis with radium.

Patient's final illness began about November 15, 1925, with a swelling of cervical glands on left side. He consulted a physician, who gave him treatments and the swelling subsided. In about two weeks a similar condition appeared on the right side of the neck and the same treatment was ineffective. About this time he had a gastrointestinal disturbance, which soon subsided. The lymph glands continued to enlarge and were painful. Patient was admitted to the hospital January 8, 1926. While in the hospital his temperatures, pulse, and respirations were as follows:

1926	Temperature	Pulse	Respiration	1926	Temperature	Pulse	Respiration
Jan. 8 (on admission), 4 p. m.	96	80	16	Jan. 9, 4 p. m.	98. 6	100	24
Jan. 8, 8 p. m.	98. 6	90	16	Jan. 9, 9 p. m.	100. 2	100	26
Jan. 9, 4 a. m.	99. 4	116	24	Jan. 10, 4 a. m.	99	104	26
Jan. 9, 12 noon	100	90	16	Jan. 10, 8 a. m.	98. 6	90	22
				Jan. 10, 4 p. m.	98	84	24

Operation for removal of enlarged glands was advised and patient refused, and left hospital of his own accord January 10.

On January 13 he changed physicians. He stated he had lost 25 pounds since the onset of his illness and complained of pain around the mastoid process and the lateral portion of the neck on the right side. He also complained of a slight indigestion.

Blood count, January 13, 1926: Hemoglobin, 90 to 100 per cent. Red blood cells, 4,600,000. White blood cells, 8,600. Wassermann negative.

Treatment: Application of radium to the swollen areas January 15, 1926.

January 26, 1926, was examined in consultation by Doctor Russell. History very much the same as previously mentioned and, in addition, patient complained of a slight cough and expectoration of a frothy mucus. He also complained of difficulty in breathing (due to pressure from the swollen areas of the neck). There were a few coarse râles due, perhaps, to mucus in the bronchi, as they cleared when patient coughed.

January 29 patient changed physicians again. This physician stated his findings very much as given above.

February 2, 1926, patient seen in consultation. He was very dyspnœic and weak; marked pallor; cough, and expectoration. There was marked anxiety and much pain.

Patient died February 3, 1926, at 4.30 a. m.

GROSS FINDINGS

Autopsy performed at 6 a. m. Patient was well developed and nourished; no deformities; age about 22. There was marked swelling in the right side of the neck and in the right axilla, and the tissues at these places were greatly indurated. Incision made in the right side of the neck and in the right axilla, and a few lymph glands and a few pieces of tissue were removed from each incision.

On opening the chest the lungs did not collapse, as they were adherent throughout. The adhesions were comparatively easy to break up, and there were two small tumors on the visceral layer of the pleura on the right side which were about the sizes of 50-cent and 25-cent pieces. The right lung was removed from the chest. The pleural adhesions were broken up on the left side, and a portion of the lower lobe was removed. The adhesions were densest on the right side and on the mediasternal and apical portions of both lungs. The tumors located on the visceral layer were apparently metastatic and were not adherent to the parietal layer. The character of the pleural adhesions was such as to indicate that they had existed prior to the onset of the final illness and may represent the inflammatory condition which takes place prior to or coincident with the beginning of a silicotic condition.

A portion of the liver was removed in order to determine if there were metastases present. The family would not give consent for a complete autopsy, and in such instance it was not possible to obtain complete specimens.

MICROSCOPIC FINDINGS

Lung.—The dominant feature is tumor. There is no evidence of tuberculosis and silicosis has not developed.

The pleura and the interlobular septa are thickened by fibrosis and adhesions on the surface of the former. Distending the veins and lymphatics are masses of tumor cells, which in many instances have invaded the connective tissue about them. Likewise the submucosa of the large bronchi and trachea are diffusely infiltrated with tumor. The air spaces are not specifically involved but show an accumulation of oedema fluid and mononuclear phagocytes.

Beneath the pleura, particularly at its junction with the interlobular septa, in the septa, and in the adventitia of some of the bronchi are small, irregular collections of green-black dust contained in elongated and compressed phagocytes. In the alveoli and lymphatics are occasional dust-containing cells.

The tumor cells are of the lymphoid series and show very numerous mitotic figures.

Tracheobronchial lymph nodes.—The tracheabronchial lymph nodes are largely replaced by tumor cells. In and about the afferent and efferent lymphatic vessels are large clusters of tumor cells. In the mediasternal tissues are also many perivascular tumor masses. The nodes show no evidence of tubercle, but there are large masses of dust in the medullary regions. This dust has provoked or is surrounded by a rather dense fibrosis.

Liver.—Not remarkable.

Diagnosis.—Rapidly growing lymphblastoma. No evidence of silicosis.

CASE A–25–25

GROSS FINDINGS

The specimen consists of the heart and lungs from a Scotchman, aged 41, single, who had cut granite since 1893 until his death, June 12, 1921. His height and weight were estimated at 70 inches tall and 175 pounds. His health was considered generally good. He was athletically inclined and did some amateur boxing. He worked cutting building stone at Bethel, Vt., in a granite which is different from the Barre granite. He died in Barre by drowning in the river, presumably while intoxicated. He was autopsied by Doctor Whitney, of the Vermont State Board of Health.

Lungs.—The pleural surface is smooth and free from adhesions. It is mottled with coarse deposits of black pigment and in addition there are occasional, small, slightly elevated yellow white nodules arranged often in clumps, which are found chiefly in the middle and lower parts of the organ. Crepitation is freely obtained in all portions.

On section no nodular lesions are visible, except for the areas noted on the pleural surface, which involve the outer 2 millimeters in the lung in some places. At various points are small soft foci of gray-black pigmentation, which exhibit no evidence of fibrosis. The interlobular septa are very prominent and may be slightly thickened.

There is no evidence of tuberculosis.

Tracheobronchial lymph nodes.—The tracheobronchial lymph nodes are very slightly enlarged. They are loosely embedded in the surrounding areolar tissue. Their peripheral portions are generally light gray and their central portions black with mottling of light gray. No calcified foci are detected.

MICROSCOPIC EXAMINATION

Lung.—The tissue is generally œdematous and congested (drowning?).

The pleura is everywhere thickened, but one section shows a localized group of nodular hyaline fibroses. The thickening is fibrous

in character, with many well-formed vessels. The reaction extends outward and does not encroach upon the pulmonary parenchyma. The nodular lesions vary in type; some are very cellular and vascular, while others are composed of contracted hyaline fibers without vessels. Dust is more abundant in the former type.

In the lung the septa and adjacent alveolar walls are thickened by fibrosis and contain heavy dust deposits. Similar changes of less marked degree are encountered in the adventitia of blood vessels and to a slight degree in that of the bronchi. In various alveoli are considerable collections of phagocytes packed with brown dust particles. There is no noticeable reaction in adjacent alveolar walls.

Lymphoid hyperplasia is not prominent, but the nodules at the junction of the pleura and interlobular septa are noticeably increased in size. Lymphatics, while not prominent, can be detected at various points along the trunks.

Tracheobronchial lymph nodes.—The tracheobronchial lymph nodes are enlarged and show many circumscribed hyaline fibrous foci. The nodes are by no means completely destroyed; they contain much normal lymphoid tissue. About and between them are patches of dust-filled cellular connective tissue. The marginal sinus of the nodes is in many places obliterated, and there is a peripheral rim of fibrous tissue. Much dust is deposited in the rim, and there is some in the surrounding areolar tissues. Dust deposits are heavy in the more central areas; where there is considerable nonhyaline fibrous reaction; mediasternal dilated lymphatics are prominent.

Diagnosis.—Silicosis, incipient.

CASE A–21–7

GROSS FINDINGS

Right lung.—The entire surface is covered with very thick, dense, leathery pleura. At the apex is a large cavity situated laterally beneath the pleura measuring roughly 8 by 4 by 3 centimeters in diameter. It has destroyed the outer third of the upper lobe. The remaining portions of this lobe show dense fibrosis deeply pigmented by dust. The fibrous tissue is arranged in whorls often surrounding a central collapsed trunk. In it are a few flecks of caseous matter not over 4 millimeters in greatest diameter.

The middle lobe presents large numbers of small caseous tubercles arranged in the cluster form characteristic of aspiration disease. About each tubercle is a ring of gray, pigmented scar tissue which in places has entirely replaced the original tubercle and formed a nodule 4 or 5 millimeters in diameter. The little intervening tissue left is dark red in color and shows emphysematous dilatation of the

air spaces. The lower lobe is similar to the middle, but both tubercles and nodules are much fewer in number and the emphysema is very well defined.

The interlobar fissures are still visible, but the lobes are partially attached by organized adhesions.

Left lung.—The upper portion of the upper lobe has been torn away in removing the lung from the thorax. This has left the inner wall of an old trabeculated cavity. The lower lobe is covered with thick shaggy pleura.

On section the upper lobe presents massive fibrosis deeply pigmented slate gray. The normal markings are obscured. Smooth rounded ends of the trabeculæ project into the lumen of the torn cavity.

The lower lobe presents larger caseous aspiration foci (5 to 8 millimeters in diameter), whose clustered arrangement is disturbed by the development of extensive fibrosis. The remaining parenchyma is emphysematous and the blood vessels are deeply injected. The interlobular septæ are thickened by fibrosis so that the division into lobules is very sharply defined.

Tracheobronchial lymph nodes.—These are greatly enlarged, measuring up to 2 centimeters in diameter. They present a well-defined, thick, fibrous capsule and an interior structure which is mottled and streaked by light gray bands of fibrous tissue on a deeper slate gray background. Some nodes show a deep black peripheral zone surrounding a lighter gray center. No evidence of calcification is detected.

MICROSCOPIC EXAMINATION

Lung.—Exhibits a mixture of chronic ulcerative tuberculosis and silicosis.

The tuberculous process consists in large caseous tubercles exhibiting only slight tendency to fibrous investment, and a more diffuse pneumonic process which varies in type from acute exudation to organization by fibrosis.

The caseous foci are large, with a marked tendency to softening and thrombosis. There is no calcification, and only an occasional one shows cumscribed fibrous encapsulation. The organizing pneumonic process is likewise unusual. A few areas of massive fibrosis are encountered whose detected can not be determined. These foci are of considerable extent types of outlines are irregular. They are composed of hyaline nondeposits fibrous tissue in which is considerable deposition of fine dust

Tracheo the lacunae between the fibers.

in places are and interlobular septa are strikingly thickened by dust filled p nding from them between the alveoli are finer bands of

fibrous tissue. Heavy deposits of dust occur in this fibrous tissue. There is also dust in scattered intra-alveolar phagocytes.

Lymphatics distended with inflammatory cells are very prominent in the pleura and peripheral ends of the septa. They can not be distinguished toward the hilum.

Tracheobronchial lymph nodes.—The tracheobronchial lymph nodes show three types of change. One small node shows little change except the deposition of an excessive amount of dust distributed from center to periphery. Often large nodes are largely destroyed by massive caseation. These also contain great quantities of dust. Finally there are some nodes entirely replaced by concentric whorls of noncellular hyaline fibrosis. In the lacunae between the fibers are considerable amounts of very fine dust.

In the mediasternal fat no lymphatics can be distinguished, but considerable dust deposition has occurred.

Diagnosis.—Silico-tuberculosis;[57] tuberculosis typical.

CASE 522

HISTORY

R. D'A., aged 51 years, Italian, single, granite cutter, surface machine operator (worked irregularly) for 20 years. Furniture maker in Italy for 22 years. Began work at the trade at age 9.

Father died at age of 72 apoplexy; mother died at 89 of the same cause.

Patient had influenza and pneumonia in 1918 and was ill for three months. According to the history obtained this man used alcoholics to excess, and was intoxicated on the evening he suicided. He did not work regularly. No history of symptoms of active tuberculosis could be obtained from his associates.

Patient suicided by drowning in the river July 5, 1926, at about 10 p. m. Autopsy performed at Barre, Vt., on July 7, 1926, by Doctors Whitney and Kent, of the State board of health.

Patient was fairly well nourished, of good physique, and there were no deformities.

There were no assymetries of the chest and the musculature good.

The lungs were free on the anterior surface, but were firmly herent on their lateral, posterior, and mediasternal surfaces adhesions were more dense on the right. The lungs were to remove from the chest, even after very free incision thoracic cavity.

[57] This is the terminology used in the South African studies and re type of silicosis seen in this study. Silico-tuberculosis corresponds rou current silicosis and tuberculosis" as used in the present bulletin.

Specimens were injected with 10 per cent formaldehyde and put away in this solution.

GROSS FINDINGS

Right lung.—Presents a dull slate-gray surface covered with tenuous but firm adhesions. Fissures are partially obliterated. On the left side only the lower lobe is present. The upper lobe has been torn away. There is a firm band adhesion on the lower lateral surface of the upper lobe.

Section of the right base shows a gray-red surface uniformly studded with discrete firm black nodules, whose average diameter is about 1 millimeter. The air spaces are emphysematous. Beneath the pleura, in the region of the above-mentioned adhesion, there is a zone of intensely black fibrosis about 2 millimeters in thickness. The trunks are thickened by fibrosis. The lymphoid tissues along the trunk bifurcations in the inner third of the lung are large and black in color.

Section of the left lung shows a similar picture except for more extensive and larger emphysematous dilatations of the air spaces, often occurring in clusters, and for the presence of stellate masses of pigmented scar tissue. The latter occur at the mesial ends of the two fissures, one in the upper lobe and one in the middle lobe. In addition there are irregularly spherical masses of more dense fibrous tissue in the posterior apex of the upper lobe. These collections of dense black scar tissue are traversed by gray-white bands of unpigmented scar.

In no place can anything resembling tubercle be detected.

Tracheobronchial lymph nodes.—Are enlarged; one measures 3.5 by 2 by 1.5 centimeter; firm in consistence, gray-black in color, and transversed by bands of white scar tissue. There is no evidence of tubercle formation except three minute pin points of calcification.

MICROSCOPIC EXAMINATION

Lungs.—Present diffuse nodular and peritrunkal fibrosis often of the hyaline type. The centers of a few of the nodules are calcified. These at least are presumably healed tubercle and many of the circumscribed nodules strongly suggest a similar origin. Nodules often lie embedded in diffuse fibrosis. No caseous or pneumonic foci can be detected. Heavy deposits of dust are found in all the different types of lesion; even in the calcified foci it appears included in the deposits of lime salts.

Tracheobronchial lymph nodes.—The marginal and central sinuses in places are difficult to distinguish because of the large numbers of dust filled phagocytes, and because of a rather extensive diffuse fib-

rosis. Some of the central sinuses are very greatly dilated. In addition, there are peripheral nodular fibroses, some cellular and others hyaline in character. There are numerous patches of calcification surrounded in some cases by fibrous tissue which are presumably healed tubercles. About the periphery of the node is a rather heavy band of fibrosis. The afferent lymph vessels are very widely dilated and are either empty or filled with lymphocytes. About them is a heavy wall of fibrosis which presents occasional deposits of dust filled phagocytes.

Diagnosis.—Tuberculo-silicosis; tuberculosis typical.

CASE 450

HISTORY

C. G.: Aged 58 years, French-Canadian, granite cutter for 26 years (hand pneumatic tool).

There is but little known of the final illness of this patient because he would not consult a physician. He had not been well for some time, was profoundly dyspnoeic and thought he had asthma. His wife stated that he never had asthmatic attacks, but was incapacitated because of shortness of breath. She wanted him to consult a physician about his illness but he refused, saying he preferred to take patent medicines.

He became acutely ill in the morning, and a physician was called to see him at 11 a. m. The physician found him extremely dyspnoeic and moribund. There were coarse râles and rhonchi throughout both lungs.

The patient died at 12.30 p. m. and autopsy was performed about 2 p. m. This patient was examined at a clinic in 1920 and at that time no evidence of tuberculosis was found.

Post-mortem examination.—Male, white, age about 55, height 65 inches, weight about 100 pounds.

He is fairly well developed but is emaciated. No deformities. Clavicles and ribs very prominent, lower parts of chest expanded as if emphysematous. There is dullness to flatness over the upper portions and hyperresonance over the expanded portions of the chest on both sides.

On opening the chest there were found massive adhesions, and it was very difficult to remove the thoracic contents. The adhesions were most dense in upper portions and on the mediasternal surfaces.

The lungs did not collapse when the chest was opened, and after their removal the imprint of the ribs was visible. The lungs had the appearance of bulging The right lung weighed 3 pounds and the left 2¾ pounds.

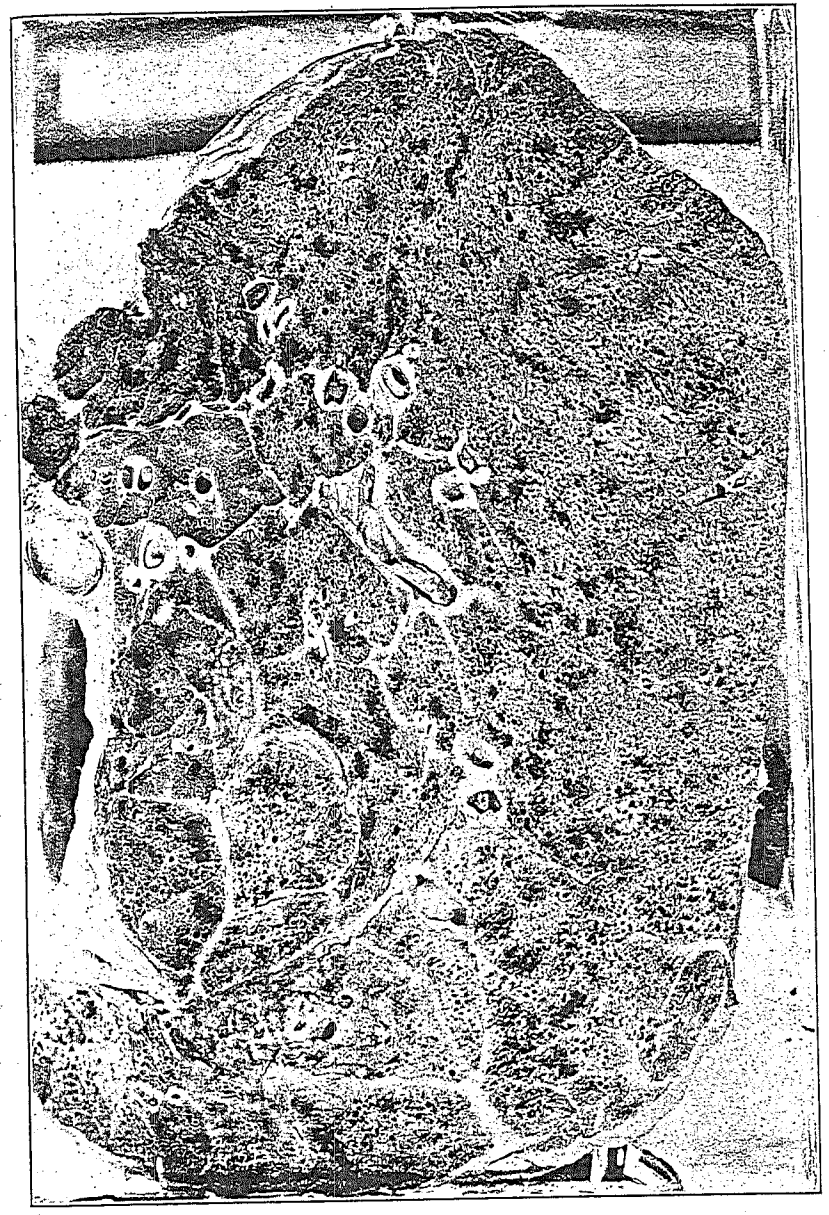


Plate 15.—Case 450. Lower lobe. Moderately advanced nodular silicosis. High grade emphysema. Section does not include the cavity



Plate 16.—Case 450. Upper lobe. Massive fibrosis and central cavity

An idea of the X-ray picture of this case in 1920 may be obtained by looking at that of Case 53 of the series of atypical cases (X-ray 19). The X rays in these two cases were quite similar.

GROSS FINDINGS

A single lung removed from a Barre granite cutter by Dr. A. E. Russell and received in 90 per cent denatured alcohol. Previous fixation in formaldehyde.

The surface of the lung is covered with dense white pleural adhesions. Numerous transverse incisions about 1 inch apart have been made across the lung from pleura to hilum. The upper lobe is extremely firm and hard while the lower is still crepitant, but contains palpable nodules.

Section of the upper lobe shows a generalized fibrosis pigmented a deep slate gray, but streaked with bands of lighter gray fibrous tissue. Closer examination shows that the fibrous tissue is made up of a series of closely packed nodules 4 to 5 millimeters in diameter, having more or less concentric or whorled arrangement. In the centers of some of the nodules are minute points of yellow necrosis. The lighter bands are apparently fibrosis in the interlobular septa and trunks. In the mid portion of the upper third of the lung is a slitlike cavity with irregular necrotic walls and no trabeculae.

Section of the lower lobe shows a markedly emphysematous parenchyma uniformly studded with irregular patches of gray-black pigmentation 3 to 5 millimeters in diameter. The interlobular septa are markedly thickened so that the secondary lobules are sharply defined.

The pigmented areas are somewhat firmer than the remainder of the lung and somewhat definitely nodular. A small strip immediately above the interlobar fissure is fibrous and similar in appearance to the lower lobe.

Tracheobronchial lymph nodes.—These are enlarged with sharply defined gray capsules, presenting a peripheral zone which is black and a central area mottled lighter gray and black. One node shows a point of calcification 1.5 by 1 millimeter in diameter.

MICROSCOPIC EXAMINATION

Lung.—The pleura is chronically thickened by noncellular scar tissue containing many large vessels. Heavy deposits of dust occcur in the compact lower layers adjacent to the lung. Extending downward from the surface the interlobular septa are extremely thick and often contain much dust. The lymphatics of the septa are greatly

dilated; their walls are thickened and sections near the pleura show these vessels surrounded by radial bands of muscle fibers. In the lumina of these vessels are great numbers of monocytes filled with dust and some lymphocytes. The lymphoid tissues have been largely destroyed, but here and there in scar tissue masses of lymphocytes without germinal centers which contain no dust are observed.

The parenchyma of the lung shows tremendous thickening of the alveolar walls in the more active stages—thickening due to infiltration with lymphocytes? (perhaps these are the nuclei of fibroblasts in cross section) and in the later stages by dense scar tissue which has completely obliterated the capillary loops. The epithelium of the alveoli is thick and cuboidal. The lumina are often compressed and are frequently packed with monocytes filled with black dust particles.

The blood vessels show a very heavy peri-arteritis which is so heavily infiltrated with dust that the character of the cells cannot be determined. In addition, various stages of endarteritis are encountered.

There are extensive areas of necrotic fibrous tissues with practically no nuclear staining. Occasionally a partially thrombosed small blood vessel and a small rim of living tissue about it is preserved. In elastic tissue stains, many more obliterated vessels can be distinguished at various points. Such stains in places also indicate the original position of alveolar walls and show that the fibrous tissue was sometimes laid down in loops within the air spaces, an arrangement characteristic of organizing pneumonia. Other areas show only diffuse fibrosis without preservation of elastic fibers. The bronchi show great thickening in the areolar coats and some deposition of dust, but not as severe as that about the vessels. The submucosa of the bronchi is greatly thickened by cellular granulation tissue. The lumina frequently contain purulent exudate which is apparently a part of an acute broncho-pneumonic process involving the less diseased areas. The broncho-pneumonia is both acute and chronic in nature and in places exhibits a marked tendency to organization.

Careful study has failed to detect any evidence of typical tubercle formation in this lung. Prolonged search for tubercle bacilli in areas of necrosis has been unsuccessful. Nevertheless the presence of such extensive necrosis both in the discrete nodules and in areas of organized pneumonia is presumably sufficient to warrant a diagnosis of tuberculosis.

Diagnosis.—Diagnosed as either tuberculo-silicosis or silico-tuberculosis. The lesion has advanced too far to permit differentiation.

CASE 37

HISTORY

A. C.: Aged 47 years, Italian, married.

Until November, 1923, he was a granite cutter, having followed this trade for 21 years. Previous occupation, marble cutter (in Italy) for several years.

Father died at age 74 with rheumatism. Mother died at age 70 with pneumonia.

Patient quit work in November, 1923, because of illness. He was a patient in the Barre City Hospital for three weeks; thought he had pneumonia. His physician, however, says it was not. The patient's complaint at that time was dyspnoea, fatigue, pains in chest, cough and expectoration, and fever.

The following has been taken from the city hospital records: Admitted November 11, 1923; discharged December 1, 1923. Total time in hospital, 21 days. Tentative diagnosis on admission, pneumonia. Diagnosis on discharge, pulmonary tuberculosis. Temperature on admission, 40° C.; pulse, 120; respiration, 40. Treatment, routine hospital care and expectorants. Patient had a cough which was productive during his period of hospitalization. November 22, 1923, patient expectorated a large amount of blood. November 27, 1923, sputum streaked with blood all day. Temperature and pulse and respiration ranges while in the hospital: First week, temperature, 37.6° to 40° C.; pulse, 84 to 120; respiration, 26 to 40. Second week, temperature, 37.2° to 39.6° C.; pulse, 88 to 100; respiration 22 to 36. Third week, temperature, 36.6° to 38.8° C.; pulse, 94 to 106; respiration, 24 to 32. Sputum contained tubercle baccilli. (Physician's statement, no report on the hospital record.)

Examination made at patient's home July 7, 1924.

Present complaint, dyspnœa, which is worse on slight exertion. Pains in chest, which are rather severe in damp weather. He has a severe cough with a moderate amount of expectoration. States that he has not expectorated blood since coming home from the hospital. He also complains of night sweats three or four times a week, poor appetite, general weakness, and loss of weight. He sleeps poorly because of cough and nervousness.

Examination.—Height 66 inches, weight about 120 pounds. He states that he has lost 20 or 25 pounds during the past 6 months. He has a diverging strabismus. Teeth are poorly kept, some caries; they are badly worn in some places almost to the gingival margins. Chronic pharyngitis present. Blood pressure 130 systolic. Chest shows evidence of tuberculosis and silicosis.

He has been bedfast for two months. Marked dyspnœa present, and he complains of pleurisy, "spes phthisica" pronounced.

Patient died May 23, 1925, autopsy performed about three hours after death.

Male, age 48, emaciated, estimated weight, 100 pounds; no deformities, musculature soft and flabby.

The lungs did not collapse when the chest was opened because of dense pleural adhesions. They were difficult to break up and left a shaggy appearance on the lungs after their removal. The manipulation incident to breaking up the adhesions produced a marked retraction of the interspaces temporarily. In the right apex the adhesions tore into a cavity on the anterior surface, which was about 5 centimeters in diameter and contained pus and cheesy material. A similar cavity which was a little smaller, was found in the left apex. The adhesions were more dense on the right side. They were so dense in the lower portion that in removing the lung the diaphragm was torn out also.

The lungs were injected and preserved with a 10 per cent formalin solution.

GROSS FINDINGS

Right lung.—The surface is uniformly covered by a greatly thickened fibrous pleura, whose outer border is shaggy with adhesions. At one point on the lateral surface at the outer end of the upper fissure is an encapsulated mass of semifluid caseous matter.

Section of the lung demonstrates extensive gray-black fibrosis in its upper two-thirds, with small collections of caseous aspiration tubercles. The fibrous tissue is composed of conglomerate nodules whose borders can only be detected on careful inspection. In the posterior portions of the lung these are more widely separated and patches of emphysematous congested lung tissue are still discernible. Beneath the pleura at the apex is a thin wall nontrabeculated cavity reported to have contained semifluid caseous matter. The lower third of the lung shows large conglomerate areas of caseous aspiration tubercle, 15 to 20 millimeters in diameter. One area of calcification 2 by 3 millimeters in diameter is noted in this region. The intervening tissue is pink in color and partially carnified.

Left lung.—It is covered by dense fibrous pleura 2 to 4 millimeters in thickness. In its substance caseous (?) patches can be distinguished. On section, the interlobar fissure is obliterated. The whole organ with the exception of a small strip immediately above the diaphragm is replaced by conglomerate nodules of dark gray fibrous tissue. The trabeculæ are very distinct because of gray fibrous thickening. A cavity 3 centimeters in diameter with thick indurated walls but no trabeculæ is situated laterally beneath the apical pleura.

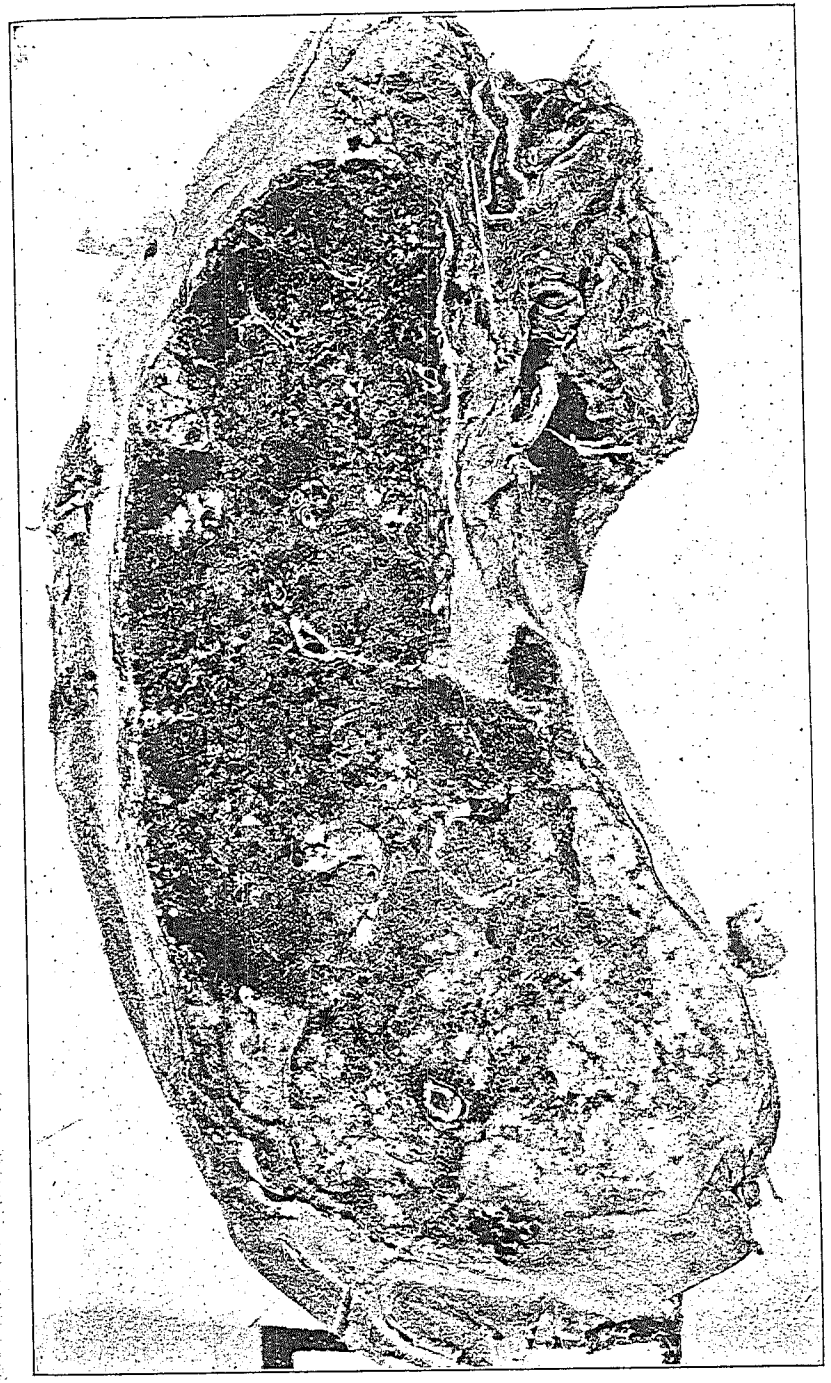


Plate 17.—Case 37. Right lung. Atypical tuberculo-silicosis in the upper two-thirds beneath greatly thickened pleura. Typical aspiration tuberculosis in lower third

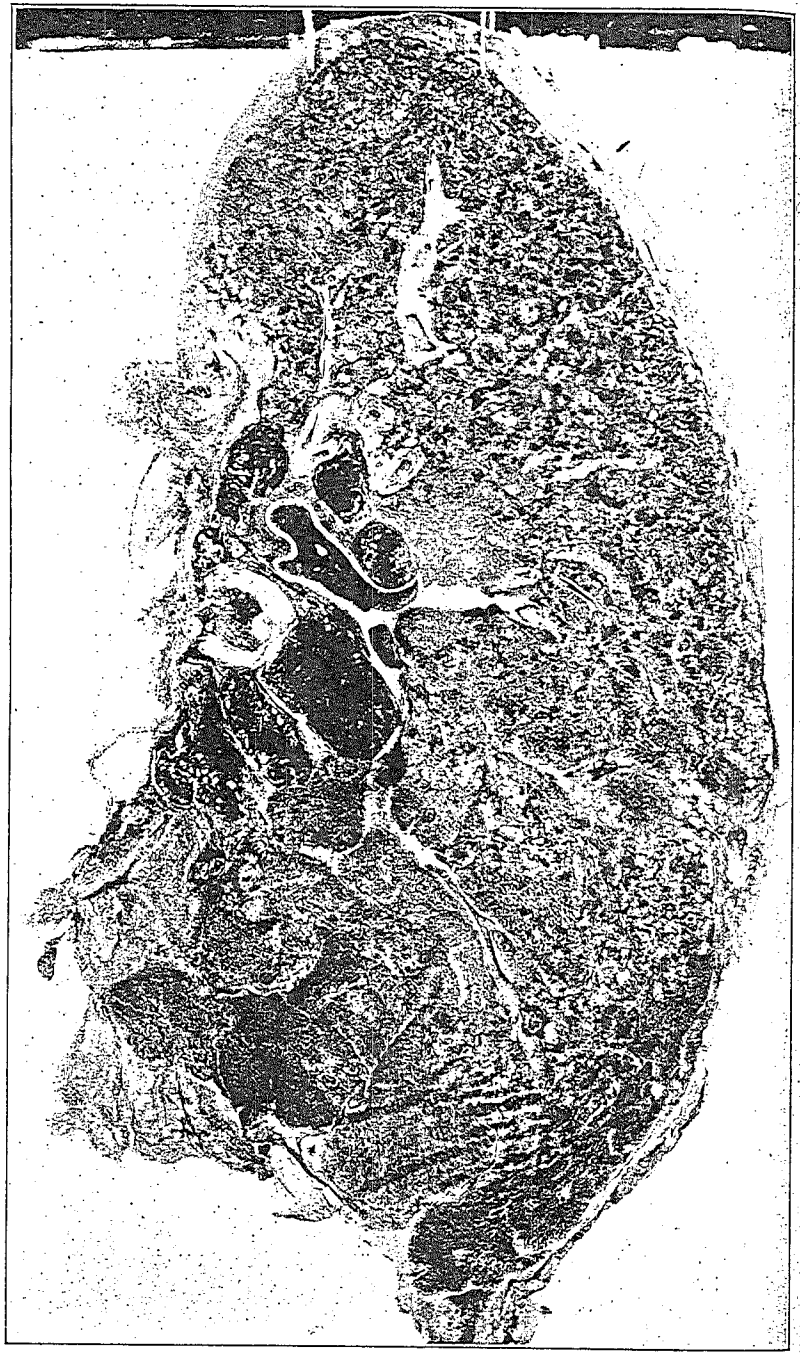


Plate 18.—Case 37. Left lung. Far advanced silicosis, slightly complicated by atypical tuberculosis

The trunks are also thickened and slightly tortuous. A few hyperplastic lymphoid nodules blackened by inhaled pigment are found at bifurcation points in the outer third of the lung.

Tracheobronchial lymph nodes.—These are large with well-defined thickened capsules and deep black central portions streaked with gray fibrous bands. Several pin-point foci of calcification are noted in different nodes of the groups.

MICROSCOPIC EXAMINATION

Lungs.—The lungs show a combination of acute and chronic tuberculosis with silicosis. The former consists of circumscribed nodular tubercle formation which, however, is largely overshadowed by an organizing pneumonic process.

The pleura is greatly thickened by granulation tissue whose inner portions have become organized, and contains many large blood vessels. These show a high grade of obliterating endarteritis. Invading the pleura at many places are tuberculous processes which are manifested either as a diffuse necrosis or as clusters of discrete tubercles, sometimes caseous, but more usually nodules of loose, cellular fibrous tissue. Beneath the line of the original pleura is an obliterating fibrosis extending 1 to 3 mm. into the pulmonary parenchyma. In this area there is a heavy deposit of dust, but little if any is found above the pleura.

The interlobular septa are greatly thickened by cellular fibrosis, and exhibit many dilated lymph vessels, usually empty, but sometimes distended with dust-filled phagocytes. Very heavy deposits of dust occur in these septa. In a few cases they are broadened by a line of good-sized tubercles usually composed of loose cellular connective tissue and perhaps a giant cell or two.

The parenchyma of the lung is largely replaced by acute and chronic organizing tuberculous pneumonia. The great majority of the lesion is of the latter type, which has become completely hyalinized and has obliterated all of the normal lung outlines. The hyaline tissue occurs in broad, irregular masses, or in some instances as more discrete concentric collections. The fibers are very thick nuclei at the borders. They have contracted to leave many wide-open, empty lacunae between them. At the borders of the circumscribed masses and at irregular intervals throughout the diffuse areas of hyaline fibrosis are bands of very cellular connective tissue containing many small vessels. In this tissue dust deposition is very heavy. In only occasional hyaline foci does much dust occur.

The more acute pneumonic foci present the usual picture varying from oedema, through acute inflammation to organizing fibrous exudate. Wide foci of caseation are encountered.

Elsewhere is lymphoid hyperplasia, marked peritrunkal fibrosis and some thickening of alveolar septa. Occasional groups of alveoli are filled with heavy masses of dust cells. A few small foci of emphysema are seen. Lymphatics can be detected only at the periphery.

Tracheobronchial lymph nodes.—The major portion of these very greatly enlarged nodes is replaced by large discrete nodules of concentric hyaline fibrosis. A few of these show calcified centers. Extremely dense black deposits of dust occur between the hyaline fibers. In a few cases there are still caseous tubercles. About the destroyed nodes is cellular fibrous tissue filled with dust, and there are also heavy deposits in the fat. A few nodes, not involved in the tuberculous process, show heavy infiltration with dust deposited in the marginal and central sinuses. About the latter is relatively little cellular connective tissue, but no hyaline substance. Most of the lymphatic trunks across the mediasternal tissues are not recognizable even in the presence of pulmonary oedema. A few are dilated by plugs of dust-filled phagocytes. Perilymphatic lymphoid infiltration is pronounced.

Diagnosis.—Tuberculo-silicosis; tuberculosis typical.

CASE 314

HISTORY

C. B.: Aged 45 years; single; Scotch; examined July 17, 1925. Granite cutter with a surface machine for 9 years and previously he was a granite lumper for 7 years (total exposure 16 years).

Parents are dead, ages and causes of death not known to him.

Patient states that he has been in good health and has not had any serious diseases. He has used alcoholics excessively. Patient states that his present illness began July, 1924, with hemorrhages from the lungs and since then has had several (recently he lost 180 cubic centimeters of blood). He was admitted to the Washington County Hospital April 23, 1925, where this examination was made.

Examination.—Height, 67½ inches; weight, 132 pounds (normal 185); teeth poorly kept, caries present; blood pressure, 100 systolic. Evidence of tuberculosis and silicosis. There is a large cavity in the left upper portion above the third rib anteriorly and the sixth dorsal spine posteriorly.

The hospital record shows that since admission, the patient has had hemorrhages from the lungs, a temperature range from 36° C. to 39° C., and that he had tubercle baccilli in the sputum.

Patient died February 19, 1926. Autopsy performed on the same date.

There were dense pleural adhesions and on the left side a large cavity was torn into while attempting to remove the lung. It extended from the level of the hilus to the apex and contained about 200 cubic centimeters of blood and pus. There were ends of eroded blood vessels extending into the cavity, most of them were thrombotic. Specimens were injected and preserved with a 10 per cent formalin solution.

GROSS FINDINGS

Right lung.—Dense pleural adhesions cover the entire surface of the visceral pleura, which measures from 3 to 5 millimeters in thickness and is hard, white, and leathery in consistence.

Section of the lung discloses a pink emphysematous parenchyma uniformly and thickly studded with firm, fibrous nodules, pigmented deep slate gray and varying from 1 to 5 millimeters in diameter. Many present central pin-point areas of softening interpreted as possible caseation. Near the borders of the lung these nodules have become confluent and that portion is solidified. The distribution is practically uniform throughout all the lobes of the lung. In the upper lobe anteriorly a few lobules exhibit red, pneumonic consolidation. Three small cavities are discovered; all have thick fibrous walls and contain a small amount of bloody purulent fluid. The first (15 by 12 by 10 millimeters in diameter) is located in the middle of the upper lobe; the second (25 by 10 by 10 millimeters in diameter) lies beneath the posterior pleura in the middle lobe, and immediately below this across the interlobar fissure is a third, 40 by 20 by 20 millimeters in diameter. The trunks exhibit a moderate degree of thickening, but there is no tortuosity.

Left lung.—It is partially collapsed above, where a large cavity has been opened. The pleura is thickened and covered with dense fibrous adhesions.

On section the pleura over the upper lobe is found to be 1 to 2 millimeters in thickness; below the thickening is much less. At least three-fourths of the upper lobe has been destroyed by a thick-walled trabeculated cavity situated beneath the mediasternal pleura. In the trabeculae the patent lumina of blood vessels are discernible. The remainder of the lung is seeded with small slate-gray fibrous nodules, which are most abundant near the cavity, to become less numerous near the outer and lower borders of the lung. In the latter area are several collections of typical caseous aspiration tubercles. The centers of some of the fibrous nodules exhibit points of softening which are presumably caseous.

Tracheobronchial lymph nodes.—Are only moderately enlarged. They are surrounded by a well-defined capsule inclosing a very deep

gray center mottled with lighter gray bands of fibrous tissue. No evidence of calcification can be detected.

MICROSCOPIC EXAMINATION

Lung.—The lung shows extensive proliferative and exudative tuberculosis, plus silicosis.

The pleura is everywhere thickened by fibrous tissue containing great numbers of thin-walled vessels. In places are long strips of adhesions of similar structure. Other areas show acute inflammation, often with much hyaline fibrin.

The consolidated portions of the lung show completely organized hyaline scar tissue which has obliterated all normal markings. In places this tissue is caseous and necrotic. Occasional small islets of unobliterated air spaces show greatly thickened walls and collections of dust cells in the lumina. In still other portions the lung exhibits earlier and more acute phases of organizing pneumonia. Near the cavities seen in gross the necrosis has liberated many dust-filled phagocytes from the scar tissue. The trabeculae in the cavities show fibrous or hyaline fibrous tubercles, sometimes caseated. Less involved areas lower in the lung show much thickening of the trabeculae extending in from the pleura. Many are outlined by a series of loose cellular fibrous tubercles. Dust deposits are very heavy in the trabeculae and about the tubercles.

In the parenchyma are very large conglomerate tubercles usually with hyaline fibrous centers, although sometimes caseous and occasionally calcified. About them is a wall of very cellular fibrous tissue which extends into the adjacent alveolar septa. Dust is very heavily deposited in the central areas and thickly scattered throughout the cellular peripheral zone. Compensatory emphysema about these isolated nodules is very marked. Some of these nodules are made up of composite collections of hyaline whorls arranged about small compressed blood vessels. Others show no such central vessel.

Tracheobronchial lymph nodes.—The tracheobronchial lymph nodes are almost completely destroyed by hyaline fibrous tubercles which in some instances have undergone subsequent caseation. Dust deposits are extremely heavy. The surrounding mediastinal areolar tissue and lymphatics have all been obliterated in the general fibrosis.

Diagnosis.—Silico-tuberculosis; tuberculosis typical.

CASE 454

HISTORY

L. F.: Aged 63, Italian, single. Examined February 8, 1926. Granite cutter with hand pneumatic tool for 24 years (did not work steadily).



Plate 19.—Case 314. Right lung. Moderately advanced silicosis in the mesial half; typical silicosis and tuberculosis on the lower and lateral half



Plate 20.—Case 314. Left lung. Typical silico-tuberculosis. Large apical cavity with trabeculæ, aspiration tuberculosis and nodules in lower portions

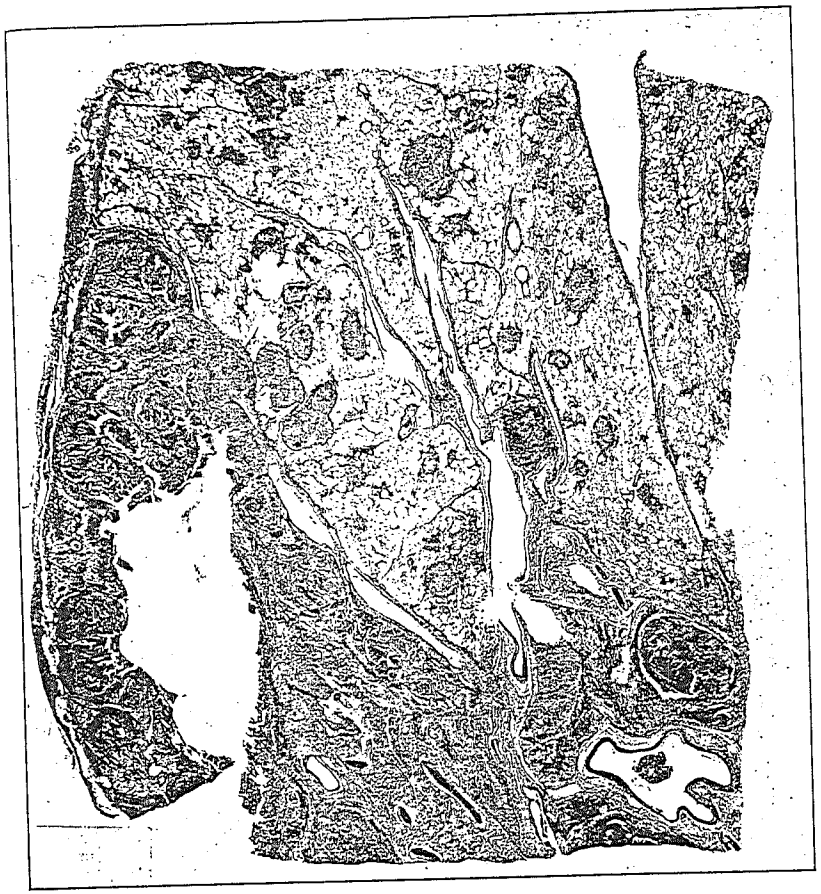


Plate 21.—Silicosis. Case 314. Silico-tuberculosis. Large cavity in area of diffuse and nodular fibrosis. Silicotic nodules in bronchial lymph nodes on lower right. Fibrosis about blood vessels

30411°—29——17

Patient states that he has not been well for about 5 years. He complains of having had a cough with expectoration, pleurisy, and dyspnoea. He had not worked for a few months prior to this examination.

At time of examination he complained of fever, cough, and expectoration, severe dyspnoea, and weakness. He was bedfast. Chest showed evidence of tuberculosis in the lower lobe of the right lung and of silicosis throughout both lungs.

He was a patient at the Washington County Hospital and the hospital records show that his sputum showed tubercle baccilli.

Patient died February 10, 1926, and autopsy was performed on the same date.

There were dense pleural adhesions in the lower right lung and in removing the lung a large cavity was broken into which contained about 30 cubic centimeters of pus. There were less adhesions on the left side.

Specimens were injected and preserved with 10 per cent formalin solution.

GROSS FINDINGS

Left lung.—There are rather firm but thin adhesions over the apex and diaphragmatic surface. About the peripheral end of the interlobar fissure there is a large white leathery scar which has obliterated this opening. Posteriorly another very heavy adhesion passes from the midportion of the lung into the mediasternal tissues. Along the anterior free borders of the lung, the air spaces exhibit well-marked emphysema. Crepitation is obtainable but the lung feels stiff and leathery.

On section the tissue is thickly studded with firm, grey-black nodules from 3 to 10 mm. in diameter. These are most numerous toward the hilum and become fewer in number in the upper third of the lung and posteriorly above the diaphragm. The nodules exhibit a moderate degree of fibrosis, but they do not present the extreme density sometimes encountered. The intervening lung tissue is yellowish-gray in color, somewhat boggy to the touch, and there is a distinct emphysematous dilatation of the air spaces.

One small thin-walled cavity 2.5 by 2 by 2 centimeters in diameter is found beneath the adhesion on the vertebral border at the apex of the lower lobe. A patch of hemorrhage or possibly early pneumonia is immediately above the cavity in the contiguous portion of the upper lobe.

Right lung.—There is a uniform fibrous thickening of the pleura with the formation of surface adhesions. In removing the lung, a cavity situated beneath the pleura of the mesial aspect of the posterior diaphragmatic surface has been exposed.

On section the upper lobe is seeded with discrete gray-black nodules reaching 5 millimeters in diameter. These are relatively few at the extreme apex, but become very abundant below. In the region of the upper fissure the nodules are confluent and become much more fibrous in character. The intervening parenchyma is generally yellow-gray in color, boggy to the touch, and presents well-marked emphysema. Immediately beneath the pleura the blebs are extremely large and apparently communicate with spaces in that structure. A few well-defined lobules on the mesial aspect of this lobe exhibit well marked red pneumonic consolidation. Toward the hilum there is a newly formed thin-wall cavity 2.5 by 2.5 by 2 centimeters in diameter. It is without trabeculae and its lumen is filled with soft purulent fluid.

On section, the middle lobe is entirely replaced by conglomerations of gray-black fibrous nodules so that the whole has the consistence of stiff leather.

The lower lobe is almost entirely destroyed by the large thick-walled trabeculated cavity partially opened in removing the lung. It measures 10 by 8 by 4 centimeters in diameter. Its walls are composed of fibrous nodules similar to those in the middle lobe. In the trabeculae the still patent lumina of blood vessels are discernible.

Tracheobronchial lymph nodes.—Are rather small, intensely pigmented, and very firm. No areas of calcification are discovered. The nodes are firmly embedded in the mediasternal connective tissues.

MICROSCOPIC EXAMINATION

Pleura.—Is extremely thick. On the peripheral surface is a layer of hyaline fibrin or fibrino-purulent exudate. Beneath this there is a very cellular young granulation tissue containing many thin-walled blood vessels and numerous dust cells, both scattered and in compact clumps; below this is a wide layer of loose, noncellular connective tissue and then comes the original pleura with its smooth muscle and elastic tissue. Beneath the pleura is a second zone of extremely cellular fibroblastic proliferation containing enormous numbers of dust-filled phagocytes. The whole is infiltrated with lymphocytes which are collected in more or less solid masses about the pleuro-septal junctions. Lymph vessels are very hard to recognize due to the cellular character of the reaction. Several adhesions on the outer surface are identical in structure with the pleura itself. They also contain masses of dust cells.

The septa.—Are generally thickened and exhibit dense fibrous tissue infiltrated with dust cells; in places nodular lesions have developed along their course. Blood and lymph vessels are generally

completely obliterated. In some of the veins are organized thrombi of dust cells and fibroblasts.

The trunks.—Both bronchial and vascular show highly developed fibrosis in their adventitial coats. Dust deposition in these areas is extremely heavy. About some of the smaller venules are very fine examples of early fibroblastic proliferation in the presence of many dust cells.

Parenchyma.—Throughout the entire substance of the lung are very numerous conglomerate nodules which are so large that their point of origin can not be determined. Many of them are typical silicotic nodules, either composed entirely of hyaline connective tissue arranged in whorls or consisting of hyaline centers surrounded by cellular connective tissue inclosing many dust cells. The remains of blood vessels can be detected in the centers of some. Others are more typical of tubercle formation presenting a central caseous zone surrounded by first noncellular, and then extremely cellular connective tissue. There is, however, no intermediate layer of epithelioid cells such as is generally seen in pure tubercle formation. In both types of nodule no difference in the deposition of dust is detected. Likewise the borders of each are practically the same, being sharply defined with radiating bands of cellular fibrous tissue extending into the walls of adjacent alveolar septa. Lymphoid infiltration is everywhere abundant. A few more typical early tubercles are present showing the usual epithelioid nodule with a caseous center, giant cells and peripheral granulation tissue mantle. Dust cells are quite generally distributed throughout them. There is some evidence of extension from caseating foci into the bronchioles; the lumen of an occasional one contains a typical purulent exudate and small patches of pneumonic exudation are occasionally encountered. The exudative phenomena in general are in abeyance, however, and even the pneumonic patches show a marked tendency to become organized.

Tracheobronchial lymph nodes.—Show either very heavy accumulations of dust cells accompanied by a diffuse cellular fibrosis partially obliterating the medullary sinuses or by hyaline or calcified nodular lesions usually repacing the whole node. The afferent lymph vessels are greatly dilated and contain either lymphocytes or thrombi of dust cells. The surrounding fat and areolar tissue is heavily loaded with dust cells and cellular fibrosis is well marked.

SUMMARY OF THE GROSS APPEARANCES

The surfaces of all but one lung exhibiting any evidences of silicosis presented extensive pleural adhesions. In the exception,

the silicotic changes were minimal in amount and apparently confined to the pleura, assuming the form of small, firm, slightly elevated grayish nodules. Where the pleura was visible through the adhesions, it presented irregular mottling with black pigment. In consistence, the organs were uniformly firmer than any process of fixation could produce.

Sections of the organs disclosed an appearance which varied with the degree of involvement. The earliest changes due to silicosis alone (A–25–25) were the small pleural and subpleural nodules of gray fibrous tissue in a lung otherwise not remarkable. The tracheobronchial lymph nodes were small, but deeply pigmented, and exhibited a few small gray scars.

An example of more advanced disease was encountered in case 522, where the section revealed a widespread studding of the tissue with gray-black nodules which were only slightly more compact and firm than the surrounding lung. The distribution was quite general, although the apices and outer third of the lung (with the exception of a zone immediately beneath the pleura) was somewhat less involved. The remaining parenchyma of the lung exhibited an emphysematous enlargement of the air spaces readily visible to the naked eye. In tracheobronchial lymph nodes were moderately enlarged and presented a well-defined fibrous border surrounding a dense steel-gray center streaked with lighter bands. This case is chosen to illustrate a moderately advanced, uncomplicated silicosis, although there was presumably a very considerable amount of tuberculosis in the lobe torn away in removing the organs from the body.

Far advanced uncomplicated silicosis such as is illustrated in the reports of the Miners' Phthisis Commission of South Africa has not been observed in this small series of cases. All the more advanced lesions showed evidence of coexisting tuberculosis. Five of these showed pulmonary cavity, which in two instances occurred in the apices of the lung, and in three others at the base or in midlung. Definite evidence of spread through the bronchial tree was found in four cases.

The silicotic nodules in these cases complicated by tuberculosis were much more dense and much more sharply outlined than in the moderately advanced case just cited. They were more steel-gray than black in color and a close examination revealed that they were composed of whorls of silky strands not unlike the appearance of a uterine "fibroid" tumor. Often they were so closely packed together that a whole lobe seemed to be replaced, as in case 37. In case 314 the nodular character of the lesion was entirely lost, and the lower lobe of the lung had been transformed into one massive area of fibrosis composed of glistening silky gray fibres. The tracheobron-

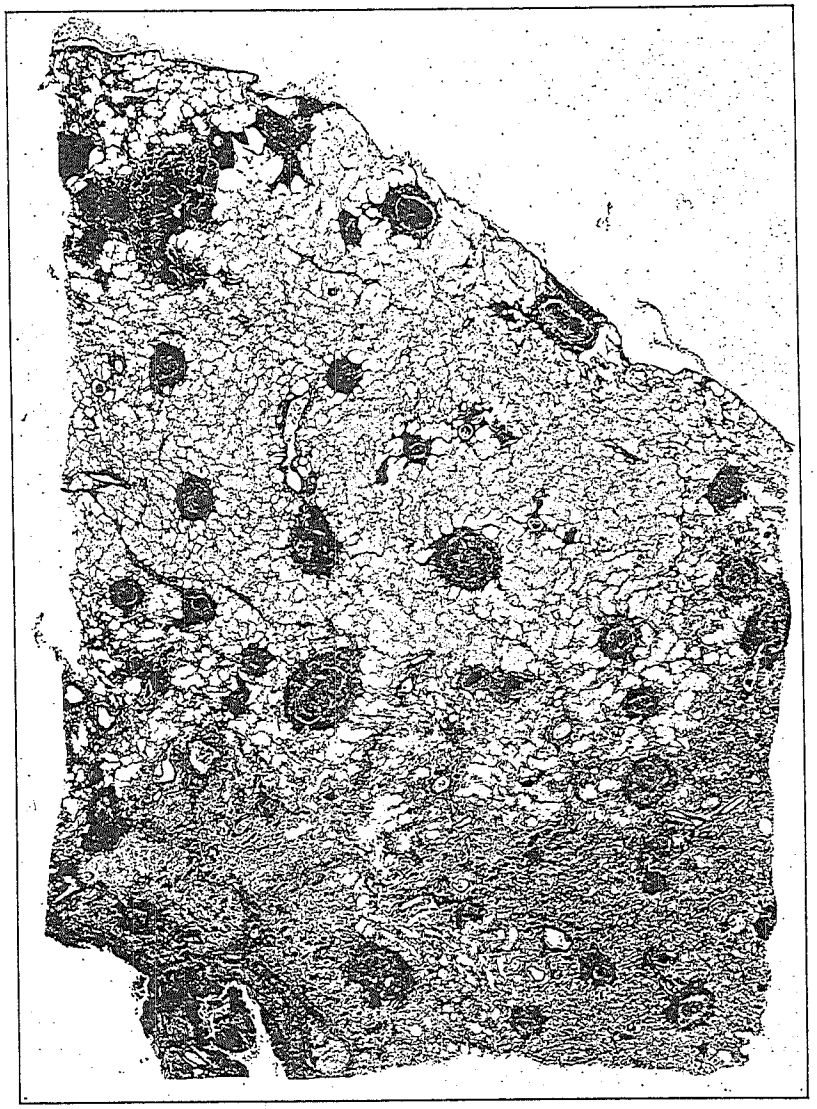


Plate 22.—Silicosis. Case 345. Isolated silicotic nodules, above. Fine nodular fibrosis, below



Plate 23.—Granite cutter. Case 345. Conglomerate tuberculo-silicotic nodules. Note the thickened interlobular septa on the right

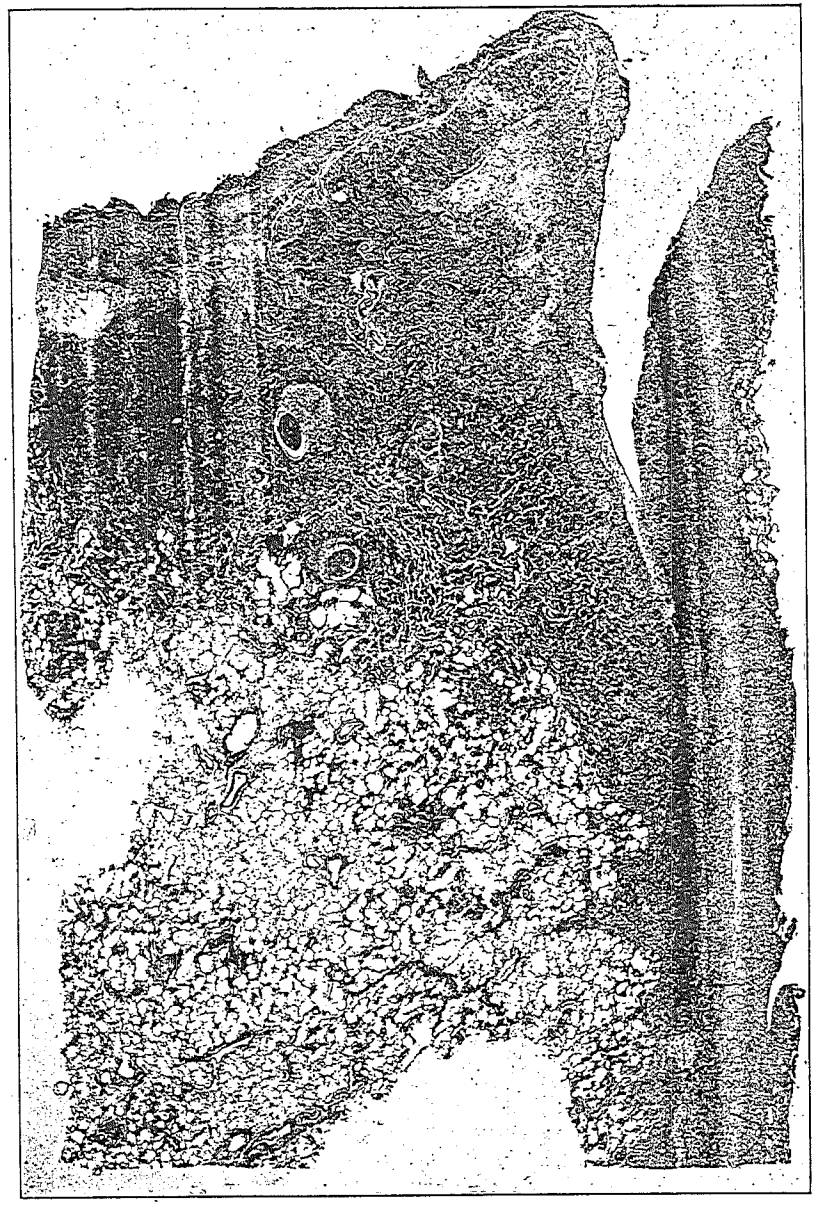


Plate 24.—Silico-tuberculosis. Barre granite cutter. Diffuse and nodular fibrosis involving lung and pleura



Plate 25.—Silicosis in sandstone cutter, Canton, N. Y. Isolated and conglomerate silico-tuberculosis

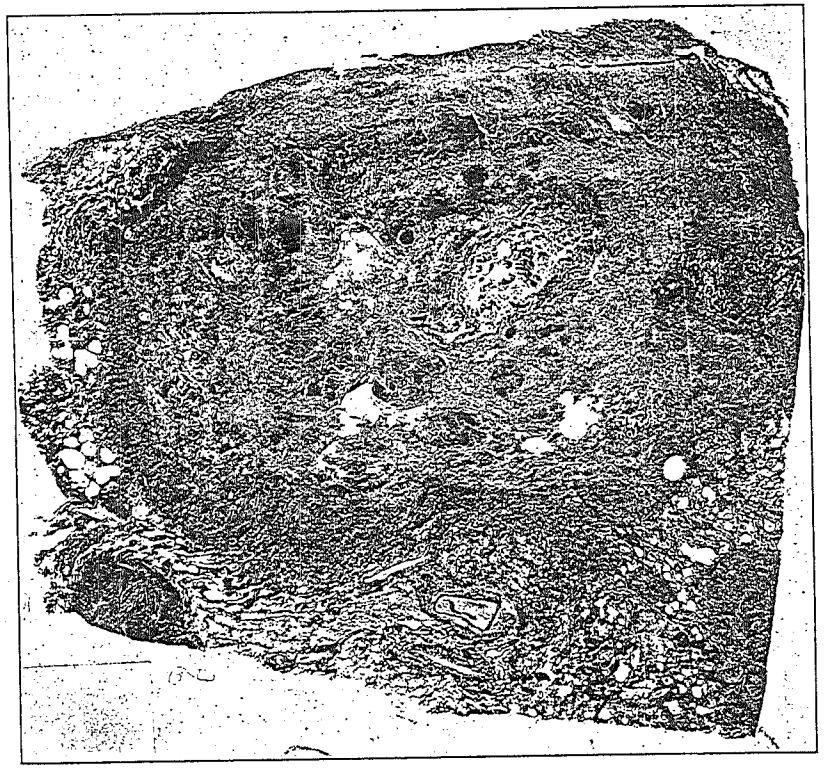


Plate 26.—Conglomerate tuberculo-silicotic nodule. Areas of necrosis in center

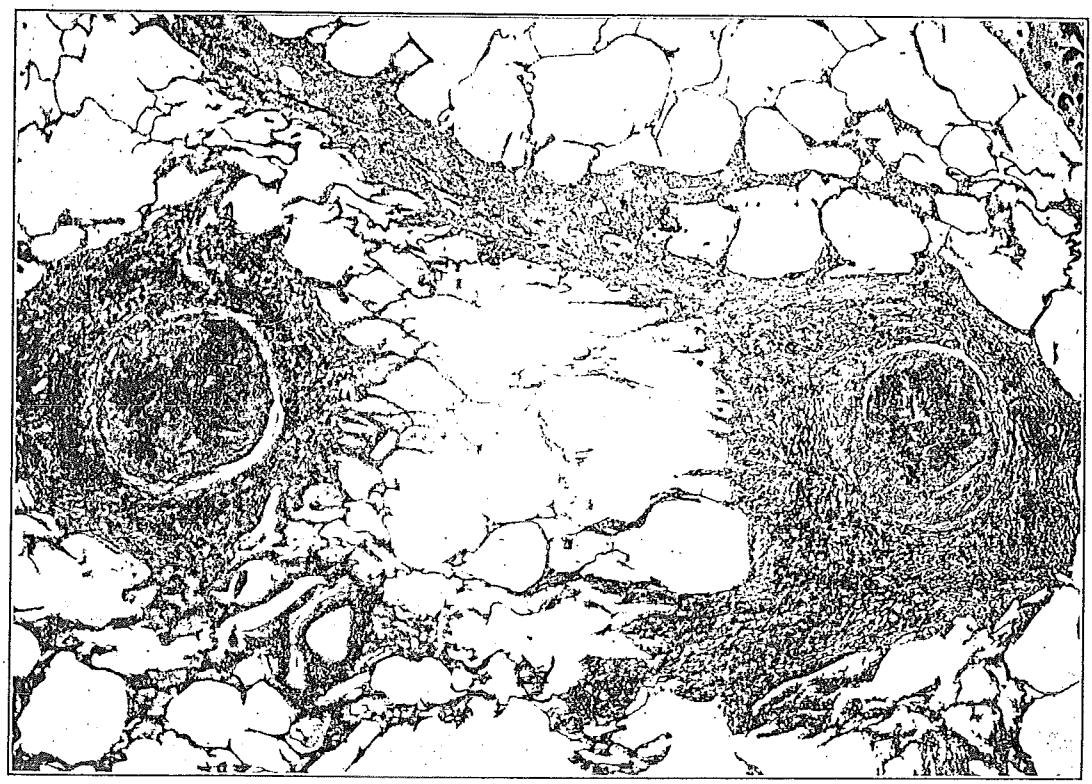


Plate 27.—Barre granite cutter. Two isolated silicotic nodules. Cellular connective tissue borders and hyaline fibrous centers. Thickened interlobular septum extending upward and to the left of the right nodule. Note dilated lymph vessels in septum

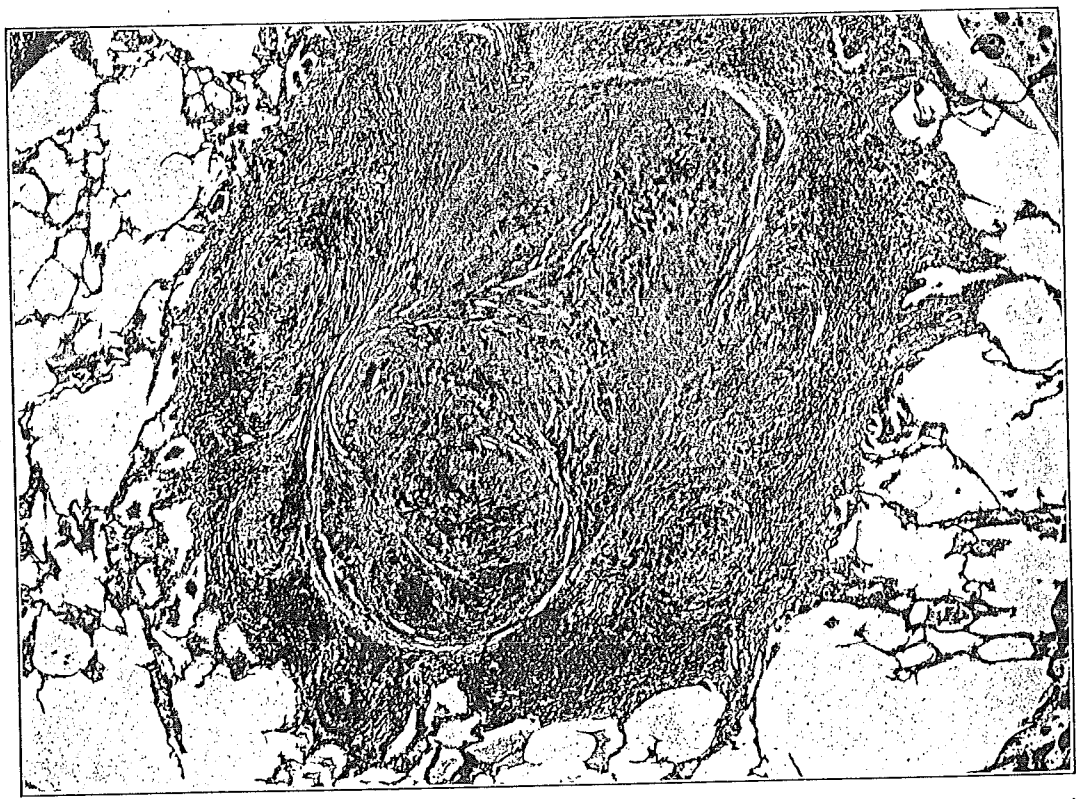


Plate 28.—Barre granite cutter. Conglomerate silicotic nodule. Characteristic slitlike spaces between hyaline fibers. Heavy deposits of carbon and granite dust in center of nodule and in the cellular connective tissue at the periphery

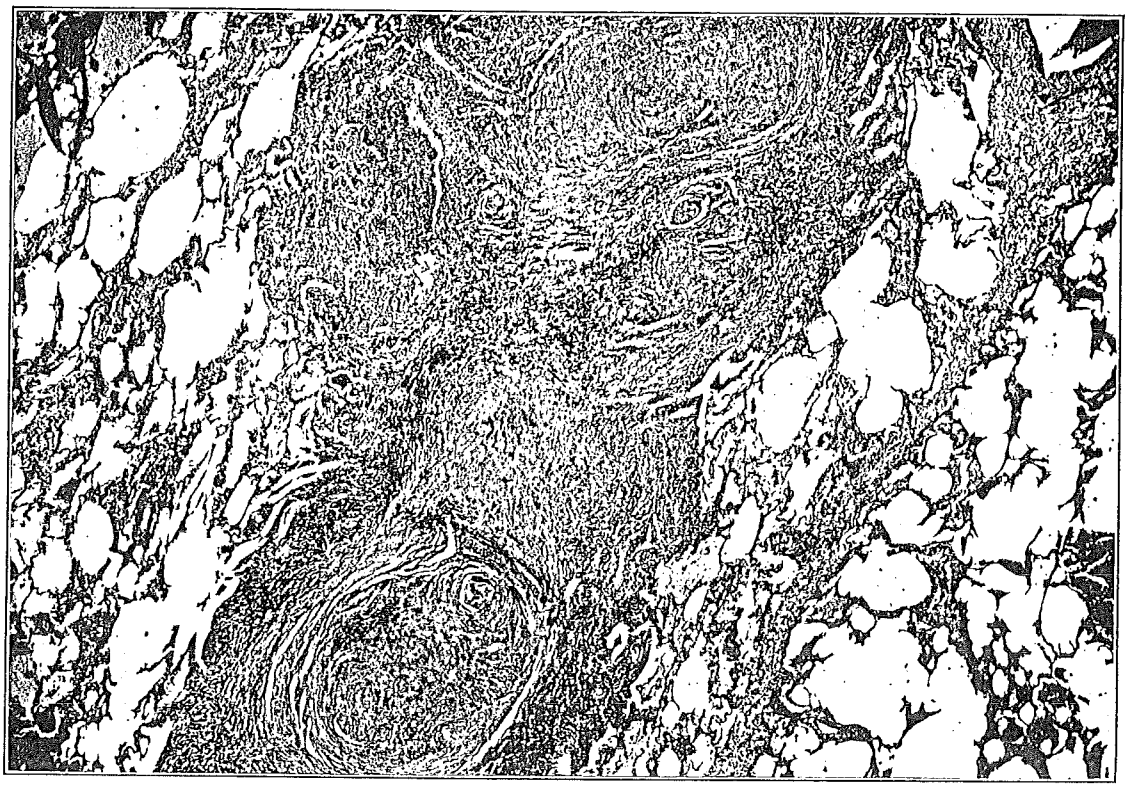


Plate 29.—Barre granite cutter. A row of silicotic nodules located within a greatly thickened interlobular septum. One nodule at the upper left has a necrotic center. Small secondary septum on the right, thickened, but without nodules

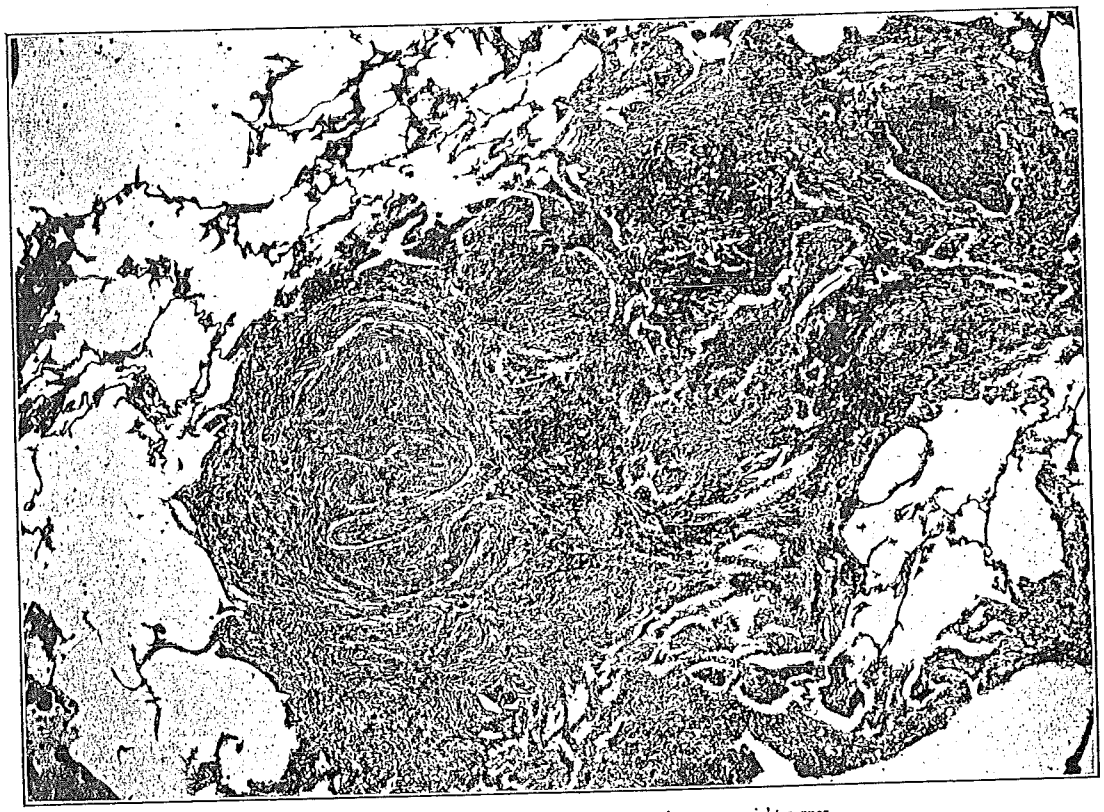


Plate 30.—Barre granite cutter. Extensive necrosis on upper right corner

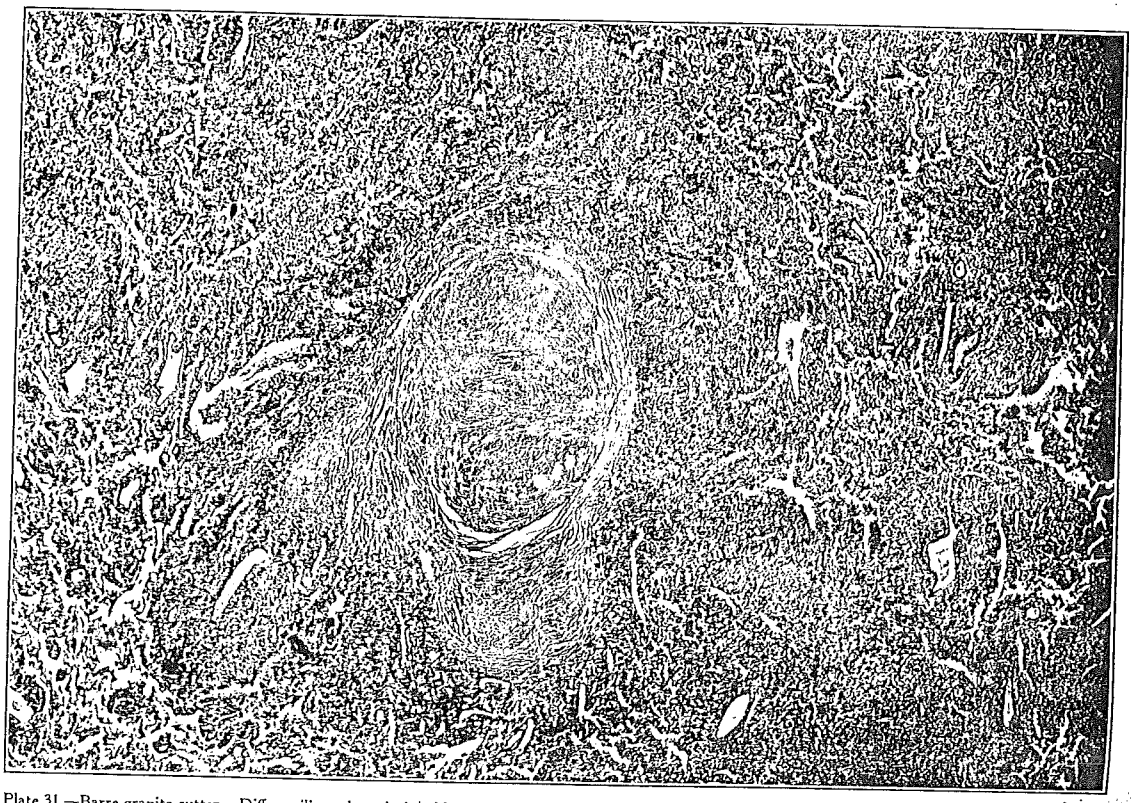


Plate 31.—Barre granite cutter. Diffuse silico-tuberculosis. Note the compressed remains of a blood vessel in center of the large hyaline nodule. The entire periphery is composed of organizing tuberculous pneumonia with marked fibrosis

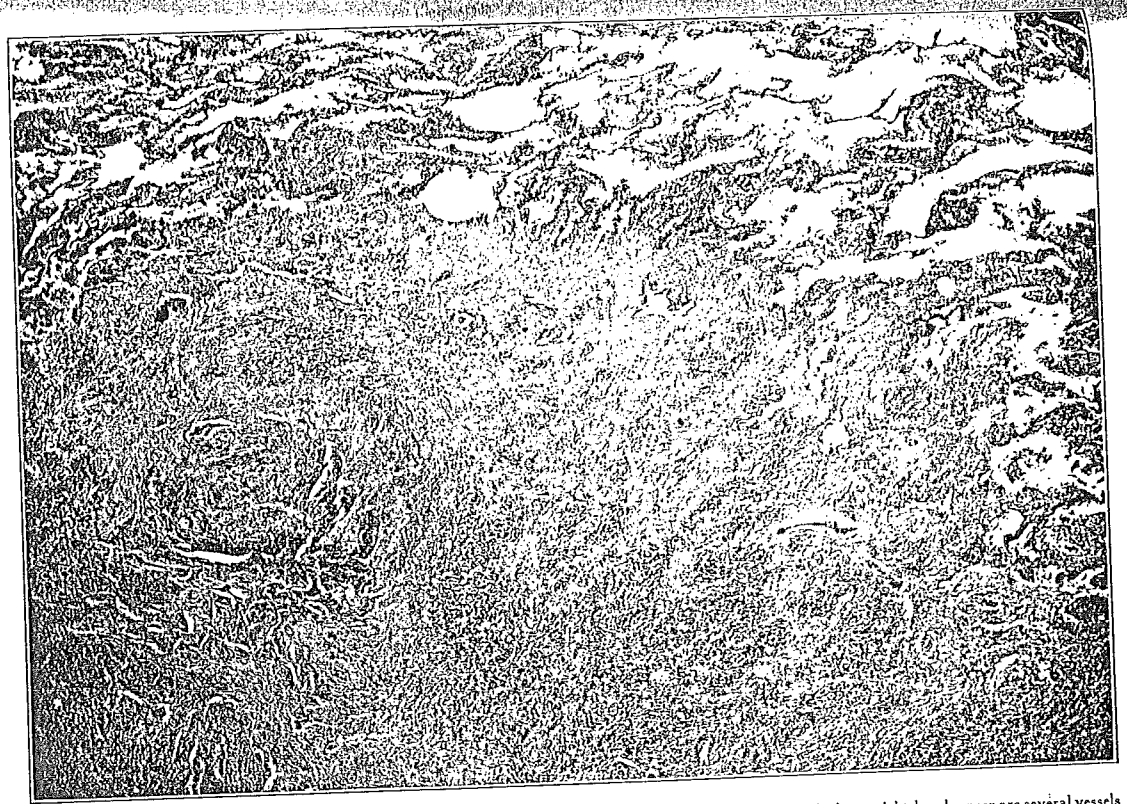


Plate 32.—Barre granite cutter. Organizing pneumonic fibrosis about the silicotic nodule on the lower left. On the lower right-hand corner are several vessels showing endarteritis and periarteritis

30411°—26——18



Plate 33.—Barre granite cutter. Series of silicotic nodules in lymphoid tissues at bifurcation of a bronchus. Lumen of one bronchus seen on upper right side



Plate 34.—Barre granite cutter. Chronic inflammation in the connective tissue coats of a large vein whose lumen is seen on the right. Note the increased vascularity and cellular infiltration. Dilated lymph vessels are marked X



Plate 35.—Barre granite cutter. Silicotic nodules and diffuse fibrosis in the wall of a large blood vessel. Endarteritis in the included branches of the main vessel



Plate 36.—Barre granite cutter. Silicotic nodule. Note the large vessels which enter and are obliterated in the nodule



Plate 37.—Barre granite cutter. Tracheobronchial lymph node showing silicotic nodules on the right and heavy deposits of carbon and granite dust in lymphoid tissues at the upper left

chial lymph nodes were larger where the silicotic lesions were less advanced, but in the extreme cases, like No. 314, they were small and shrunken, and so firmly attached to the surrounding fat and areolar tissue that they could only be detached with difficulty.

MICROSCOPIC APPEARANCES

PURE SILICOSIS

The lungs exhibiting pure silicosis will be considered in the order of their degree of involvement.

The least amount of pulmonary reaction to inhaled dust is exhibited in the lung of the individual dying of lymphoblastoma (case 452), with an exposure to granite dust of two and one-half years.

In this case there are slight amounts of dust deposited in the pleura, septae, and adventitial coats of the vascular and bronchial trunks. These deposits are surrounded by a very slight amount of cellular connective tissue. In various alveoli are scattered free phagocytes containing dust particles.

In the medulla of the tracheobronchial lymph nodes are rather ill-defined areas of noncellular fibrous tissue containing compressed dust filled phagocytes.

The whole picture in this case is so obscured by tumor growth that it would be difficult to affirm with certainty that this individual had been engaged in the granite industry.

Case A–25–25 consists of the lungs of a Scotchman 41 years of age who had cut granite for 28 years. Death was due to suicidal drowning, and the autopsy was performed by Doctor Whitney, of the Vermont State Board of Health.

Intracellular dust deposits in the area already described are much heavier than in the previous case; many alveoli, especially those beneath the pleura, are completely filled with phagocytes whose structure is entirely obscured by dust particles. The pleura, especially at its points of contact with interlobular septae, shows areas of thickening produced either by masses of cellular connective tissue, or by circumscribed nodules of noncellular hyaline connective tissue. Likewise the interlobular septae and the adventitial coats of the bronchial and vascular coats, particularly the veins, exhibit a slight but definite thickening due to proliferation of the connective tissue. This new tissue is extremely cellular, and collagen formation is very slight. The lymph vessels are dilated, but usually empty except for the presence of a few lymphocytes.

In the tracheobronchial lymph nodes the medullary portions are largely obscured by a widespread proliferation of the connective

tissue cells, between which are many compressed dust cells. In addition, there are circumscribed nodules situated in the cortex between or overlapping the follicles which exhibit various stages of development. Some are composed of young fibroblasts with little intercellular substance, while others consist largely of hyaline collagen within which are elongated and compressed nuclei. Slitlike openings between the collagen are probably artefacts due to shrinkage during fixation. As in the previous case the reaction has extended into the fat and areolar tissues about the lymph nodes.

The fourth case (522) consists of the lungs of an Italian, 51 years of age, who had worked in the granite industry for 20 years, and who died by suicidal drowning. He gave a history of having been ill of influenza complicated by pneumonia eight years before his death. This case should not perhaps be included under the heading of pure silicosis as there is evidence of tuberculosis in the lower border of the right upper lobe (the major portion of this lobe was apparently torn away in performing the autopsy and only fragments were submitted). Furthermore, three small pin-point foci of calcification are detected in the tracheobronchial lymph nodes, suggesting healed childhood tuberculosis. The major portions of these lungs, however, present lesions which are unquestionably due to dust inhalation, possibly influenced by the tuberculosis in the right upper lobe and lymph nodes, and conceivably accelerated by influenzal pneumonia.

Very massive collections of cellular connective tissue are observed beneath the pleura in the septae and about both the bronchial and vascular trunks. In these areas of cellular proliferation the nuclei are so large and swollen that tumor formation is suggested. Between them lie many dust-filled phagocytes and not infrequently multinucleated giant cells are found. Some of the areas, notably at the pleural junction with the septae and at points of bifurcation of the trunks, have lost their cellular character and are transformed into nodules of hyaline fibrous tissue. Two such nodules, located in the outer third of the lung, contain foci of calcification in their centers. An elastic tissue stain reveals the remains of blood vessels or bronchioles in the centers of the younger, more cellular nodules, but in the older hyaline foci no traces of elastic tissue can be detected. One nodule in the pleura is of particular interest. It lies in the plane of a dense and continuous band of elastic tissue which passes a short distance into either side of the nodule and then ceases abruptly. Many of the smaller blood vessels are completely obstructed by endarteritis. The lymph vessels at the periphery of the lung are widely dilated and often filled with lymphocytes or thrombi of dust-filled phagocytes.

The tracheobronchial lymph nodes present even more extensive lesions than are found in the lung. The sinuses are in most places obliterated by reaction to excessive amounts of dust or by healed and calcified tubercles. In other places they are greatly dilated. Around the node is dense fibrous tissue which has caused a dilatation of the afferent lymph vessels.

Comments.—While it would not be justifiable to draw any definite conclusions as to the mechanism of the development of silicosis from such a small series of cases, nevertheless these observations tend to confirm deductions drawn from the author's experimental study of silicosis.

Before discussing the findings it is well to recall certain points in reference to the anatomy of the pulmonary lymph vessels. They are divided into two sets, a superficial system which forms an anastomosing network in the pleura and drains through the pleura into the tracheobronchial lymph nodes. The second set is known as the deep system, and consists of a series of four or five large trunks accompanying each bronchus, artery, and vein. In the deep lymphatics the drainage is toward the tracheobronchial lymph nodes through the substance of the lung. The superficial and deep sets of lymphatics communicate with one another by a series of large short lymph vessels accompanying the radicals of the pulmonary veins which arise in the pleura and pass down through the interlobular septae. These vessels are provided with valves directed toward the pleura which allow the escape of lymph from the deep set into the superficial set when the former may become obstructed by pathological changes.

Intercalated along the lymph vessels are collections of lymphoid tissue which are regularly found in the following locations: The pleuro-septal junctions where the deep and superficial lymphatics communicate; at points of bifurcation of blood vessels and bronchi; and at the distal ends of the alveolar ducts. All of these lymphoid tissues serve as sedimentation basins in which foreign bodies like dust particles or dust cells tend to accumulate. The last named group, the masses at the end of the alveolar ducts, receive dust cells which are migrating out of the primary units (i. e., the alveoli, alveolar sacks, and atria). In experimental animals exposed to long-continued inhalation of large quantities of dust, it is possible to observe accumulations of dust-filled phagocytes about and inside these peripheral lymphoid tissues. That is more difficult in the human lungs which are not fixed in the distended state and in which the anatomical relationships are distorted.

It will be noted in the four cases reported that dust is collected in certain definite portions of the pulmonary stroma—i. e., the

pleura, and especially the pleuro-septal junctions, the septae and the areolar coats of the bronchial and vascular trunks, especially the veins. These are areas where large lymphatic trunks are found.

The accumulation of dust particles in very large amounts about the lymph vessels would suggest some interference with free flow of lymph, or otherwise the dust cells would be carried out of the lung to the tracheobronchial lymph nodes. The large collections of dust cells about the pleuro-septal lymph vessels would suggest that both the superficial and deep sets of lymphatics were obstructed. Obstruction in the deep set of lymphatics diverts the flow through the communicating branches toward the pleura, but there a counter-resistance is met in the superficial set of vessels. As a consequence, the dust cells pass through the walls of the lymph vessels and accumulate in the surrounding connective tissue at the point where these two systems communicate. After lymph stasis is well established, numerous thrombi of dust-filled phagocytes are encountered in the dilated vessels. This point is well illustrated in the last case of the series.

The question now arises as to the source of the obstruction to the lymph vessels. Most writers follow Watt, Irvine, Johnson, and Stewart, who have written a classical description of silicosis in South African gold miners, and who believe that the lymphatics in the lung are choked by accumulations of dust cells within their lumen and by contraction of the new connective tissues formed about them.

This explanation is open to criticism on several counts. The lymph vessels both in the pleura and in the trunks become dilated before the connective tissue about them has become sufficiently abundant and well organized to contract and obstruct the flow of lymph. In the pleura particularly the lymph vessels are dilated, indicating stasis before sufficient dust has accumulated to provoke a local fibrosis. Furthermore, thrombi of phagocytes within these vessels do not appear until after a lymph stasis is established.

These criticisms, however, are overcome if the obstruction to the lymph flow is situated not within the lung *but in the tracheobronchial lymph nodes.* These nodes receive the drainage of lymph from both the superficial and deep sets of lymphatics. An obstruction in them would produce stasis equally early in both systems. If all pathways are partially obstructed or closed to the egress of dust cells, they must naturally accumulate within the lung, and the greatest accumulation would naturally occur in the immediate vicinity of the drainage vessels. A more intensive and rapid reaction would then be expected in these locations. After the establishment of the primary central obstructions, other obstructions would occur from the accelerated connective tissue growth at various points in the lung.

Study of experimental material has shown that the first reaction on the part of the connective tissues occurs in the tracheobronchial lymph nodes. The medullary sinuses become packed with dust filled phagocytes. This is followed by gradual thickening of the sinus walls. Slowly the channels are narrowed and the flow of the lymph through the node is impeded. The afferent lymph vessels are dilated where they traverse the fat and areolar tissues of the mediastinum, and dust cells begin to accumulate outside the vessels in the connective tissues. Finally the connective tissues within the node become so abundant that all traces of lymph channels disappear. The cellular connective tissue becomes hyaline in character and true silicotic nodules are formed. Only after the flow of lymph through the nodes has been obstructed do significant reactions occur in the pulmonary connective tissues.

In this small series of human cases of silicosis these experimental observations find confirmation. The first two cases with relatively little dust show more reaction in the lymph nodes draining the lung than in the organ itself. The third case shows very extensive cellular fibrosis and the development of true hyaline silicotic nodules in the lymph nodes with only a moderate reaction in the lung. The last one exhibits almost complete obstruction in the lymph nodes and an attendant peripheral lymph stasis. Dust cells are collected in great numbers along the course of the dilated lymph vessels from the mediastinal connective tissues to the pleural surface of the lung. This localization of the dust has resulted in an accelerated reaction of the connective tissues.

The hypothesis that the primary lesion of silicosis is located in the tracheobronchial lymph nodes may explain why certain individuals develop the disease rapidly and why in others much more time is required. If a workman whose lymph nodes are already partly obstructed by healed foci of infantile tuberculosis continues to inhale siliceous dust, he will rapidly develop sufficient connective tissue to complete the obstruction to the flow of lymph. On the other hand, the individual who enters the industry with relatively normal nodes will work many years before the nodes draining his lungs develop sufficient reaction to interfere with proper elimination from the lungs.

THE SILICOTIC NODULE

This paper is not the proper place for an exhaustive discussion of the cytological characteristics of the so-called silicotic nodule, but attention should be called to its general features, for it is the

characteristic and pathognomonic lesion of the disease. A fully developed silicotic nodule consists of a discrete mass of hyaline connective tissue generally surrounded by a capsule of young fibroblasts. The outer area is extremely cellular and between the proliferating fibroblasts are great numbers of dust-filled phagocytes, so that the capsule is frequently pigmented. In some very old nodules this outer zone is lacking. In the central area the nuclei are compressed to thin, elongated spindles lying between very thick, heavy bands of collagen. The latter are separated by slit-like spaces possibly because of shrinkage during fixation. Many of the nodules show a uniform staining of the central collagenous tissue; in others the more central portions show a peculiar swelling and tendency to intense staining with eosin; more rarely calcification of the center is observed. In many instances the central hyaline nucleus of the nodule contains no dust; in others, collections of dust-filled phagocytes are found within the central area.

One interpretation of these various aspects of the silicotic nodule is suggested by a study of the early stages of reaction to the inhaled dust. As has been said, after the establishment of a partial lymph stasis in the lung, the dust-filled phagocytes tend to accumulate about the large lymphatic trunks. In some way as yet unexplained, these aggregations of dust cells provoke the proliferation of connective tissue. The result is the formation of a collar of newly formed connective tissue cells about the lymph trunk. As these vessels run in the outer coats of blood vessels and bronchi, a larger collar is formed about the whole trunk. With the passage of time, the connective tissue cells lay down an abundance of collagen which ultimately contracts and squeezes down the nuclei of the other cells which produced it, so that the mass becomes hyaline in character. At the same time the contraction of the collagen exerts its effect upon the vascular or bronchial trunk which it surrounds. In preparations stained to demonstrate elastic tissue, it can be shown that before the nodule becomes completely hyaline, many of the central vessels and bronchi are obliterated, the former and perhaps also the latter become occluded by a new growth of connective tissue within the lumen. In some the obstruction presents new small endothelial lined channels (cf. the canalization of a thrombus). The lack of nutrition to the central cells of the collar of connective tissue causes them to undergo a peculiar type of necrosis manifested by swelling and deep staining. As far as has been observed, leucocytes are not generally attracted, presumably because of the lack of circulation in the nodule. Some of the necrotic central areas attract lime salts, and the central portions become calcified. These changes of necrosis and calcification can apparently take place apart from infection with the tubercle bacillus.

TUBERCULOSIS AND SILICOSIS

For purposes of compensation to employees, the Miners' Phthisis Commission of South Africa differentiates between lesions due purely to the inhalation of siliceous dust and those due to complicating tuberculosis. They diagnose pure silicosis, silico-tuberculosis, and tuberculo-silicosis. Silico-tuberculosis refers to cases in which the signs of pulmonary tuberculosis appeared first. Such a differentiation is most important for their purposes, but in terminal cases seen at the autopsy table it is sometimes difficult to apply.

To the student of tuberculosis it is important to discover, first, whether the inhalation of silica dust will render progressive a quiescent focus of tuberculosis already present in the lung; and, second, whether there is evidence to indicate that the tuberculosis may have developed from new infections acquired after the establishment of the silicosis. A comparison of the tuberculous lesions in the individual with silicosis with those of uncomplicated disease should throw light on the solution of these questions.

The usual lesions of tuberculosis in the otherwise normal individual are generally divided into three main groups: (1) Lesions of infection, also known as the Ghon tubercle, the primary complex, or childhood tuberculosis; (2) apical tuberculosis; (3) bronchogenic tuberculosis, which involves the lower portions of the lung as a result of aspiration from the apical focus. Miliary tuberculosis is a relatively rare accident which plays little or no part in the ordinary case of chronic ulcerative tuberculosis of the lungs.

Lesions of infection.—These are generally acquired in childhood in the civilized races where opportunities for contact with the tubercle bacillus are almost ubiquitous. As seen in adults coming to autopsy they consist of one or more subpleural foci of calcification and fibrosis situated usually in any portion of the lung except the apex, although they may rarely be found in that location. In addition, there are similar areas in the tracheobronchial lymph node draining the affected portion of the lung. Primary foci of infection may also occur in other portions of the body—e. g., the alimentary tract, but this is uncommon in the United States. Such lesions represent the remains of the first reaction of the body to the tubercle bacillus. Often they are sterile, but occasionally they still retain living tubercle bacilli.

The presence of an active primary focus of disease produces a profound change in the cells of the entire body. They become sensitive to the tubercle bacillus so that on subsequent contacts with this organism or its products, they react in a different manner; whereas they formerly responded by slow and leisurely proliferation, in the sensitized state they respond promptly by inflammation.

Apical tuberculosis.—From about the time of puberty there are increasingly frequent manifestations of tuberculosis in the apices of the lungs. In Europe, Naegeli's autopsy experience demonstrated such disease in 90 per cent of cases. In this country it is much less frequent.

Apical tuberculosis is a reinfection, and because of the sensitizing effect of the primary lesions, the response is inflammatory in character. The result is a small patch of tuberculous pneumonia which may spread locally or even form a cavity, or it may heal with the formation of a puckered scar. Usually the overlying pleura is involved and adhesions are formed. Apical tuberculosis does not always heal completely; it frequently sequesters a focus containing living tubercle bacilli. This is the source from which subsequent involvement of other parts of the lung may occur.

Bronchogenic tuberculosis.—Either immediately following the establishment of apical disease or after a period of years tubercle bacilli spread from it into the bronchial tree and are carried by aspiration into the lower portions of the lung. Aspiration tuberculosis is the dominant lesion of the great majority of cases with clinical disease. The pathological picture is extremely characteristic, consisting either of an acute exudative bronchopneumonia or of a proliferative nodular tubercle occurring in clusters. The difference in the type of lesions following aspiration can be explained on an immunological basis.

With these points in mind, it now becomes pertinent to examine the silicotic lungs to determine whether lesions of these three main types are also present in them. If the disease should be found to progress in the same stages, it might be reasonable to assume that the inhalation of siliceous dusts simply tends to cause dissemination and spread of tubercle bacilli from the usual foci already established in the body. If on the other hand a different sequence of events were encountered, it might be argued that infection took place during the course of employment.

Primary foci.—In the Barre granite industry a large proportion of the employees are Europeans, usually Scotch or Italians, races which have long been in contact with the tubercle bacillus. It is to be expected that the majority of them would show evidence of childhood infection.

Of the eight cases submitted for examination, calcified foci were found in both the lungs and lymph nodes of six. This proportion may not have been sufficiently high, as the method of conducting the study precluded the use of the most valuable method for detection of such lesions, i. e., radiography of the lungs distended with air immediately after removal from the body. On the other hand, a calcified

area in the lung of a silicotic may not necessarily indicate tuberculosis for it has been shown that necrosis followed by calcification is a possible result of the inhalation of siliceous dust alone. The fact, however, that the calcification occurred simultaneously in both the lymph nodes and lungs lends plausibility to the tuberculous origin. It may be concluded then that the majority of this group had been infected with the tubercle bacillus probably long before they entered the granite industry.

Apical tuberculosis.—The presence of old healed tuberculosis may be difficult to recognize in a disease which is characterized by widespread fibrosis in the lung and by the formation of chronic fibrous pleurisy. However, the active manifestations of such a disease, and particularly the old thick-walled cavity should be readily discovered and identified. Such cavities were found in three cases (A–21–7, 37, and 314) of the six cases manifesting evidence of progressive tuberculous disease elsewhere in the lung.

In case 454 there is a small cavity in the middle of the right upper lobe, but this is apparently of recent origin and is probably secondary to a large and much older trabeculated cavity situated at the base of the right lower lobe. Three other fresh cavities similar to that in the right apex are found in other parts of the lungs. Such an arrangement is decidedly different from the usual form of chronic ulcerative tuberculosis. In case 450 there is a slit-like cavity of the upper lobe, which has been entirely replaced by deeply pigmented scar tissue. This cavity has ragged gray walls, no trabeculae and presents no evidence of caseous degeneration in its walls. It is possibly of tuberculous origin, but its appearance and location are not typical.

Aspiration tuberculosis.—Proliferative, and to a limited extent, exudative foci of aspiration disease were found in four of the six cases with active tuberculosis. In three of these it seemed likely that aspiration had occurred from a cavity in the apex. In one case (case 454) aspiration probably proceeded from the cavity at the base of the right lung. In case 450 the centers of some of the silicotic nodules contained points of caseation. The grouping of the nodules is not unlike that of aspiration tuberculosis and it is possible that the nodules may have developed as the result of fibrosis about tubercles of bronchogenic origin, but this could not be definitely established.

Those cases in which the tuberculous process develops in the same manner as it does in the individual not exposed to the inhalation of siliceous dust have been designated as "typical." Those in which the lesions and their development differ from the usual type have been labeled "atypical." The significance of these terms will be subsequently discussed.

Table 70 summarizes the various manifestations of tuberculosis in the cases of the series.

TABLE 70.—*Manifestations of tuberculosis in each case*

Case number	A-21-7	450	37	522	314	454	A-25-25	452
Primary complex	+	+(?)	+	+	0	0	0	0
Apical tuberculosis—old cavity	+	+	+	0		0	0	0
Aspiration disease	+	0	+	0	+		0	0
"Typical" or "atypical" tuberculous process	Typical.	Atypical.	Typical.	Atypical.	Typical.	Atypical.		
Years of exposure	(?)	26	21	20	9	[1] 24	28	2½

[1] Did not work steadily.

The table shows that in one-half of the six cases with active tuberculous disease the process is typical in its development.

The significance of these findings may be disputed, but if certain assumptions regarding the development of tuberculosis in general are conceded, data of this kind based on a study of a much larger amount of material would go far in answering the question as to when and how tuberculosis becomes a complication of silicosis. For purposes of discussion, let it be assumed that the individual becomes sensitized to the tubercle bacillus in infancy or in early childhood; that he is reinfected shortly after puberty; and that before entering the granite industry he has developed an apical form of the disease. Men of this type usually enter an occupation early in life, and many of the granite cutters have worked at their trade since boyhood. Dust, therefore, begins to accumulate about the apical focus before it has had opportunity to heal. Under experimental conditions it can be shown that dust inhalation tends to prevent the healing and sterilization of foci or tubercles which would otherwise disappear entirely. The caseous center of the lesion is not absorbed and the living tubercle bacilli are encapsulated. It can also be shown that if the dust inhalation be continued long enough, dissemination of bacilli can occur from these encapsulated lesions. If the experimental findings can be applied to the human being the apprentice granite cutter would encapsulate his apical focus and thus maintain a depot of living tubercle bacilli in his lungs. Subsequently, whether because of the continued inhalation of dust or because of the little understood factors operative in the general run of human beings, whatever their occupation, the apical focus becomes active and aspiration of bacilli into the bronchial tree is followed by clinical tuberculosis. Such a series of events might well explain the developments of the "typical" tuberculosis, a complicating terminal infection from infection already existing within the body.

The "atypical" cases are not so readily interpreted. As in civilized races sensitization from childhood infections has

ably occurred. In them it might be argued that the reinfection responsible for the development of exudative tuberculosis and cavity formation comes from exogenous sources. Possibly it is an industrial reinfection, for the chances for contact with the tubercle bacillus in the industrial environment are said to be numerous. But the reinfecting bacilli enter a lung whose physiological activities are abnormal. Long continued dust inhalation has disturbed the functions of the lymphatic system, the normal respiratory movements are deranged. As a consequence, the reinfection does not tend to localize in the apex of the lung and to progress in the accustomed manner. The tuberculosis may appear first at the base as manifested in the cavity found in case 454 and subsequent aspiration produces disease in portions of the lung higher up.

The discussion resolves itself into the problem of exogenous versus endogenous reinfection as the cause of clinical tuberculosis. Most of the writers in the field of silicosis believe that tuberculosis is the result of exogenous reinfection, i. e., an industrial reinfection. But it is believed that evidence is available to indicate that reinfection from within the body may also play a part. Obviously the number of cases on which this report is based is too small to permit any conclusions as to the relative frequency of typical and atypical tuberculosis as a complication of silicosis. But it is to be hoped that the opportunity will arrive to study at autopsy a sufficiently large amount of material to establish the value of this method of inquiry.

Among the gold miners of South Africa there exists an unusual opportunity for such a study. The employees in the mines consist of three distinct groups: White European miners, native white South African miners, and native black laborers. The majority of the Europeans presumably already possess latent apical foci of tuberculosis; the white South African may or may not have developed such lesions; the native blacks must be relatively free. The reports of the Miners' Phthisis Commission of that country indicate that the black laborer is most susceptible to tuberculosis and that he develops an acute form of the disease, as is the case with all aboriginal races. His case is not germane to this discussion.

The native-born white miner exhibits only about one-fourth as much uncomplicated tuberculosis as the miner from overseas, and only one-tenth as much tuberculo-silicosis. These data might be interpreted as an argument in favor of reinfection from endogenous sources. The European miner already has his focus from which reinfection may develop after it is sufficiently affected by the inhalation of dust. The South African white miner, being of a more vigorous stock, has perhaps never developed apical tuberculosis, or if he has, the focus has healed. He would become reinfected in the

industry and should exhibit an atypical form of tuberculosis. These again are somewhat speculative arguments, but it would be most enlightening if data were available from that country to show the incidence in tuberculous infection among the black laborers as demonstrated by intracutaneous tests. A radiographic study of the lungs of native white applicants for the mining industry should demonstrate the frequency of latent apical disease in them.

No formal conclusions will be drawn from the study of these eight lungs from Barre granite cutters. It can be definitely stated that the long-continued inhalation of this type of dust is capable of producing a true silicosis. A hypothesis has been proposed to explain the development of the lesions in silicosis. It can be affirmed that of the cases coming to autopsy the majority died of tuberculosis. In half of this group, the infectious process developed and proceeded in a manner similar to that ordinarily encountered; in the other half, the silicosis changed and modified the course of the complicating tuberculosis. These differences in the character of the lesions have suggested the hypothesis that tuberculosis as a complication of silicosis arises from both endogenous and exogenous sources. The relative frequency of these two types of reinfection can not be determined from the study of such a small series of cases.

XI. MORTALITY AMONG GRANITE WORKERS AS INDICATED ON DEATH CERTIFICATES

Transcripts were made of the death certificates for all deaths occurring in Barre from 1900 to 1925, inclusive, with information as to age, occupation, primary and secondary causes of death, and some other factors. In addition, deaths from tuberculosis from 1890 to 1899 were also transcribed. In using the results for Barre alone, some error is introduced because of the fact that deaths of persons in sanatoria outside of Barre would not be included, although the men had worked in the granite-cutting industry in Barre.

In studying the statistics of such a character, it is evident that the foremost obstacle is the absence of any information about the group of persons exposed to death. No death rates can be determined and it is necessary to fall back upon the percentage of deaths from various causes, termed "proportionate mortality." Since the mortality from all causes will not be the same in any two groups compared, the percentage of deaths due to a particular cause is not an altogether reliable index of the mortality from that cause. In the present instance, where only very general conclusions are derived from the data, it is believed that the method of proportionate mortality is sufficiently precise. All percentages in this section are calculated after deducting deaths from external causes from the total. This was deemed advisable because of the widely differing hazards of accidental death in the various occupations. In all tables deaths occurring during September and October of 1918 are omitted because of the epidemic of influenza.

PROPORTIONATE MORTALITY FROM TUBERCULOSIS BY SPECIFIC OCCUPATION

The first figure and table give the proportionate mortality from tuberculosis in specific occupations in the granite industry. For comparative purposes, data are used for occupied males in the registration area, 1908 and 1909, the only two years in the period covered in which deaths by occupation have been published by the Census Bureau. Since the census statistics did not give a total for all forms of tuberculosis, it was necessary to use pulmonary alone, so the percentages for the registration area is slightly less than if all forms had been use. It did not seem practicable to limit the Barre deaths to pulmonary tuberculosis, because in so many cases the death

certificate read simply "tuberculosis." However, the table gives the number of deaths from pulmonary tuberculosis, "phthisis," and other or unspecified forms of tuberculosis. Deaths classified as "phthisis" were in most cases pulmonary tuberculosis, as this is the interpretation put upon this word by local physicians working out the death certificates.

TABLE 71.—*Percentage of deaths in the granite industry due to tuberculosis, 1900–1925, compared with occupied males generally, 1908 and 1909*

	Percentage due to tuberculosis	Number			
		All causes [1]	Pulmonary tuberculosis	"Phthisis"	Other or unspecified tuberculosis
Cutters	65.6	631	327	60	27
Other granite [2]	45.0	158	62	6	3
Lumpers	52.0	25	12	1	
Manufacturers and dealers	50.0	58	26	2	1
Polishers	40.5	37	12	2	1
Grinders	31.3	16	5		
Quarry	16.7	24	2		2
Others [3]	39.1	23	7	1	1
Occupied males, registration area, 1908 and 1909	[4] 17.1	353,153		[4] 60,492	

[1] Except external.
[2] Excludes quarrying.
[3] Tool carriers, bed setters, sawyers, etc. Eight is maximum in any one occupation. Derrickmen work outside, yet 5 out of 8 deaths in this occupation were due to tuberculosis, suggesting that the men had not always been in an atmosphere free from granite dust.
[4] Pulmonary only.

The proportionate mortality from tuberculosis among cutters is 65.6 per cent; among other granite workers (excluding quarry workers) it is 45 per cent; among quarry workers, 16.7 per cent, and among occupied males in general (1908–9), 17.1 per cent. The proportionate mortality among occupied males is about twice as high as would be expected in the general population, partly because of higher mortality rates from tuberculosis among workers, but mostly because of the difference in age distribution—the industrial population is concentrated at the ages when the mortality from tuberculosis is greatest.

Figure 24 gives the bars for the specific occupations in the granite industry, compared with occupied males. What is of special interest here, in addition to the obvious contrast between granite workers and occupied males generally, is the high percentage among certain granite workers who do not fall in dust groups A or B, as classified in this study. The group termed "manufacturers" must be thought of to a large extent as made up of persons who had formerly been cutters and therefore previously exposed to a large amount of granite dust, or who in small plants might have acted as foremen. But lumpers, polishers, and workers in miscellaneous occupations, such

as derrick men, bed setters, sawyers, etc., also show an excess of mortality from tuberculosis. It is possible that conditions in previous years were less favorable than at the present time. We are, of course, unable to estimate, from dust counts made in this study, what the dustiness of specific occupations has been in previous years.

However, the failure to obtain the same clear difference between occupations which was found in the material previously taken up

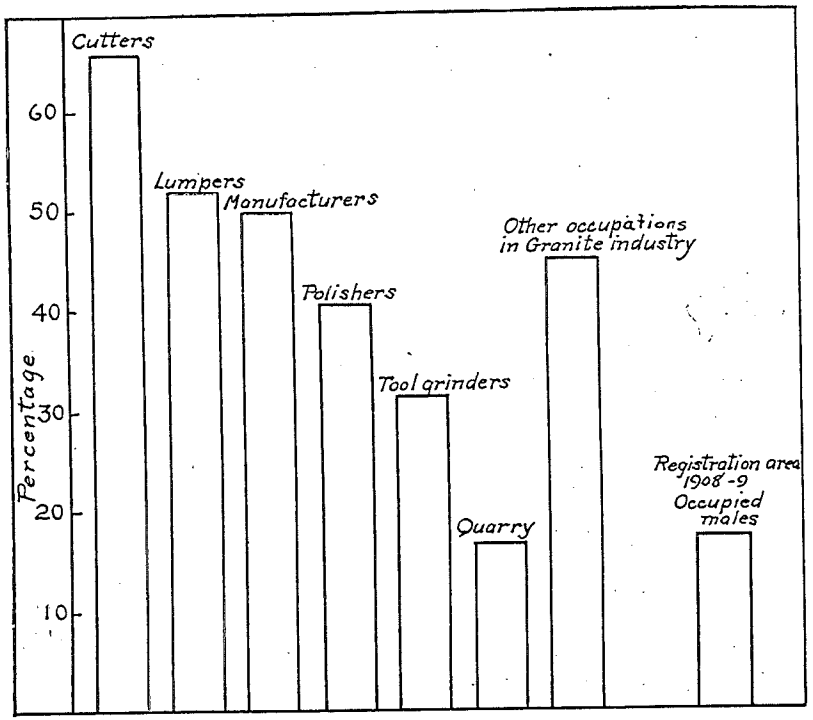


FIGURE 24.—Proportionate mortality from tuberculosis (1) in specific occupations of granite industry compared with data for occupied males. Registration Area, 1908–9

may be due primarily to the lack of precision in recording occupation on death certificates. The result would be more or less a blurring of the proportionate mortality in each occupation, which is what appears to have occurred.

To eliminate the possibility that the high percentages of deaths due to tuberculosis among Barre granite workers is general in the industries of that city, Table 72 was prepared to give the proportionate mortality for other occupations, following the classifica-

(1) For Registration Area, pulmonary tuberculosis only

tion of the Census Bureau of 1909. The proportionate mortality for occupied males generally is included.

TABLE 72.—*Percentage of deaths in Barre (1900–1925) due to tuberculosis in various occupations, compared with corresponding data from occupied males of registration area, 1909 (Barre, all forms of tuberculosis, registration area, pulmonary alone)*

	Percentage		Number			
			Barre		Registration area	
	Barre	Registration area	Total [1]	Tuberculosis	Total [1]	Pulmonary tuberculosis
Clerical	40.6	23.3	32	13	[2] 12,049	[2] 2,809
Professional and public	19.3	13.2	57	11	8,356	1,105
Trade and transportation	19.0	19.9	105	20	37,503	7,454
Manufacturing and mechanical industries [3]	17.7	18.1	164	29	54,487	9,875
Domestic and personal	15.4	22.3	39	6	36,708	8,186
Laborer	14.6	----------	55	8	(4)	(4)
Agriculture	7.1	9.7	98	7	45,823	4,439
All occupations [5]	17.1	17.0	550	94	182,877	31,059

[1] Exclusive of external causes.
[2] Heading "clerical" does not appear in 1909 census classification, the deaths being assigned to other headings, therefore, the 1908 figures have been susbtituted, but are not included in the total for all occupations.
[3] Data for Barre exclusive of granite industry (cutting and quarry).
[4] Only laborer unspecified is given separately in census volume; therefore no comparison is attempted.
[5] Housewives excluded.

Owing to the relatively small number of deaths among specific occupations in Barre, only a rather crude comparison is possible, but it will serve the present purpose. All occupations in Barre, excluding granite workers and housewives, show a proportionate mortality of 17.1 for all forms of tuberculosis; whereas in the registration area the figure for pulmonary tuberculosis is 17.0. As stated previously, the census data are not in such form as to give the figure for all forms of tuberculosis. Clearly there is no general excess of tuberculosis in the various occupations of Barre. If we look at specific occupational groups, no excess shows up except in clerical (40.6 against 23.3) and professional and public (19.3 against 13.2). The first figure is based on only 32 deaths and therefore of questionable significance. The figure for professional and public is not particularly above the average for all occupations.

PROPORTIONATE MORTALITY FROM TUBERCULOSIS, BY AGE

Up to this point no consideration has been given to age. Although the age distribution of the population is unknown, some advantage can be secured by considering the age at which death occurred. In view of the age curve of mortality from tuberculosis among granite cutters, it is to be expected that the proportionate mortality from

tuberculosis among cutters will gradually become greater with increasing age, relative to proportionate mortality among occupied males generally. This is found to be true.

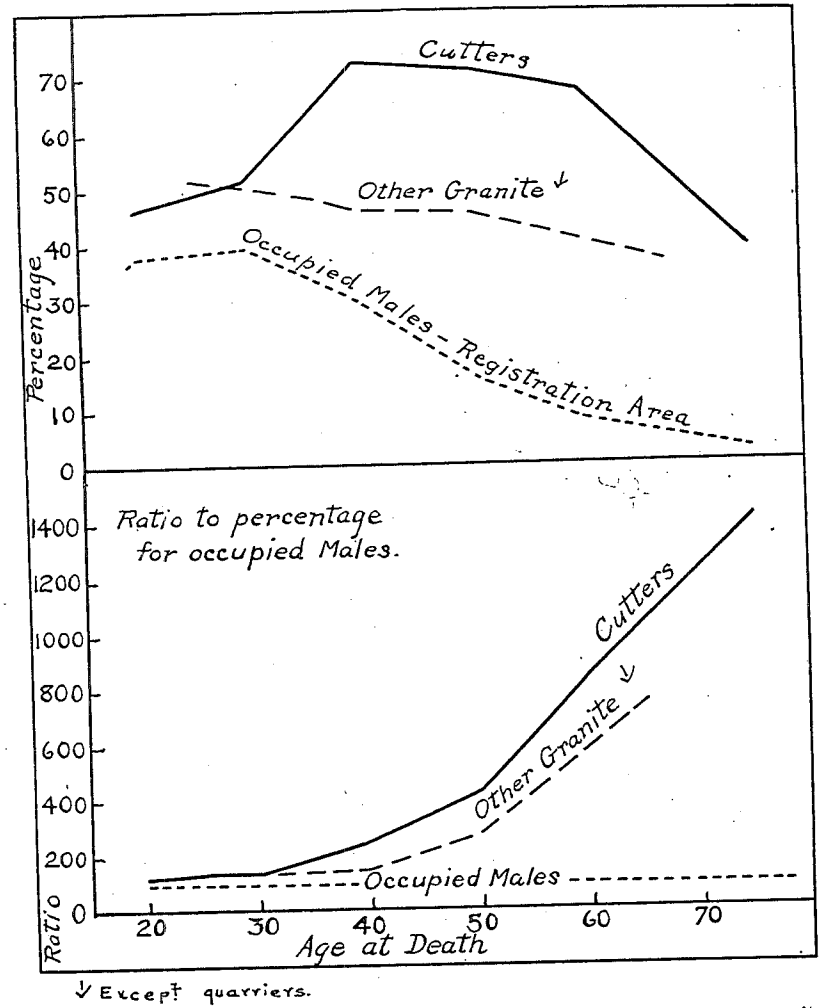


FIGURE 25.—Proportionate mortality from tuberculosis (2) by age among granite cutters and other granite workers, 1900–1925, and among occupied males, Registration Area, 1908 and 1909

Table 73 presents the proportionate mortality for cutters, all other granite workers (except quarry), and occupied males. The deaths are also given by age for specific granite occupations, but the numbers are too small to permit the calculation of percentages. Figure 25 accompanies the table.

(2) For Registration Area, pulmonary tuberculosis only

TABLE 73.—*Percentage of deaths from tuberculosis at each age: (a) Cutters and other granite workers, 1900–1925; (b) occupied males, registration area 1908–1909*

	Up to 25	25 to 34	35 to 44	45 to 54	55 to 64	65 to 74	75 and over
	Percentage						
Cutters	46.4	51.5	73.2	71.4	68.0	39.1	
All except cutters [1]	52.0		46.5	45.7		36.6	
Occupied males, registration area, 1908–09 [2]	37.9	39.5	29.2	16.7	8.3	2.8	
	Ratio to occupied males, registration area						
Cutters	122	130	251	428	819	1,418	
All except cutters [1]	134		159	274		763	
	Number						
Cutters:							
All causes	28	68	138	220	128	40	6
Tuberculosis	13	35	101	157	87	17	1
All except cutters:							
All causes	12	13	28	35	45	21	5
Tuberculosis	5	8	13	16	16	9	1
Lumpers:							
All causes	3	3	4	5	6	3	1
Tuberculosis	1	3	2	3	2	1	
Manufacturers and dealers:							
All causes		2	14	19	16	5	2
Tuberculosis			7	11	10		1
Polishers:							
All causes	1	2	6	5	16	7	
Tuberculosis	1	1	2	1	2	7	
Tool grinders:							
All causes	1	4	2	3	4	2	
Tuberculosis		3	1		1		
Others:							
All causes	7	2	2	3	3	4	2
Tuberculosis	3	1	1	1	1	1	
Registration area:							
All causes	26,025	43,850	51,850	59,412	63,254	108,413	
Tuberculosis	9,854	17,326	15,128	9,910	5,231	2,992	

[1] Quarry not included. [2] Pulmonary only.

Since it is necessary to deal with the percentage of deaths due to tuberculosis in any one age, rather than with the actual death rate, no true mortality curves by age are possible. The percentage declines rapidly with age in the general occupational population, owing to an increasing number of deaths from other causes, so that the curve looks entirely unlike that based on true rates. This fact must be kept in mind in studying the curves for granite cutters and other granite workers. In fact, the comparison can be made more justly by taking the ratio of the proportionate mortality among cutters in each age to that among occupied males generally for the same age. These ratios are given at the bottom of the graph and are included in the table.

A very striking result is found. Although the proportionate mortality among cutters does have a tendency to decline, the curve is altogether unlike that among occupied males generally. Starting at the beginning of industrial life with a proportion little greater than that in the general population, the ratio curves for both cutters and other granite workers rapidly rise above that for occupied males, the mortality becoming proportionately more excessive as age advances. In the end, cutters show a proportion fourteen times as high as that among occupied males generally. The curve for other granite workers also rises very rapidly. These ratio curves present a very important picture of the effect of granite cutting on the workers, and their meaning can hardly be misinterpreted.

COMPARISON CHRONOLOGICALLY

Up to this point, all deaths from 1900 to 1925 have been grouped together and compared with the only data available for occupied males generally (1908–9). As a matter of fact, however, the mortality among granite cutters has been increasing rapidly during that period. In Table 74 an attempt is made to divide the period into four parts, 1900–1906, 1907–1912, 1913–1919, and 1920–1925. No comparison with occupied males in the registration area is possible since the data were not published. Instead, the proportionate mortality has been included for the total population of Vermont.

TABLE 74.—*Percentage of deaths due to tuberculosis among cutters, other granite workers, and other Barre occupations, in four periods, 1900–1906, 1907–1912, 1913–1919, and 1920–1925, together with corresponding data for Vermont's total population (males)*

	1900–1906	1907–1912	1913–1919	1920–1925
	Percentage			
Cutters	51.1	54.5	64.2	71.9
Other granite workers	29.4	38.9	52.5	47.6
Other occupations (Barre) [1]	17.2	16.9	13.0	19.4
Total population	9.1	8.2	6.9	[2] 5.9
	Number			
Cutters:				
All causes	90	134	159	185
Tuberculosis	46	73	102	133
Other granite workers:				
All causes	17	36	40	63
Tuberculosis	5	14	21	30
Other occupations:				
All causes	87	124	169	175
Tuberculosis	15	21	22	34
Vermont, total population (males):				
All causes	37,611	31,622	35,059	24,328
Tuberculosis	3,437	2,578	2,431	1,437

[1] Housewives excluded. [2] 1925 missing.

In spite of the general decline in mortality from tuberculosis during these 26 years, the proportionate mortality among cutters

rises from 51.1 in the first period to 71.9 in the last period; that among other granite workers, from 29.4 in the first period to 47.6 in the last period. Other occupations in Barre show no consistent changes. The data for Vermont's total population shows, as would be expected, a distinct decline, the final figure being only two-thirds of the first.

Thus the increase in proportionate mortality among granite workers is much more significant than the figures themselves indicate. The proportion from tuberculosis has been increasing steadily in the face of a decreasing proportion among the general population. Moreover, the proportionate mortality figures themselves rather cloak the extent of this increase, since the percentage can not rise above 100, even if all of the deaths were from tuberculosis. The change from 51.1 to 71.9 per cent must be considered in the light of the ratio between deaths from tuberculosis and deaths from other causes—a method of calculation which is not usual, but which means more where the proportion becomes much greater than 50 per cent. For instance, 46 deaths occurred from tuberculosis and 44 from other causes among cutters in the first period; for succeeding periods the figures are, respectively, 73 and 61, 102 and 57, and 133 and 52. The four ratios are 105, 120, 179, and 256. This way of putting the increase (a percentage increase of 144) is much more logical than to compare directly the proportionate mortalities (a percentage increase of only 41).

The increase is about equally great at all ages. For instance, if the two periods 1900–1912 and 1913–1925 be compared, the percentage increases in the proportionate mortality for the various age groups are up to 35 years, 48 per cent; 35 to 44, 47 per cent; 45 to 54, 47 per cent; and 55 and over, 77 per cent. The higher percentage in the 55-year-and-over group is possibly not significant.

TREND OF MORTALITY AMONG CUTTERS BASED ON DEATH RATES

The rise in mortality from tuberculosis among granite cutters in recent years can be brought out clearer by calculating death rates on the basis of the known population (from figures supplied by the Granite Cutters' Union) and the deaths recorded on death certificates. The data have been carried back to 1890. For the most recent years (1924–1926), we have used the deaths of persons known to be cutters in a known population (i. e., in the plants where the morbidity records were kept). The death rate was reduced to an annual basis by dividing the number of deaths occurring during the study and in immediately succeeding months by three. The rates are shown in Table 75 in 5-year periods.

TABLE 75.—*Average annual death rate from tuberculosis among Barre granite cutters in 5-year periods from 1890*

	Annual death rate per 1,000	Deaths (5 years)	Average annual population		Annual death rate per 1,000	Deaths (5 years)	Average annual population
1890 to 1894	1.5	5	673	1910 to 1914	10.8	96	1,779
1895 to 1899	3.1	15	960	1915 to 1919	10.4	86	1,649
1900 to 1904	4.3	29	1,345	1920 to 1925	14.7	107	1,459
1905 to 1909	7.5	62	1,656	1924 to 1926 (study)	19.5	[1] 36	614

[1] Estimated period, 3 years.

The result is almost overwhelming. The death rate from tuberculosis has climbed from 1.5 per thousand in 1890–1894 (which is not above that of the general population at that time) to 19.6 per thousand. The latter figure is, of course, more reliable than any of the preceding because it is based on deaths known to be due to tuberculosis and silicosis among persons known to be granite cutters. But the consistent rise in mortality from 1890 on lends credence to the rates based on the death certificates and the union population figures.

It is of course unmistakably shown in these rates, rising as they do from 1.5 to 19.6 while those in the general population have declined more than 50 per cent, that there is a causal relation between tuberculosis and the use of the pneumatic hammer for granite cutting. These tools came into general use at the end of the nineteenth century, and from then on the rate of mortality rose persistently. What is more significant is the premonition one gets from such figures that the crest has not been reached. It is to be expected, in view of what has been learned about so-called "latent" silicosis, that the rate will continue upwards for a period even if the dust could be forthwith brought down to a safe limit in these plants. And if the conditions are left as they are, a rise in mortality of a staggering amount is to be expected.

In Hoffman's [58] bulletin, rates were given for New England granite cutters, having been obtained by a method similar to that used above (except for the 1924 to 1926 rate). They are for pulmonary tuberculosis only. In Figure 26 are presented Hoffman's curve, the curve based on Table 75 above, and also a curve for rural Vermont (males) from 1900 to 1921 from the census reports.

It will be observed immediately that the mortality data in this bulletin are consistent with what Hoffman found. They show that the upward trend which was evident in the New England figures in 1916 and earlier still persists to an alarming extent. There is even some suggestion that the increase has been more or less at a constant

[58] Hoffman, Frederick L.: The Problem of Dust Phthisis in the Granite-Stone Industry. Bulletin of the United States Bureau of Labor Statistics No. 293.

rate (i. e., a geometrical progression). If this is true, an alarming condition exists.

Crude rates have the difficulty of being dependent more or less on the proportion of young persons coming into the industry, and must

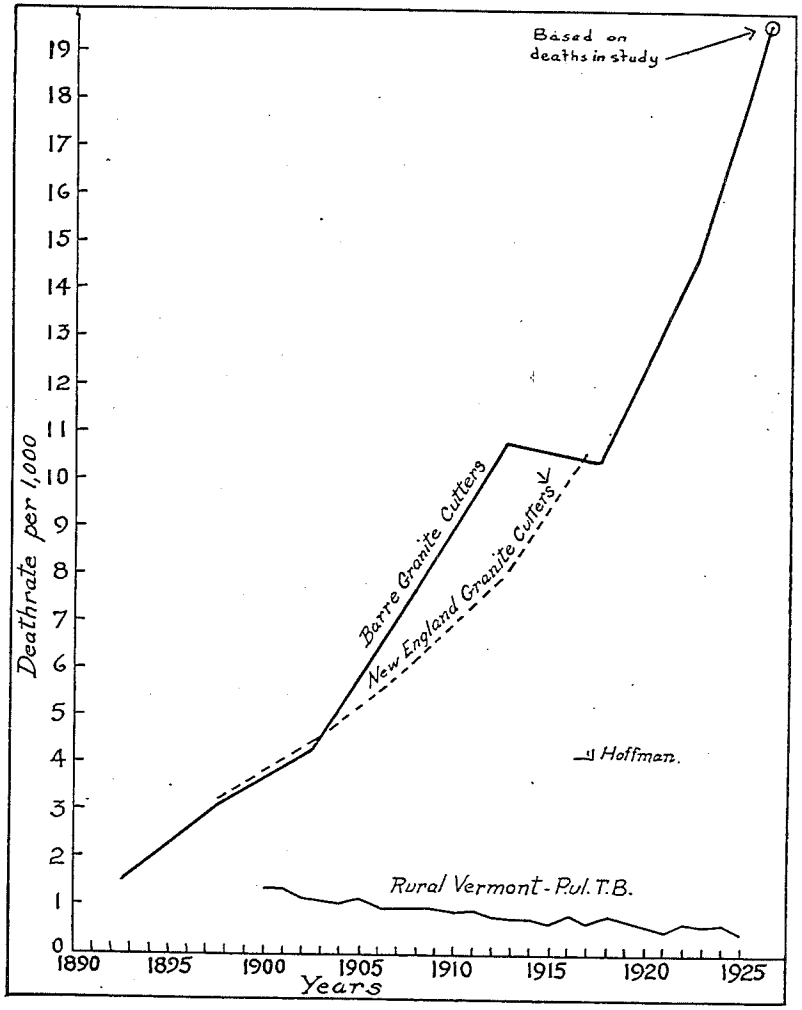


FIGURE 26.—Trend of mortality from tuberculosis among granite cutters compared with rural Vermont

therefore be accepted with some reservation. It would be preferable to show the increase for specific ages, but this is not possible.

The curve for rural Vermont shows that in 1890 to 1894 the mortality from tuberculosis among granite cutters in Barre was not particularly excessive. No comment is needed as to the rapid departure of the curve for cutters from that for rural Vermont.

CAUSES OF MORTALITY OTHER THAN TUBERCULOSIS

No information as to mortality from causes other than tuberculosis could be secured from the direct study of plants in Barre, so that particular interest attached to the analysis of the death certificates from this point of view.

It is immediately evident that the proportion of deaths from any specific cause will depend to a large extent on the proportion from tuberculosis. If granite cutters show between 50 and 70 per cent of deaths due to this cause and another occupation shows only 15 per cent, the same rate of mortality from pneumonia in the two occupations will result in a much larger proportionate mortality in the latter. A fair comparison can only be made by omitting from consideration the tuberculosis deaths in both groups. That has been done in the succeeding tables. As a result the percentage of deaths from individual causes is higher than might be expected from previous experience; but it is necessary to bear in mind that the figures do not represent strictly proportionate mortality, as generally understood, but the proportion of nontuberculosis deaths which are due to any specific cause.

Table 76 gives the percentage of deaths from certain causes among cutters and other granite workers, compared with similar data for occupied males, registration area, 1908 and 1909. The deaths are also given for specific granite occupations, but no percentages have been worked because of small numbers.

TABLE 76.—*Percentage of deaths from certain causes among Barre cutters and other granite workers, 1900–1925, and among occupied males in registration area, 1908–1909 (tuberculosis excluded from the total*[1])

	All except tuberculosis	Pneumonia[2]	Bronchitis	Other respiratory	Nephritis and Bright's disease	Heart	Cancer	Cerebrohemorrhage, apoplexy	All other
	Percentage								
Cutters, Barre, 1900–1925	100.0	22.1	2.8	8.3	11.5	12.4	7.4	5.5	30.0
Other granite[3]	100.0	13.9	.9	6.5	12.0	20.4	14.8	7.4	24.1
Occupied males, registration area, 1908–1909	100.0	10.9	1.2	1.8	11.7	16.3	7.4	10.0	40.8
	Number								
Cutters	217	48	6	18	25	27	16	12	65
Other granite[3]	108	15	1	7	13	22	16	8	26
Manufacturers and dealers	29	2	1	4	3	6	4	2	7
Polishers	21	3	-------	2	3	4	4	2	3
Lumpers	12	3	-------	-------	2	3	2	-------	2
Quarry	21	3	-------	1	2	3	3	3	6
Others	25	4	-------	-------	3	6	3	1	8
Occupied males, registration area	292,661	31,889	3,522	5,311	34,165	9,653	47,616	21,627	109,531

[1] In case of occupied males, pulmonary only could be excluded.
[2] All forms, except influenza-pneumonia.
[3] Except quarry.

What stands out is the high percentage from pneumonia among granite cutters (22.1), while the occupied males generally show a percentage of only 10.9. Other respiratory conditions, including bronchitis, seems also abnormally high among granite cutters.

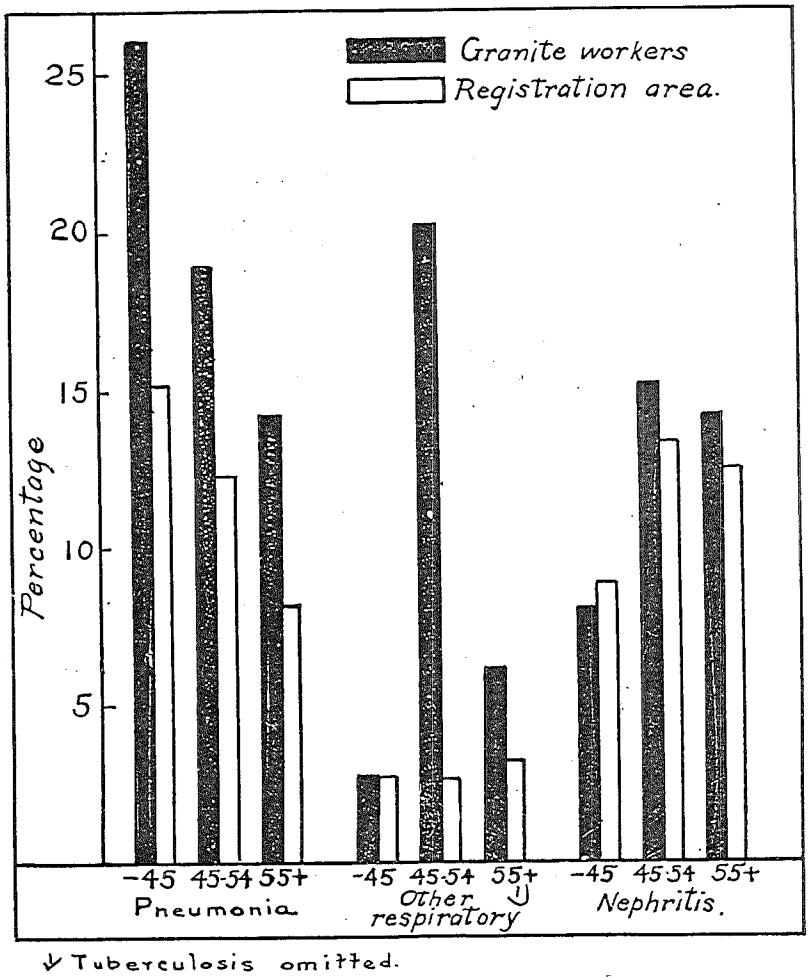


FIGURE 27.—Proportionate mortality in three age groups from pneumonia, other respiratory, and nephritis. Barre granite workes, 1900–1925, and occupied males in Registation Area, 1908–1909

In Table 77 all granite workers (except quarry) have been combined to give larger numbers, and an effort has been made to show the differences by age. Only three age groups were feasible (those under 45, 45 to 54, and those over 54). The table is limited to those conditions which had shown something of interest in the previous table (except nephritis, which was included because of the general belief of a relation between this disease and silicosis). As in the previous table, the percentages represent mortality from a specific cause in proportion to all causes (except tuberculosis). In figure 27 pneumonia, other respiratory, and nephritis are graphed separately.

TABLE 77.—*Percentage of deaths in three age groups from certain causes among Barre granite workers, 1900 to 1925, and all occupied males in registration area, 1908 to 1909 (tuberculosis excluded from total)*[1]

	Age group	All except tuberculosis	Pneumonia [2]	Other respiratory	Nephritis	Others
		Percentage				
Granite (all except quarry)	up to 45	100.0	26.1	2.7	8.1	63.0
	45 to 54	100.0	19.0	20.3	15.2	45.6
	55 and over	100.0	14.2	6.2	14.2	65.5
Registration area	up to 45	100.0	15.3	2.7	8.9	73.1
	45 to 54	100.0	12.4	2.7	13.3	71.5
	55 and over	100.0	8.3	3.2	12.5	76.0
		Number				
Granite (all except quarry)	Up to 45	111	29	3	9	70
	45 to 54	80	15	17	12	36
	55 and over	113	16	7	16	74
Registration area	Up to 45	79,417	12,121	2,163	7,056	58,077
	45 to 54	49,502	6,143	1,353	6,601	35,405
	55 and over	163,444	13,593	5,308	20,489	124,054

[1] In case of occupied males, pulmonary only excluded.
[2] All forms except influenza-pneumonia.

The excess mortality from pneumonia stands out clearly, and is a point of deep interest. There seems to be a real excess in the case of other respiratory conditions also. Nephritis probably shows nothing significant.

In view of the statement which has been made by Doctor Collis and others that the pneumonia rate is higher during the early exposure to dust, the group under 45 has been broken up into three groups: Under 25, 25 to 34, and 35 to 44. Although the number of deaths is too small to warrant a definite conclusion, the high rate in the group under 25 years of age is worth noting.

TABLE 78.—*Proportionate mortality due to pneumonia for three age groups under 45 years of age*

	Age	Percentage due to pneumonia	Number of deaths from pneumonia	Number of deaths all causes except accidents and tuberculosis
Granite	Up to 25	40.9	9	22
	25 to 34	18.4	7	38
	35 to 44	25.5	13	51
Registration Area, 1908–1909	Up to 25	14.4	2,335	16,171
	25 to 34	15.3	4,068	26,524
	35 to 44	15.6	5,718	36,722

ACCIDENTS

Certain miscellaneous comparisons were made on the basis of the death certificates, but few facts of particular interest were unearthed. The only point which will be referred to is the question of accidental deaths, which have been omitted from the preceding discussion. In view of the close connection between granite cutting and quarrying it seemed of interest to give the proportionate mortality from accidental deaths. Where the accident was clearly nonindustrial it was omitted. Hence, in the main, the accidents included in these percentages are industrial. While cutters have only 1.7 per cent (the lowest of any occupation according to this classification), quarrymen have 36.8 per cent.[59] Another occupational group with a high percentage is transportation, due to railroad accidents among brakemen, etc. In the granite-cutting industry the percentage is high among lumpers and miscellaneous workers—in other words, the workers engaged in moving the stone. The table follows:

TABLE 79.—*Percentage of deaths which were accidental (deaths clearly nonindustrial are not considered), 1900 to 1925*

Occupation	Percentage	Total [a]	Number accidents (mostly industrial	Occupation	Percentage	Total [a]	Number accidents (mostly industrial
Cutters	1.7	642	11	All except cutters and quarrymen	7.0	171	12
Manufacturers and dealers	3.3	60	2	Others:			
Polishers	5.1	39	2	Transportation	17.2	29	5
Lumpers	13.8	29	4	Manufacturing	6.3	175	11
Grinders		16		Others	2.7	373	10
Quarry	36.8	38	14				
Other granite	14.8	27	4				

[a] Exclusive of accidental deaths clearly nonindustrial.

[59] The quarries are located outside the city and therefore only a portion of the deaths among quarrymen are registered in Barre. It is not possible to determine whether the proportion given here is too high or too low.

SUMMARY AND CONCLUSIONS

The method of study used in this investigation was approximately the same as that followed in the study of workers exposed to cement and other dusts, and comprised:

1. Examination to determine general physical condition of workers under observation.
2. Special physical examination to determine the prevalence of specific diseases of the respiratory system, and the lung pathology resulting from exposure to silica dust, including X-ray plates.
3. Record of the nature and severity of disabling illness.
4. Analysis of the occupational environment.

In addition to these four fundamental divisions which comprised the basis of the calcium-dust study, two additional sections were added:

5. Occupational mortality statistics.
6. Autopsy findings.

The physical examinations in this particular investigation in addition to covering the group of workers on whom morbidity records were kept, also included a number of workers in other plants where no morbidity was obtained and a certain number of workers who had left the industry and were at the time employed in nondusty occupations. Some examinations were also made of members in the families of granite cutters.

Again, in this investigation special attention was given to obtaining sputum examinations, in view of the relationship of tuberculosis to silicosis. These examinations were particularly important in fatal cases to determine whether tuberculosis had intervened.

As in the case of workers exposed to cement dust, the investigation should not be understood as involving a study of the granite industry as a whole, or of the sanitary conditions or environment of any particular plant or group of plants. It was a study of the effect on workers of a silica dust of a definitely known composition.

I. OCCUPATIONAL ENVIRONMENT

Survey of plants.—The 14 plants dealt with in the report were located in 17 frame buildings, one story in height, so that in general the cubic capacity of the sheds would be ample if used for housing any nondusty trade. Natural ventilation by means of numerous

windows—which were generally kept closed during the winter season—was depended upon for removal of dust except in the case of sand blasters and inside surface cutters. Of a total of 76 inside surfacing machines, 28 per cent were equipped with individual fans, the remainder having a single fan for several exhausts. In general, the ventilating systems were not usually designed to meet the particular problem, and in some cases were not properly installed.

Occupational analysis.—A thorough occupational analysis was made. The processes used in granite cutting in the plants surveyed in this study differed in no way from those generally observed in this section of the country. Of the persons on whom sickness records were obtained (972 individuals), 68 per cent were in occupations in which pneumatic tools were used.

Chemical and petrographic analyses of the dust.—Silica forms 70 per cent of the total constituents of granite. Silica is the most abundant constituent of the minerals and rocks that make up the earth's crust. It occurs in two ways—as combined silica in silicates and as free silica in 10 different forms. There are three principal forms of anhydrous free silica: Quartz, tridymite, and cristobalite. In addition, there is a hydrous form, which is known as opal.

Quartz is by far the most common of the silica materials used in industrial processes or encountered in mining operations. Tridymite and cristobalite are rare, and hardly occur in the raw materials used industrially. They are the chief constituents in silica bricks, in which, however, they are of artificial origin. Opal, on the other hand, is abundant, being the chief constituent of diatomite, a substance that is finding increasing industrial applications.

Chalcedony is an important constituent of many of the free-silica materials of commerce.

A number of samples were taken of granite dust, and of these two were analyzed as being representative. Both chemical and petrographic analyses of these samples were made. The first sample showed 31.8 per cent free silica as quartz, and the second sample 38.6 per cent. The samples were also analyzed for steel fragments which might have been worn away from the tools. These fragments constituted about 0.1 of 1 per cent of the samples.

Extent of plant dustiness.—A total of 220 dust determinations were made, 100 during the summer, and 120 during the winter, to determine the extent of atmospheric pollution of granite-cutting plants. As in all of the studies, a microscopic count of the particles above and below 10 microns in diameter was made. The average dust counts for the various occupational groups varied from 59.2 million particles per cubic foot for all hand pneumatic-tool operators to 1.9 for office employees. Between these two limits were found the other occupational groups, the more important of which gave an average of

approximately 44 millions for inside and outside surface cutters, 37 millions for carvers and letterers, and 27 millions for tool grinders. While these figures represent the averages, maximum counts were between 100 and 200 millions. Polishers, sand-blast operators, sawyers, and blacksmiths gave average dust counts varying between 3 and 9 millions.

The general plant atmosphere gave an average dust count of 20 million particles, and the groups of workers exposed to this atmosphere consisted of foremen, tool boys, lumpers, boxers, cranemen, bed setters, carpenters, and mechanics.

Dust-count groups.—The wide differences in the dust counts made it possible to divide the occupational groups into four general classes based on the amount of dust exposure. These groups consisted of:

(A) Hand pneumatic-tool cutters, 614 persons, exposed to an average of approximately 60 million particles.

(B) All other occupational groups exposed to more than average plant dustiness. This group contained 104 persons in occupations where the dustiness averaged between 27 and 44 million particles.

(C) Those occupational groups consisting of 146 persons exposed to average plant dustiness (20 million particles).

(D) Those occupational groups exposed to less than average plant dustiness. This group contained 108 persons in occupations where the dustiness averaged between three and nine million particles.

This grouping was based entirely on the amount of exposure in the various occupational groups without reference to the physical examination findings or the sickness records.

Summer and winter conditions.—Practically no differences between summer and winter conditions as to dustiness were found in any of the occupations. This was due to the fact that in the summer time the dust removed by the ventilation systems was blown back into the plant through the open windows.

Helmets for sand blasters with positive air pressure.—The dust counts showed that approximately one-sixth as much dust was breathed by a sand-blasting operator using a helmet which was supplied with positive air pressure as by an operator using a helmet without positive air pressure.

Types of exhaust systems for surface cutting machines.—Two types of exhaust systems were in general use for surface cutting machines: (1) Where an individual blower was supplied to each machine; (2) where a large blower was used to remove the dust for from two to eight surfacers. The latter system was in more general use (only 28 per cent of the surface machines being equipped with individual exhausts). Due to improper design, this system was sometimes less effective for machines farthest away from the blower.

Dust counts in various dusty trades.—In comparison with the dust counts made in the other dusty trades studied by the Public Health Service, granite showed the highest average count, except for hard and soft coal. Due to the higher percentage of free silica as quartz, however, granite cutting was certainly first in the list so far as the magnitude of exposure and dangerousness to health were concerned.

II. FACTORS INFLUENCING SICKNESS RATES

General considerations.—A year of observation (which was either the record for a single individual for a year or for several individuals for parts of a year, the sum of whose periods of observation as to sickness equaled one year) was the unit usually employed for the calculation of sickness rates.

Morbidity records were obtained on 972 persons, totaling 1,346 years of observation. Physical examinations were made of 503 granite workers, of whom 296 were in plants where morbidity records were kept. In addition, 24 persons who had formerly been employed in granite cutting, but who at the time were employed in nondusty trades, and 12 persons in the families of cutters were given physical examinations.

Physical characteristics of granite workers.—The average height of granite workers was found to be 66.9 inches, which is about the average found in general industry. The average weight of workers who had not been exposed to granite dust for a long period of time was higher than that of general industrial workers of corresponding ages. The group should therefore be considered as sturdy and should not be *per se* particularly susceptible to tuberculosis. In comparing the diseases and defects found on physical examination for granite workers with short length of service and general industrial workers of corresponding ages, there did not seem to be any marked excess in the more serious impairments. The two manifest differences appeared to be associated with the dust hazard in the granite industry—the percentage with silicosis, and the high proportion with chronic rhinitis or pharyngitis.

Length of service in the industry.—Granite workers remain in the industry longer than workers in general, and are accordingly older on the average. In fact, 75 per cent of the workers observed had been employed for 10 years or more, whereas among industries observed in other Public Health Service studies the percentage varied from 61 to 8. In comparing the various occupational groups arranged according to dust count, workers with 20 years or more service formed 55 per cent of the total in Group A, 59 per cent in B, 31 per cent in C, and 36 per cent in D. The most important percentage here is that for Group A, since 68 per cent of the workers studied fell in this group.

Age distribution.—In view of the fact that granite workers did remain in the industry for long periods of time and that the group was older on the average than the usual industrial group, it was possible to express the age of these workers in terms of their length of service, or vice versa.

Race and social conditions.—Eighty-three per cent of the workers in the industry fell in five racial groups—American, Italian, Scotch, Spanish, and French-Canadian. The Italians represented in the study were principally from northern Italy and the Swiss border. In general, the groups are rather stable groups, tending to remain in the industry, and because of the wages paid the general living conditions are above those of the average industrial population.

Effect of alcoholism on sickness rates.—In some of the other dust studies, illnesses from alcoholism caused an appreciable part of the total amount of time lost and it was necessary to consider this in the general discussion of sickness. Among the granite workers only seven 2-day or longer cases occurred. This low sickness rate due to alcoholism, however, should not be taken as an indication of the amount of drinking which may have been done among the workers.

Epidemic conditions.—No epidemics of any consequence which would tend to invalidate comparisons with other data occurred during the period of observation.

III. GENERAL SICKNESS RECORD

Morbidity records were commenced in practically all of the plants at about the same time and were carried on for two and one-fourth years.

In this particular study 68 per cent of the cases of illness were 8 days and longer, whereas in the ordinary experience among industrial workers the percentage is from 35 to 40. Therefore to make this study comparable with others and to place the emphasis on the same illness it was necessary to consider for most purposes only the serious sicknesses—that is, 8 days and longer. While this comparison is generally used, the nature and amount of 2-day and longer sickness was also determined.

General incidence of sickness.—The sickness rate per thousand years of observation for 8-day and longer cases was 176.1, exclusive of accidents. To determine the significance of sickness rates in this industry, they were compared with four other industrial groups: (*a*) Hard rock gold miners, (*b*) cement workers, (*c*) workers in the iron and steel industry, and (*d*) general sick-benefit experience.

The high rate from tuberculosis among granite workers is the outstanding point of interest (see p. 49). In addition to tuberculosis, the high rates for diseases of the nasal fossae and pleurisy stand out. The rate for all causes, eight days and longer, is much higher than the general sick benefit experience. For respiratory conditions granite is higher than any other groups compared; but for nonrespiratory illnesses granite shows nothing significant.

To obtain a more correct view of the influence of dust in the causation of specific types of sickness, comparison has been made between sickness in the granite industry and that in other dusty trades studied by the Public Health Service. (In this particular comparison, because the other studies were made on that basis, 2-day and longer cases have been used.) This comparison shows that there is evidently a difference in the nature of respiratory diseases occurring among persons exposed to different kinds of dust. Hard coal and cement have high rates for grippe and certain other minor respiratory affections. In soft coal, bronchial diseases and pneumonia are excessive; in cotton, grippe and nasal fossae conditions; in granite, tuberculosis. Pleurisy is excessive in granite and hard coal. The dusty occupations in silver polishing show no excess from any cause.

Incidence in the various dust-count groups.—In Groups A and B the incidence rate for all causes (8-day and longer) was 215 per thousand years of observation; in Group C, 105; and Group D, 61. All respiratory conditions show a striking difference due to tuberculosis (see p. 52). Even when sickness from tuberculosis and suspected tuberculosis is eliminated, the respiratory rates are still higher in Groups A and B than in Groups C and D, due primarily to influenza and colds. Nonrespiratory diseases are higher in Groups A and B than in Groups C and D but do not show as marked a contrast. There is a positive suggestion in this material that the general sickness rates among granite cutters, as well as the tuberculosis prevalence, reflects excessive dust hazard.

Incidence by length of service.—The incidence rates for C and D groups declined with increasing length of service or age. A and B groups show a rapid increase in rates from 116 per thousand to 325 per thousand for A, and from 108 per thousand to 375 for B. Tuberculosis accounts for a large proportion of the increase in A and B groups, but respiratory diseases still show an increase even after sickness from tuberculosis and suspected tuberculosis has been subtracted. It is of considerable importance to note that groups A and B at the beginning of industrial life have sickness rates which correspond to those in C and D groups.

A somewhat higher rate of respiratory sickness was found among persons diagnosed as having silicosis than among those diagnosed as not having silicosis. This difference is especially noted in illnesses from colds and influenza (2-day or longer cases).

Duration of sickness.—The severity rates among granite workers were excessive, more than 16 days per person per year. Most of this excess is due to tuberculosis (see p. 59). Severity of respiratory diseases in the granite industry as compared to a rubber company shows very little difference in all respiratory conditions except tuberculosis. Comparison of days lost in the different dust-count groups in the granite industry itself shows a slight excess in the A and B groups over the C and D groups for nonrespiratory illnesses and for all respiratory except tuberculosis and suspected tuberculosis. This difference is especially marked among persons with advanced length of service.

Percentage of workers sick during the study.—The occupational groups with highest exposure to dust show the largest percentage of persons with illnesses, whether the criterion be all illness, respiratory, colds, influenza, or nonrespiratory illness. Also the percentage of persons affected in the A group generally shows the tendency to be higher among those with advanced length of service.

Absence from causes other than sickness.—Higher rates of sickness in dust-count groups A and B could not be due to failure to classify absence as due to sickness, since there was also a much greater proportion of absence from causes other than sickness in these two groups.

Sickness prior to the development of tuberculosis.—The rate for all causes among persons who subsequently developed tuberculosis was nearly three times as high as among those who did not. The excess is found in the case of nearly all diagnoses. Special note should be given to the large number of ill-defined conditions from which this group suffered, especially "fatigue."

Mortality during period of study.—Tuberculosis caused 81 per cent of the deaths during the period of the study (see p. 69).

IV. PHYSICAL EXAMINATION FINDINGS APART FROM SILICOSIS AND TUBERCULOSIS

The group of short-time workers who received physical examinations is believed to be representative of such workers in the granite industry in this locality. The fact that all persons with tuberculosis were given physical examinations makes the longer-service group unrepresentative of the average long-time worker.

Chest expansion and vital capacity.—The average chest expansion among granite workers starts at 7.7 centimeters. After 20 years of service this is 6.4; after 35 years, 3.6 (among persons without tuberculosis or suspected tuberculosis). This more rapidly diminishing

chest expansion is regarded as a cardinal physical sign accompanying silicosis. Vital capacity showed little relation.

Bronchitis.—The fact that the diagnoses used in the morbidity records were usually obtained from physicians in private practice removed any personal factor in the diagnosis. Bronchitis was not frequently found as the cause of sickness among these granite workers. The low incidence of this disease was also borne out by the small percentage of cases found on physical examination.

Hearing.—There is a more rapidly increasing rate for defective hearing among granite workers with length of service than found for industrial workers generally. In fact the contrast in later industrial life is so great that there seems no reasonable doubt of the relationship between defective hearing and granite cutting.

Blood pressure.—Except for workers with tuberculosis, no differences were found in the blood pressure in comparison with the general industrial population.

V. SILICOSIS

The basis of diagnosis in uncomplicated cases.—The diagnosis as to the nature and extent of silicosis was made from the history and physical examination findings and was corroborated by X rays where obtained. Apart from the X rays the main points on which the diagnosis of silicosis was made were the history of exposure to dust, record of the development of a nonproductive cough, and occasional pains in the chest which are incident to the development of pleurisy in relation to silicosis. In early cases there was generally a beginning of impairment in resonance and a diminished tactile and vocal fremitus, with diminished breath sounds; hyperplasia of the muscles of the chest; evidences of still greater impairment in resonance and in the most advanced cases evidences of consolidation. Tactile and vocal fremitus appeared to diminish in proportion to the length of exposure, and there was a general softening of all respiratory sounds.

Medical findings.—Patients with silicosis in general appeared to be well nourished, and, except in advanced cases, there was usually no evidence on casual examination of any impaired physical ability. Very early in silicosis there is a limitation in the expansibility of the chest. In some of the advanced cases the maximum chest expansion was 2 centimeters.

Dyspnœa is the principal complaint of workers with silicosis, which in the early stages was noticeable only on exertion. It increased in direct proportion to the exposure to dust.

Another common complaint was pains in the chest, usually of a transient nature. The pains are part of the development of pleurisy which is coincident with the progress of silicosis. When the condition is severe enough to cause loss of time from work, it is usually a sign of incipient tuberculosis. No case of pleurisy with effusion was found either on physical examination or in the sickness reports.

An additional important symptom is that of a slight cough, usually without expectoration, and probably not of a pulmonary origin, but resulting apparently from mechanical irritation of the upper respiratory tract.

Changes in breath sounds, together with impaired resonance, limited chest expansion, and changes in fremitus were the most constant findings in these cases of silicosis. Tuberculosis or bronchitis as complications of silicosis produce râles, but in uncomplicated cases râles are absent. Toxemia is absent in silicosis uncomplicated by infection.

Findings based on examination of X rays.—The X ray indicates that silicosis follows a rather definite form in its development. There is a general thickening of each hilum and of the trunk shadows, the latter being indicated by linear markings throughout. In advanced cases there was confluence of shadows, forming consolidations. Mottlings, frequently referred to by other investigators, were conspicuously absent in these cases of silicosis. The angles of the diaphragm are not always clear, particularly at the cardiac end, and the overlapping of thickened pleura also adds to the densities in this region. Irregularities of the diaphragm were frequently observed, being present in 40 per cent of the cases. It is evident from clinical and X-ray findings that a chronic pleurisy is a definite part of the pathology of silicosis.

Percentage of workers with silicosis by length of service.—Having a clear-cut diagnosis of silicosis and complete information with regard to the magnitude of dust exposure, it was possible to study the proportion of persons developing silicosis by length of service. In the A group, or that group in which there was heaviest dust exposure, the first case of silicosis appeared after approximately two years of service, and by four years of service all in this group seemed to have developed at least an early case of silicosis. In the same dust-count group the first case of more developed silicosis appeared after five years of service, and by nine years approximately 90 per cent had advanced to this stage. The study of the other dust-count groups showed that the development of silicosis was proportionate to the dust exposure. In the case of the D group, two cases of early silicosis occurred after 10 years' exposure, and one case of moderately developed silicosis after 6 years' exposure.

Atypical cases.—The summary of the physical and X-ray findings which have been given inclines one to the belief that as a rule silicosis of granite workers takes a rather regular form in development. A

few cases were found, however, which presented signs or X-ray findings indicating a departure from the usual type. The whole group of atypical cases is considered here, although some of them were complicated by tuberculosis.

Several cases showed consolidated areas in the apex or upper portion of the lungs but no indication of a tuberculous condition; in one of these cases such areas were of a bilateral nature.

In several other atypical cases the site of pathology was in the bases and it was of a more acute nature. In one of these cases there were physical signs of pneumonia but no toxic symptoms. Resolution took place very slowly, over a period of several months. Another case showed unilateral consolidation, with sudden onset. This case, instead of resolving in the way in which the previous case did, showed the presence of tuberculosis during a similar prolonged resolution.

One case simulated miliary tuberculosis but the general condition of the worker was good. Perhaps the lesion was latent.

An additional case was that of a person with extreme dyspnoea but no toxic symptoms. This condition appeared to exist because of the development of a far-advanced silicosis to which the tuberculous condition was only incidental.

The last of these atypical cases had tuberculosis about the time he began to work, 32 years previously, and had bacilli in the sputum at least 5 years previously. The case was unusual, due to its long duration and the slow progress of both the tuberculous and silicotic conditions.

VI. TUBERCULOSIS COMPLICATING SILICOSIS

The prevalence of tuberculosis was based on the proportion of persons found to have the disease rather than on the incidence of the disabling illness resulting from it.

With accurate chest examinations and the use of laboratory methods in the differential diagnosis, it was generally found possible in this study to differentiate between silicosis and silicosis complicated with tuberculosis. This was especially true in early silicosis, but in advanced stages, on account of the enormous amount of pathology present, the diagnosis of tuberculosis was much more difficult. In cases of silicosis, tuberculous lesions, although abnormally located, are generally found in the base of the lung, and do not lose the definite and consistent signs found in tuberculosis. Practically no nonpulmonary tuberculosis was observed except as associated with the pulmonary forms of the disease.

Types of tuberculosis found.—Two distinct groups of cases of tuberculosis were found among granite cutters, the principal differences be-

ing found in the ages of the patients, the length of exposure to granite dust, location of the lesions, and the course and prognosis of the disease. The first type of tuberculosis found—which forms the great majority of the cases—was comprised of workers who had a well-developed silicosis. The average age of these workers was 49, with an average dust exposure of 28 years. In contrast to the second group the onset of the disease was rather sudden, and ran a rapid course, terminating fatally. The general location of the tuberculous lesion was basal. There were no periods of quiescence in any of the cases which came under observation, nor were there any recoveries. Some of the cases found near the end of the study had not been observed sufficiently long to determine the end result. The second type of tuberculosis observed, which has been termed concurrent silicosis and tuberculosis, resembled the disease in persons not exposed to dust. In this group of cases the lesions were usually located in the apices; the course of the disease was slower than in older cutters; and the ages of the group ranged from 24 to 38 years, with a length of exposure to dust of from 3 to 13 years, averaging 8 years.

Institutional treatment appeared to have no effect in retarding the development of the disease. Patients were perhaps more comfortable and obviously were less of a menace to their families and to the public, but the course and the prognosis of the disease did not appear to be altered.

The basis of diagnosis.—The physical signs which were taken as a basis of diagnosis of tuberculosis complicating silicosis were unilateral limitation of expansion, areas of dullness, in addition to the general impaired resonance already existing, increase of tactile fremitus over the tuberculous lesion or cavity, change in breath sounds where cavity formation existed, and in many cases, bronchial breathing near the tuberculous lesion. The last-mentioned diagnostic sign was much less conspicuous because of the diminished breath sounds resulting from the silicosis. The presence of râles was an almost constant finding in cases of tuberculosis, and these were of the latent or post-tussic type. These physical signs considered in connection with the clinical symptoms of the patient were the main points upon which diagnosis was made.

Sputum analyses.—Sputum analyses in cases of tuberculosis complicating silicosis showed that bacilli were present in the first specimen in 20 cases, in the second specimen in 4, and in the third specimen, 3. Cases which showed an absence of bacilli in sputum were 8 in number. With an average of approximately 2 tests per person 77 per cent of active, excluding early, tuberculous cases gave a positive result. These findings taken in connection with the findings of the Vermont State Sanitorium (for early cases only), which showed that

76 out of 88 granite workers had tubercle bacilli in the sputum, and from the records of the Washington County Hospital at Barre, which showed that out of 34 cases only 1 gave negative test, indicate that in the great majority of instances at least the diagnosis of tuberculosis as a complication of silicosis made from the diagnostic signs, symptoms, and X rays was correct, and accordingly that deaths from silicosis uncomplicated by tuberculosis did not occur in this study.

General prevalence of tuberculosis complicating silicosis.—In plants carrying morbidity records, where it was believed certain that all cases of tuberculosis were diagnosed as such, the total rate was 5.7 per cent or 6.5 per cent if early cases are included. Latent or suspected cases of tuberculosis (among those given physical examinations) gave an additional 3.8 per cent. These figures represent the number of cases found over a period of two and one-fourth years, and consequently the rate is different from what would be obtained on an ordinary cross-section survey.

Age distribution of cases.—The age curve of pulmonary tuberculosis among granite workers was found to be greatly different from that in the general population. The characteristic high point in middle life has disappeared and instead the curve rises steadily to the end of life. No cases were found under 20 years of age. Beginning with an approximate average of 2 per cent in the 20 to 24 year age group, in the age group 55 years and over the rate rises consistently to about 20 per cent.

Tuberculosis by dust groups and years in granite.—The association between the high tuberculosis prevalence among granite workers and the dust hazard was shown by determining the rates for that disease in the different dust-count groups by length of service in the granite industry. The comparison between A and B groups and C and D groups was extremely significant. No cases were found in the D group, and C group furnished but three cases, one of which occurred under 5 years' exposure; another, under 10 years. Of particular importance is the fact that in 35 years of exposure the rate did not rise. Rates for the A and B groups rise steadily with increase of length of service to 15.5 per cent in Group A and 19.1 per cent in Group B. Even when the suspected tuberculosis cases are added, the general picture is not materially changed. In neither the C or D groups does there occur any excess of cases after long exposure, while in the A and B groups the rate rises with length of service in a similar manner as for active tuberculosis.

Morbidity from tuberculosis.—It was possible to obtain a very clear picture of the clinical progress of tuberculosis, including, in many instances, the nature of any sickness prior to the development of the

condition, and frequently the course and duration of the disease itself, terminating in death. Because of the long period of observation it was possible to determine the average time elapsing between the beginning of disability from tuberculosis and death. This average was found to be about 15 months. Not only is the course of the disease comparatively short among granite workers, but, as has been referred to, except in one instance, we have no record of any cases becoming quiescent such as are generally found in cases of tuberculosis in the general population, and no record of any recovery. When considered from another angle, that is, days lost from active tuberculosis by length of service and dust-count groups, the same conclusion as to the relationship between length of service and magnitude of dust exposure is borne out. It is noted that for persons in Group A with more than 25 years' length of service, 31 days were lost per person per year, a figure which is in great contrast to the amount of disability from tuberculosis occurring in the general industrial population.

Racial susceptibility.—Only two racial groups, Italians and Scotch, contained sufficiently large numbers to obtain accurate rates for cases of tuberculosis. The Scotch showed a percentage of 13.6 as compared to that for Italians of 19.1, for workers in Groups A and B. It is felt that this indicates no special racial susceptibility.

Mortality from tuberculosis.—Since the period for which deaths were collected covered about three years and the population in the plants carrying morbidity records was accurately known it was possible to obtain an annual death rate. This rate for deaths from tuberculosis was 14.1 per thousand workers, a rate which is in excess of the death rate for all causes in the general population, and, of course, very much in excess of the corresponding rate in an ordinary industrial population. The annual death rate per thousand was considered for the various dust-count groups and found to be 19.5 in Group A, 12.8 in Group B, 2.3 in Group C (one death only), and no deaths in Group D. Groups A and B were combined and annual deaths from tuberculosis were found to be 25.8 per thousand for the length-of-service group 20 to 24 years, 29.2 for the length-of-service group 25 to 34, and 46.5 for longer periods of exposure.

As in the case of morbidity from tuberculosis, the age curve for mortality among granite cutters forms a striking contrast with that of the general population. For this comparison rural Vermont was selected in order to have a group as comparable as possible. In rural Vermont the annual death rate from tuberculosis is approximately 1.5 per thousand for males over 40 years of age, showing no great variation among adults from one age to another. On the other hand,

the rate for hand pneumatic-tool cutters, which is about the same for adult persons under 35 years of age as in rural Vermont, rises rapidly, reaching a maximum of 60.6 for workers over 55 years of age.

VII. CONCURRENT TUBERCULOSIS AND SILICOSIS

(Discussed on p. 195.)

VIII. COURSE OF SILICOSIS AMONG WORKERS NO LONGER EXPOSED TO SILICA DUST

Because of the interest and the difference of opinion which exists as to the result on health of granite workers who have left the industry and gone into other occupations, special effort was made to obtain as many histories of such workers as was possible. These workers had carried on various nondusty occupations since their exposure to granite dust. In all, 24 histories were obtained. Eighteen case histories are given in detail. In 11 of these cases X rays were obtainable. All cases showed evidences of silicosis at the time of their examination, and in four the condition was in a more or less advanced stage. Again, of these 11 cases, 6 were diagnosed as having active tuberculosis, and 1 having suspected tuberculosis. An additional case, who did not have tuberculosis when examined, died of the disease three years later. All of the remaining seven cases of whom no X rays were taken were diagnosed as silicosis with tuberculosis, and all of them died prior to the termination of the study.

IX. HISTORY OF TUBERCULOSIS AMONG MEMBERS OF GRANITE CUTTERS' FAMILIES

Incident to the study of tuberculosis among granite cutters, it was possible to obtain some information regarding tuberculosis in some of the families of these cutters. Eight such examinations were analyzed. Five of the cases were under 20 years of age, and all were diagnosed as pulmonary tuberculosis, tuberculous meningitis or peritonitis. All the cases recorded were in households where a granite cutter lived or had lived who had a definite case of tuberculosis.

X. PATHOLOGICAL STUDY OF EIGHT LUNGS FROM EMPLOYEES IN THE GRANITE INDUSTRY

Pathological study was made of eight lungs from employees of the granite industry. One of these cases, a granite cutter apprentice with two and one-half years' occupational history, did not show any silicosis, his death being recorded as resulting from a rapidly growing lymphoblastoma. The remaining seven cases showed an early silicosis in one, moderately advanced in three, and far advanced in three, and of these cases there was a combination of tuberculosis and silicosis in five instances.

Gross appearances.—No case of advanced uncomplicated silicosis was found, all these cases showing lesions of a coexisting tuberculosis. Five showed a pulmonary cavity, occurring in two instances in the apices, and in three others at the base or in mid lung.

Generally, the surfaces of the lungs presented extensive pleural adhesions. The tracheobronchial lymph nodes were moderately enlarged. The silicotic nodules of cases complicated by tuberculosis were much more dense, and the tracheobronchial lymph nodes appeared smaller and more shrunken as the silicotic lesions advanced.

Microscopic appearances.—In the earliest case presented slight amounts of dust were found in the pleura, septa, and adventitial coats of the vascular and bronchial trunks. These deposits were surrounded by a very slight amount of cellular connective tissue. In the alveoli a few free phagocytes containing dust particles were found.

As the silicotic condition advances many alveoli, especially those beneath the pleura, are found completely filled with phagocytes.

The pleura, especially at its point of contact with the interlobular septa, shows areas of thickening produced either by masses of cellular connective tissue or by circumscribed nodules of noncellular hyaline connective tissue. In the tracheobronchial lymph nodes connective tissue cells largely obscure the medullary portions of the nodes.

Massive collections of cellular connective tissue are observed beneath the pleura in the septa and about both bronchial and vascular trunks. An elastic tissue stain may reveal the remains of blood vessels or bronchioles in the centers of the younger, more cellular nodules, but in the older hyaline foci no traces of elastic tissue can be detected.

In half of this group the tuberculous process developed and proceeded in a manner similar to that ordinarily encountered; in the other half, the silicosis changed and modified the course of the complicating tuberculosis. These differences in the character of the lesions have suggested the hypothesis that tuberculosis as a complication of silicosis arises from both endogenous and exogenous sources. The relative frequency of these two types of reinfection can not be determined from the study of such a small series of cases.

XI. MORTALITY AMONG GRANITE WORKERS AS INDICATED ON DEATH CERTIFICATES

It was possible to make transcripts from the death certificates for all deaths occurring in Barre from 1900 to 1925. Deaths from tuberculosis were transcribed from 1890 to 1925. Although the occupations of the persons dying and the cause of death could be obtained with some accuracy, no information was available as to the population among whom these deaths occurred. It was therefore necessary to use proportionate mortality in analyzing the material from the standpoint of occupation.

Crude proportionate mortality from tuberculosis.—It was found that whereas the proportionate mortality due to tuberculosis among occupied males in the registration area (1908–9) was 17.1 (pulmonary only), the proportionate mortality for granite cutters was 65.6. For other granite workers the proportion varied from 52 for lumpers, 50 for manufacturers and dealers (including a number of cutters), and 40.5 for polishers, to 31.3 for grinders. The high proportion for such occupations as lumpers and polishers is possibly due to a confusion in the statement of occupation made to the attending physician or a transfer from one occupation to another within the granite industry.

The high proportion of deaths due to tuberculosis in the granite industry is not common to the industries of that city, as was found by determining the proportionate mortality for such other industries. With the exception of clerical, these industries did not vary widely from the figures for the registration area.

Age.—As in the case of previous comparisons, the most significant contrast is obtained when age (equivalent to length of service) is considered. While the proportionate mortality from tuberculosis according to age among occupied males in the registration area is highest from 25 to 34 years of age and thereafter declines very rapidly, among cutters it remains very high up to 65 years of age. When the ratio is taken for corresponding ages between the proportionate mortality for cutters and that for occupied males in the registration area, the contrast becomes very clear, the ratio, rising from little over 100 under 35 years of age to 1,400 in advanced ages.

Comparison chronologically.—Taken chronologically, it was found that while the proportionate mortality from tuberculosis in the general population has shown a remarkable decline, the proportion among granite cutters, on the other hand, has risen from 51 in 1900 to 1906 to 72 from 1920 to 1925. This change must be considered in the light of the ratio between deaths from tuberculosis and deaths from other causes; for instance, 46 deaths occurred from tuberculosis among cutters from 1900 to 1906 and 44 from other causes, while

from 1920 to 1925 the figures were respectively 133 and 52; thus there was an increase in the ratio from 105 in the first period to 256 in the last period, making a percentage increase of 144.

Using population figures supplied by the Granite Cutters' Union, it is possible to determine approximate annual mortality rates among the cutters from 1890 up to the present time, the figures increasing from 1.5 in 1890 to 1895 to 14.7 in 1920 to 1925. As previously shown, the annual mortality rate in this study itself covering the period of 1924–1926 was 19.5. This rapid increase in the annual mortality rate from tuberculosis among granite cutters was coincident with a very rapid decrease in the rate in the general population.

Causes of mortality other than tuberculosis.—In view of the large proportion of deaths from tuberculosis it was necessary to subtract these deaths before calculating the percentage of mortality due to other causes. It was then found that there was a percentage of mortality from pneumonia among granite cutters of 22.1, while occupied males (1908 to 1909) showed a percentage of only 10.9 of all nontuberculous deaths. Other respiratory conditions, including bronchitis, also seemed abnormally high among granite cutters. In case of pneumonia the highest proportion was in the age group under 45 years. This would seem to indicate that pneumonia is probably more prevalent among new workers in the industry. Deaths from accidents were excessive only among persons working in the quarries.

GENERAL COMMENTS

The most important contribution of this study has been a picture of what happens to men working for many years under a dust hazard of a known character.

The significant features of this picture are:

(*a*) The long period of service before the liability to tuberculosis becomes manifest (generally 20 years or more).

(*b*) The sharp correlation between length of exposure to the dust and the prevalence of tuberculosis and also the death rate from this disease.

(*c*) The close relation between extent of dust exposure and health of the men.

(*d*) The universal occurrence of silicosis among the workers.

(*e*) The large proportion of workers finally succumbing to tuberculosis.

(*f*) The almost invariably fatal form of the disease within a short time after the onset.

(*g*) The different character of silicosis as manifested by X rays compared with that shown where there is exposure to a dust with a much higher content of free silica.

(*h*) The location of the tuberculous lesion, usually basal, where the disease complicates silicosis.

(*i*) The absence of deaths from silicosis per se, tuberculosis apparently always intervening.

(*j*) The failure of workers to recover from their condition upon going into nondusty trades.

(*k*) The high incidence of sickness of a severe nature from causes other than tuberculosis.

(*l*) The rising sickness and mortality rates from tuberculosis due to longer use of the hand pneumatic tool.

(*m*) The appallingly high death rates at the present time from tuberculosis, compared with normal industrial experience.

Dust exposure in the past.—The question of the approximate magnitude of exposure of all workers in granite-cutting processes throughout their period of industrial life is a most important one, if we are to relate this exposure to its effect on health and to have a basis upon which sensible recommendations for future control of the hazard may be constructed.

The use of hand pneumatic tools in granite cutting in the United States first became general approximately 30 years ago. There seems every indication, both from such observations as have been made as to the amount of dust caused by hand tools (not pneumatic) and the much lower tuberculosis rate found in granite cutting before introduction of pneumatic tools, that the dustiness was very much less than to-day.

The intensity of exposure during the period since the use of hand pneumatic tools became general is a matter of more or less supposition, except for certain facts which have been gained from a personal study of the industry and from information obtained from the workers themselves. It seems certain that the introduction of pneumatic cutting was gradual, so that there was no abrupt change in dustiness during a short period of time. On the other hand, there is definite information to the effect that there were a smaller number of sheds and greater concentration of workers in these sheds 10 or 15 years ago than is found at the present time. The use of ventilating devices for the removal of dust from surface-cutting machines belongs to a still more recent period and there is little doubt that the efficiency of these devices has been improved in recent years. These several conditions would indicate that in the early period of use of the hand pneumatic tool there was probably a greater amount of dustiness, especially in the general plant atmosphere, than exists at the present time. On the other hand, the fact that the dust counts for the hand pneumatic-tool operators were taken near the source of dust inclines to the

belief that conditions for these operators individually have not materially changed since the introduction of the pneumatic tool.

Practicable limits of dustiness.—On the basis of the foregoing statements of the past record of dust exposure of granite workers, if we may accept these in a general way, and our more accurate knowledge of present exposure, together with the information obtained from the mortality and morbidity studies, it is possible to form some rough ideas of the limits of dustiness which may be regarded as reasonably safe from a health standpoint.

In estimating such limits consideration must be given to the record of tuberculosis and other sickness in the four dust-count groups, each having a known concentration of dust exposure. It was found that the A and B groups show unmistakable indications of the serious effect of the hazard. In those groups the average dustiness was from 40 to 60 millions of particles per cubic foot of air. Group C, which represented the occupations with a dust count equal to that of the general plant atmosphere, showed an average of about 20 million particles. There was little indication in the study as a whole of any serious effect on the men in this group. The death certificates showed, to be sure, unusually high proportionate mortality from tuberculosis among polishers and lumpers, who fall into Group C. Confusion between occupations or change in later life from cutters to a less exacting occupation may explain part or all of the excess. But one would hesitate to be positive that no harm would come to persons working for many years under a concentration of 20 million particles. In Group D, where the average concentration was 6 million particles, there was no indication whatsoever of any unfavorable effects on health, either from the physical examinations, the sickness records, or such mortality data as were applicable to this group.

From this line of reasoning, the average dust exposure for Groups A and B must be considered as definitely harmful to the worker. There remains, then, Group C in which, with an average exposure of 20 million particles, there is some question as to the harmful effect, and Group D, with an average exposure of 6 million and a limit of 9 million,[60] where no harmful effect is found. Thus it would appear that a safe limit lies somewhere between the amount of dustiness found in Groups C and D or between 9 and 20 million particles.

The ventilation problem.—The practicable means of attaining such a limit of dustiness for all workers in the plants lies in the provision of adequate ventilating devices for hand pneumatic-tool cutters, so arranged as to remove the dust practically at its source.

A few points of particular importance must be brought out.

First. Observations in certain granite plants located in other cities have shown that local exhaust devices can be economically

[60] Polishers in one plant were housed separately.

installed which will reduce the dust count for the dust-making occupations to less than 20 million particles per cubic foot of air and the general plant atmosphere to approximately 5 million particles. The cost of the devices installed in these plants was not found to be prohibitive; in fact, the dust problem had been met adequately in these plants with a comparatively small expense. The subject is covered fully in an article to be published in the United States Public Health Reports,[61] both as to the required amount of air to be exhausted and the type of ventilating devices used.

Second. In observations made both in the plants in which the present study was conducted and in the plants in which proper types of ventilating devices had been installed, there is evidence of conclusive nature of the necessity for the maintenance of these ventilating systems in proper running order through competent supervision of intelligent foremen or machinists, if the full value of the devices both from an economic and a health standpoint is to be maintained. It is impossible to emphasize this point too strongly. In the poor plants observed in this study, the ventilating equipment was not only of little value, but in the case of many of them, as shown by the comparison of summer and winter dustiness, there was an actual menace to the workers because dust was blown back through the windows when open. Even in the better equipped plants improper placing of exhausts or clogging due to improper maintenance largely negatived the full value of the devices.

Third. From observations in both types of granite plants, it is evident that, in so far as possible, ventilating devices which operate irrespective of the attention or desire of the worker himself are most desirable, and that common sense education of the worker to understand and utilize the devices which are provided for the protection of his health is a vital necessity.

Fourth. By segregating in separate rooms or buildings those occupational processes in which little dust is produced.

Although reference has been made to the studies of Bloomfield in the more modern equipped granite-cutting plants, and their success in reducing the amount of dust at its source, namely, in the operation of hand pneumatic tools, it is on this particular phase of the subject that our information is weakest and where there is a vital necessity for additional research work. Fortunately, the department of ventilation of the Harvard School of Public Health under the charge of Dr. Philip Drinker has been investigating this problem for the past year, and with this work completed, the problem of the health hazards of the granite industry in America seems well on its way to a solution.

[61] Bloomfield, J. J.: A study of the efficiency of dust-removal systems in granite-cutting plants.

Medical supervision.—The control of the intensity of dust exposure of granite workers will for the most part solve the important problems of the health hazards in this industry. On the other hand, it would seem wise that a check should be made as to this expected improvement in health conditions by some sort of medical supervision of the workers to prevent the entrance into the industry of individuals more than usually susceptible to tuberculosis, to remove workers from the industry if tuberculosis does develop, and, of most importance, to recognize the development of silicosis among these workers.

This final question is far from being a simple one, since neither this study nor any other observations which have been made with respect to granite cutting in the United States give us information as to the amount of silicosis which may develop without making the worker more susceptible to tuberculous infection.

This study does suggest several broad conclusions which appear to bear on this point. In Group D, where there was exposure to small amounts of silica dust over long periods of time, there was no tuberculosis, although silicosis did exist. On the other hand, the group of workers who had left the industry after severe exposure and gone into nondusty occupations appeared to develop tuberculosis to almost the same degree as workers who remained in the industry. This would incline to the belief that a moderate amount of silicosis, slow in developing, is not incompatible with a long working life and is not a serious inconvenience to health; but that the contrary is true of a severe exposure even for relatively a short period, and that in these cases removal of the worker from the dusty occupation is of no avail. A clearer understanding of the factors which bear upon the developing silicosis and the susceptibility to tuberculosis must be reached. It is desirable that research work should be continued both in the laboratory and among workers exposed to silica dust to determine some of the points which have been raised in this summary.

What appears to stand out most clearly is that a maximum of dust exposure, falling somewhere between 10 and 20 million particles per cubic foot of air for the dust-making occupations, for a dust which contains from 25 to 35 per cent of free silica in the form of quartz, is a desirable limit, and that it can be obtained by the use of economically practicable ventilating devices applied to the source of the dust.

A warning.—The rapid rise in mortality from tuberculosis among granite cutters since the adoption of the hand pneumatic hammer, forming so sharp a contrast with the course of the disease in the general population, is of peculiar significance. It has been found that little tuberculosis under the atmospheric conditions existing in these plants develops until after 20 years exposure to the dust, after which period the liability to the disease increases rapidly. It is natural therefore that the full force of the hazard is only just beginning to

be felt. Since it may well be that the dustiness of the atmosphere in these plants is less to-day than in recent years (when larger numbers were employed and less precautions taken), there is something ominous about the persistently rising mortality rate. Justification for this apprehension may be found in the section devoted to workers formerly employed as granite cutters, but afterwards engaged in non-dusty trades, together with similar experiences in other studies. The silicosis has continued to progress even after removal from the dust hazard, and the liability to tuberculosis has not decreased and may have, indeed, become greater. In fact, even if adequate local exhaust ventilation were immediately provided in all of the plants to reduce the dust level to a safe limit, it seems evident that the deaths from tuberculosis among workers who have used the hand pneumatic hammer for a long period would continue to occur and that perhaps the death rate would rise much beyond its present level.

ADDITIONAL COPIES
OF THIS PUBLICATION MAY BE PROCURED FROM
THE SUPERINTENDENT OF DOCUMENTS
U. S. GOVERNMENT PRINTING OFFICE
WASHINGTON, D. C.
AT
$1.15 PER COPY
▽