PLAINTIFF'S EXHIBIT 01289.00

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PITTSBURGH PLATE GLASS COMPANY

GENERAL OFFICES
ONE GATEWAY CENTER, PITTSBURGH 22, PA.

May 16, 1962

PLAINTIFF'S EXHIBIT WV-009069

Mr. Karl Baumler
Vice President
Pittsburgh-Corning Corporation
4th Floor

Dear Mr. Baumler:

We are pleased to enclose the following items relative to your recent request about asbestos.

Toxic Properties - from "Sax"
Article on Asbestos - from a book by "Ladov"
A quote on "Asbestosis" - from a book by "Patty"
A discussion about "Asbestosis" - from a book by "Drinker & Hatch"
Hygienic Guide Series on Asbestos
Threshold Limit Values for 1961 - as established by the American Conference of Governmental Industrial Hygienists
A chart from "Patty" on "Asbestos Warts"

We asked the Library to trace down four articles on the subject. If and when they arrive, I'll forward them.

You will note that "Patty" quotes from a Dr. Carey P. McCord (M. D.). Dr. McCord is an authority and is retained by our company. Should you have any technical, medical or toxicological questions, we will be pleased to write him about them.

Of course, you know about our membership in the Industrial Hygiene Foundation and its services and advice are at your call.

Yours,

C. C. Ruddick, Manager
Safety & Plant Protection

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resulting anemia is responsible for the production of many of the symptoms accompanying arsine poisoning; other symptoms result from the hemolysis itself, and occur during the excretion of the hemoglobin. Hemoglobin and its degradation products are commonly found in the urine. Less commonly whole blood may be passed. Occasionally, the renal tubules may be plugged by débris, with resultant suppression of urine. Jaundice, which may be severe, is a common result of the hemolysis. Frequently there is edema of the lungs, which may be accompanied by cyanosis. Kidney damage is common in patients surviving acute affects of the gas.

Signs of poisoning usually develop within several hours of exposure. Headache, dizziness, nausea and vomiting, epigastric pain and weakness occur early, followed by tea-colored urine, or bloody urine in the more severe cases. Some time later, albumen and casts may appear in the urine, or, in serious cases, there may be suppression of urine. Jaundice and tenderness over the liver may appear about the same time. Blood examination shows an anemia which may be marked. In fatal cases, the patient may develop delirium, followed by coma and death. During the acute stage of poisoning and for some weeks after, arsenic may be demonstrated in the urine. See also Arsenic and Arsenic Compounds.

Fire Hazard: Moderate, when exposed to flame (Section 6).
Explosion Hazard: Moderate when exposed to flame (Section 7).
Disaster Control: Dangerous; when heated to decompositon, it emits highly toxic fumes of arsenic; can react vigorously with oxidizing materials.
Ventilation Control (use moderate rate): Section 2
Storage and Handling: Section 7

ARSPHENAMINE

Synonym: 3-Diamino-4-dihydroxy-1-arsenobenzene hydrochloride.
Description: Light yellow, hygroscopic powder.
Formula: $C_{12}H_{12}As_2N_2O_2 \cdot 2HCl \cdot 2H_2O$
Constant:
Mol. Wt. 475.0
Toxicity: See Arsenic Compounds.
Disaster Control: See Arsenic Compounds.
Ventilation Control (use moderate rate): Section 2
Personnel Protection: Section 3
Personal Hygiene: Section 3
First Aid: Section 1
Storage and Handling: Section 7

ASBESTOS PARTICLES

Synonym: Asbestos dust.
Toxic Hazard Rating:
Acute Local: Irritant 1; Inhalation 2
Acute Systemic: 0
Chronic Local: Inhalation 3
Chronic Systemic: U
MAC: ACGIH (accepted): 5 million particles per cubic foot of air.
Toxicology: The essential lesion produced by asbestos dust is a diffuse fibrosis which probably begins as a "collar" about the terminal bronchioles. Usually, at least 4 to 7 years of exposure are required before a serious degree of fibrosis results. There is apparently less predisposition to tuberculosis than is the case with silicosis.

Clinically, the most striking sign is shortness of breath of gradually increasing intensity, often associated with a dry cough. In the early stages physical signs are absent or slight; in the later stages rales may be heard, and in long-standing cases there is frequently clubbing of the fingers. In early stages of the disease the chest x-ray reveals a ground-glass or granular change, chiefly in the lower lung fields; as the condition progresses the heart outline becomes "shaggy" and irregular patches of mottled shadowing may be seen. Asbestos bodies may be found in the sputum.

At autopsy, the pleurae are thickened and adherent and thick subpleural fibrous plaques are often present. Where the disease is far advanced there are usually

From "Dangerous Properties of Industrial Materials"
By N. Irving Sax
Pub. By - Reinhold Publishing Corpn. N.Y. - 1957

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large areas of fibrosis, with emphysematous changes in the apices and bases. The alveolar walls are thickened, and the characteristic "asbestos bodies" are found.
Ventilation Control (use normal rate): Section 2
Personal Hygiene: Section 3

ASCARIDOLE
Description: Liquid.
Formula: $C_{10}H_{16}O_2$
Constants:
Mol. Wt. 168.2
B. P. 115°C @15 mm
Density 1.011 @13°/15°C
Toxicity: Details unknown. See also Peroxides, Organic.
Fire Hazard: Moderate, by spontaneous chemical reaction (Section 6).
Caution: An oxidizer.
Explosion Hazard: Explodes at 250°C.
Disaster Control: Dangerous; when heated, it emits toxic fumes and may explode; it reacts with reducing materials.
Storage and Handling: Section 7

ASPHALT
Synonyms: Bitumen; petroleum pitch.
Description: Black or dark brown mass.
Constants:
B. P.: < 470°C
Flash P. 400+°F (C.C.)
Density 0.95 - 1.1
Autoign. Temp. 905°F
Toxic Hazard Rating:
Acute Local: Irritant 2
Acute Systemic: U
Chronic Local: Irritant 2
Chronic Systemic: U
Fire Hazard: Slight, when exposed to heat or flame.
Spontaneous Heating: No
To Fight Fire: Foam, carbon dioxide, dry chemical or carbon tetrachloride (Section 6).
Personnel Protection: Section 3
Personal Hygiene: Section 3
Storage and Handling: Section 7
Shipping Regulations: Section 11.
Coast Guard Classification: Hazardous Article.

ASPIDIUM
Synonym: Male fern.
Toxic Hazard Rating:
Acute Local: Irritant 1; Allergen 1
Acute Systemic: Ingestion 2
Chronic Local: Allergen 1
Chronic Systemic: U
Fire Hazard: Slight; when heated, it emits acrid fumes (Section 6).
Personal Hygiene: Section 3
Storage and Handling: Section 7

ASPIRIN. See Acetol.

ATABRINE DIHYDROCHLORIDE. See "Atabrine" Hydrochloride.

"ATABRINE" HYDROCHLORIDE
Synonym: Quinacrine hydrochloride.
Description: Bright yellow crystals.
Formula: $C_{23}H_{30}ClN_3O \cdot 2HCl \cdot 2H_2O$
Constants:
Mol. Wt. 508.9
M. P. Decomposes 248 - 250°C
Toxic Hazard Rating:
Acute Local: Allergen 1
Acute Systemic: Ingestion 2
Chronic Local: Allergen 1
Chronic Systemic: Ingestion 2
Disaster Control: Dangerous; when heated to decomposition, it emits highly toxic fumes of chlorine.
Personal Hygiene: Section 3
Storage and Handling: Section 7

ATROPINE
Synonym: Daturine.
Description: Colorless, crystalline alkaloid.
Formula: $C_{17}H_{23}NO_3$
Constants:
Mol. Wt. 289.4
M. P. 115.5°C; sublimes at 118°C
Toxic Hazard Rating:
Acute Local: Allergen 1
Acute Systemic: Ingestion 3; Inhalation 3
Chronic Local: Allergen 1
Chronic Systemic: Ingestion 2
Fire Hazard: Slight; on decomposition it emits toxic fumes.
Ventilation Control (use moderate rate): Section 2
Personal Hygiene: Section 3
First Aid: Section 1
Storage and Handling: Section 7

ATROPINE METHYL BROMIDE. See Atropine.

ASBESTOS

Definition.—The term "asbestos," as now used, is not the name of a distinct mineral, but is a commercial term applied to any mineral which can be readily separated into more or less flexible fibers. The original asbestos was a variety of amphibole, of little present importance, but now there are several important varieties of asbestos, of which chrysotile is in most common use.

Varieties of Asbestos and Their Properties.—*Chrysotile* is a fibrous form of serpentine, with which it is always associated. It is a hydrous magnesium silicate, represented by the empirical formula $H_4Mg_3Si_2O_9$, and contains 12.9 per cent of water of composition. It occurs in aggregates of fine, crystalline silky fibers, which are flexible and have considerable tensile strength. These fibers usually range in length from less than ⅛ to 1 or 1½ inches, but fibers as long as 5 to 6 inches are sometimes found and an extreme length of 24 inches has been noted.[1] Chrysotile fibers are nearly always brilliant white, but aggregates of fibers may vary from white and pink, through yellowish and yellowish-green to olive-green. Its *Hardness* is 3 to 3.5; *Specific Gravity* 2.2 to 2.3; *Luster* sub-resinous to greasy, pearly and silky.

Crocidolite is a soda-iron, monoclinic amphibole, having the formula $NaFe(SiO_3)_2.FeSiO_3$. It is highly fibrous, like chrysotile, but its fibers have a higher tensile strength, and a much lower resistance to heat. Its color is a characteristic lavender-blue, and it is thus often called "blue asbestos" or "Cape Blue" (from Cape Province, South Africa). Fibers commonly range in length from less than ⅛ to 1½ inches and rarely exceed 3 inches. It has a specific gravity of 3.20 to 3.30 and a silky luster.

Anthophyllite is an anhydrous iron-magnesium silicate, having the formula $(Fe,Mg)SiO_3$. It belongs to the orthorhombic group of the amphiboles. It occurs in rather coarse, fairly long and usually rather brittle fibers of low tensile strength. It is more resistant to heat and to acids than chrysotile, so that anthophyllite low in iron is especially suitable for making chemical filters.

Amosite is an iron-rich anthophyllite found chiefly in South Africa. It was thought originally to be a new species and was described by Hall[2]

[1] HALL, A. L., "Asbestos in the Union of South Africa," *Memoir* No. 12, p. 15, Union of South Africa, Dept. of Mines and Industries, Geol. Survey, 1918.

[2] HALL, A. L., work cited, p. 21.

From - "NON METALLIC MINERALS"
BY - LADOO
PUB. BY - McGRAW-HILL BOOK CO. 1925

as a monoclinic amphibole. Wherry[1] later examined amosite both chemically and microscopically and found it practically identical with ferroanthophyllite, an orthorhombic amphibole having the formula (Fe, Ca, H_2, Mn)O.SiO_2. When amosite contains considerable soda it approaches crocidolite in composition. Amosite is characterized by a well-developed fibrous structure, having fibers of unusual length. Lengths of 4 to 7 inches are common and an extreme length of a little over 11 inches has been observed. The fibers are flexible, but usually have less tensile strength than chrysotile. Amosite is harder and harsher than chrysotile and is said to cause excessive wear on the teeth of carding machines. It varies in color from a pale dirty-brown through various shades of gray and pale yellowish-green to nearly white. Acids have little effect on amosite and it withstands heat better than crocidolite.

Asbestos, "*amphibole*" *asbestos*, "*hornblende*" *asbestos* and "*Italian*" *asbestos* are various terms given to the monoclinic amphiboles, tremolite (formula $CaMg_3(SiO_3)_4$) and actinolite (formula $Ca(Mg,Fe)_3(SiO_3)_4$) when they occur in fine silky fibers. This is the original type of material to which the mineralogical name "asbestos" was given. The fibers may be fine, silky and of great length, but they usually have little tensile strength. A small amount of Italian amphibole asbestos has been used for spinning, but most of it is too weak. When pure tremolite asbestos is chemically stable and may be used for making chemical filters.

Mountain leather and *mountain cork* are, respectively, thin and thick flexible sheets made up of interlocked fibers. The "cork" variety has the elasticity and lightness of cork. It is usually from light-brown to white in color and has a specific gravity of 0.68 to 0.99. One analysis[2] of mountain cork showed silica, 57.20 per cent; peroxide of iron, 4.37 per cent; magnesia, 22.85 per cent; lime, 13.39 per cent; and water, 2.43 per cent; total, 100.24 per cent. These substances have no value as sources of asbestos fibers.

Mountain wood is a compact, fibrous substance made up of interlaced mineral fibers and closely resembling dry wood. It is usually gray to brown in color. It is sometimes found in Canadian asbestos deposits, but has no present economic value.

Analyses of Asbestos.—The following table shows the average composition of the principal types of asbestos:

[1] WHERRY, E. T., "Amosite," *Am. Mineralogist*, vol. 6, No. 12, p. 174, December, 1921.

[2] CIRKEL, FRITZ, "Chrysotile-Asbestos, Its Occurrence, Exploitation, Milling and Uses," *Mines Branch Bull.* 69, p. 21, Can. Dept. of Mines, 1910.

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	1 Chrysotile	2 Crocidolite	3 Amosite	4 Anthophyllite	5 Amphibole
SiO_2	40.49	51.22	49.58	57.12	57.72
Al_2O_3	1.27	.....	2.25	0.75	0.53
Fe_2O_3 and FeO	2.53	34.08	39.64	6.36	2.80
MgO	41.41	2.48	4.79	29.44	22.61
CaO	.....	0.03	0.53	.....	13.54
Na_2O	.....	7.07	.....	.....	0.50
H_2O (const.)	14.06	4.50	3.16	5.47	0.81
MnO_2	.....	0.10			
K_2O	.....	.....	.....	.....	0.30
Total	99.76	99.48	99.95	99.14	99.11

1. Canadian chrysotile—Average of eleven analyses by Cirkel, work cited, p. 31.
2. South African crocidolite—Analysis quoted by Cirkel, work cited, p. 22.
3. Amosite, Transvaal, South Africa—Average of seven rather widely varying analyses quoted by Wherry, work cited, p. 174.
4. Anthophyllite, Georgia—Analysis quoted in "Asbestos (1913–1919)," p. 6, Imperial Mineral Resources Bureau (Great Britain), 1921.
5. Italian amphibole asbestos—Analysis quoted by Marcuse, B., "The Marketing of Asbestos," *Eng. Mining Jour.-Press*, vol. 114, No. 7, p. 278, Apr. 12, 1922.

Types of Structure[1]

Most asbestos minerals are found in veins, but some may make up the whole mass of a rock. The veins contain both cross-fiber and slip-fiber asbestos. Cross-fiber asbestos lies perpendicular or nearly perpendicular to the walls of the vein. Chrysotile, crocidolite and amosite occur in this way. Slip-fiber asbestos lies parallel to the walls of the vein. Chrysotile, tremolite, actinolite and anthophyllite occur in this way. Much slip-fiber chrysotile is rather harsh. An excessively harsh slip-fiber chrysotile is known as *Picrolite*. Anthophyllite, tremolite and actinolite may occur as mass fiber, the minerals forming interlocking bundles or radial groups of fibers.

Geologic Occurrence

Chrysotile.—Chrysotile asbestos is found in two entirely distinct geologic associations—in altered peridotite, an igneous rock very low in silica and high in magnesia and iron, and in limestone near its contact with sills or intrusive sheets of basic igneous rock.

Chrysotile occurs in peridotite in veins which either form a network in several directions through the rock or less commonly lie parallel. The peridotite near the veins is altered to serpentine. Few of the veins are more than an inch wide. The

[1] This section and the following section on "Geologic Occurrence" are taken from Sampson, Edward, "Asbestos in 1920," *Mineral Resources of the United States*, part 2, pp. 312–313, U. S. Geol. Survey, 1920.

great deposits of this kind are those of Quebec and of the Ural Mountains, regions that before the World War furnished nearly all the world's supply of asbestos. Deposits are worked in California, Wyoming and Vermont.

Deposits of chrysotile in limestone are rather widely distributed, but compared to those in peridotite they are small. The fiber may be rather harsh, but it is very long, unbroken fiber over 6 inches in length and of the finest quality having been found, whereas fiber over 2 inches in length is very rare in the deposits formed in peridotite. Chrysotile occurs with serpentine at or near its contact with sills of olivine diabase, usually the upper contact. The deposits in Arizona and in the Carolina district of the Transvaal are of this type. Deposits in limestone are found in Arizona, in southwestern Montana, and probably also in New Mexico.

Anthophyllite.—Deposits of mass-fiber anthophyllite occur in Georgia, North Carolina and Idaho. The occurrence of anthophyllite has been most fully described by Hopkins.[1] The anthophyllite in Georgia is a product of the alteration of peridotite. The altered rock consists almost entirely of anthophyllite. Hopkins points out that the fiber in the commercially valuable deposits has been greatly softened by weathering, which in this region has been very active. In fact, the anthophyllite appears to have been made fibrous by weathering, for the fresh anthophyllite, although it has a good prismatic cleavage, is splintery and of little or no value.

Two interesting deposits of slip-fiber anthophyllite in Maryland and California have recently been operated.

Crocidolite.—The only worked deposits of crocidolite and amosite are in the Union of South Africa.[2] Both occur as cross-fiber veins parallel to the bedding of an iron-rich siliceous argillite locally known as "ironstone." According to the published descriptions, the material of which the vein minerals are composed has been derived from the inclosing rocks as a result of regional metamorphism. The deposits cover a wide area over which they occur at the same stratigraphic horizon.

Actinolite and Tremolite.—Actinolite and tremolite usually occur in veins as slip fiber, generally in highly magnesian rocks. They appear to have been formed by metamorphic agencies, which have also extensively affected the country rock.

Geographical Distribution.—The only types of asbestos of any considerable commercial value are those which occur in strong, fine, flexible fibers ¼ inch or more in length, that is, fibers capable of being spun and woven into fabrics or matted into paper and similar products. The longer fibers, that is, those over ¾ inch, are by far the most valuable. Flexible fibers shorter than ¼ inch are used extensively, but are of such low value that they usually are mined only in conjunction with the longer fibers.

[1] Hopkins, O. B., A Report on the Asbestos, Talc and Soapstone Deposits of Georgia," *Bull.* 29, Ga. Geol. Survey, 1914.

[2] Hall, A. L., "Asbestos in the Union of South Africa," *Memoir* No. 12, Geol. Survey, 1918; "On the Mode of Occurrence and Distribution of Asbestos in the Transvaal," *Trans., Geol. Soc. S. Africa*, vol. 21, pp. 1-36, 1918.

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While deposits of asbestiform minerals are widely distributed over the world, there are but few localities in which high-grade spinning fibers are found in important commercial quantities. Before the World War, Canada (Quebec) and Russia furnished most of the world's supply of high-grade asbestos. At present Russian production is small and South Africa (including Rhodesia) is the only other large source besides Canada. The United States has produced some spinning-fiber asbestos (Arizona chrysotile), chiefly during the past 10 years, but most of the domestic production has been of non-spinning anthophyllite. Other countries which are small producers are Australia, Cyprus, Italy, China and India.

Canada.[1]—Canada is the largest producer of asbestos in the world, and Canadian spinning fiber is generally regarded as of the highest grade marketed in important quantities. All the asbestos now produced is of the chrysotile variety.

While asbestos occurs in a number of districts in Canada, the only deposits which have been of great commercial importance are located in an area of Cambrian serpentine rocks which extends from northern Vermont to the Gaspé Peninsula. Within this area in Quebec asbestos occurs in three prominent belts.

1. The Danville-Orford-Bolton area, which extends into Vermont.
2. The Thetford-Black Lake area.
3. The Gaspé Peninsula area.

The *Danville-Orford-Bolton area* consists of numerous, apparently disconnected outcrops of serpentine in a narrow belt about 62 miles long. The area is heavily wooded and the rocks are so deeply covered with soil and humus that prospecting and development are difficult. There has been little production from this belt.

The *Thetford-Black Lake area* is the most important area in Quebec and is, at present, the most productive asbestos district in the world. In this area some of the most productive mines are in Coleraine, Thetford and Broughton townships. In the main area the total length of the chief serpentine belt is 23 miles and the width varies from 100 to 6,000 feet in the Black Lake area and to 3½ miles in Coleraine Township. The serpentine forms knolls and ridges from a few hundred to a thousand feet in height above the surrounding country. The Broughton and the central and eastern Thetford areas contain mainly slip-fiber deposits. The vein-fiber belt, which includes western Thetford, South Ireland and North Coleraine townships, has a developed length of about 12 miles and a maximum width of about 3½ miles. The vein-fiber belt produces the highest-grade crude and spinning fiber.

[1] The most extensive work on Canadian asbestos is that by Cirkel, F., work cited, 316 pp.

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The chrysotile veins intersect portions of the serpentine in every direction, but they usually follow straight lines. The cross-fiber veins vary in thickness from mere threads up to 2 or 3 inches, but the bulk of the asbestos mined is from 1/4 to 1/2 inch in length. The longer fiber is often divided in the middle by a seam of serpentine carrying magnetite or chromite. Usually, the asbestos can be easily separated from the rock. Slip fiber occurs along slickensided fault planes and the fiber is arranged parallel to the walls in thin films, or in layers up to 3/4 inch or more in thickness. The slip-fiber veins yield only mill fiber; it is often of as good grade as mill fiber prepared from cross-fiber veins, but it is sometimes rather harsh.

The Canadian deposits are very extensive and the known ore reserves are large. Apparently the quality or the percentage of fiber varies little with depth. While the long fiber is the most valuable, it occurs in relatively small amounts and the chief production (by tonnage) is of the mill-fiber grades.

In the *Gaspé Peninsula area* some asbestos has been found, but difficulty of access has prevented the region from being adequately explored.

A small amount of chrysotile asbestos has been produced at Deloro, near Porcupine, Ontario. The absestos is reported to occur in veins, up to 2½ inches wide, in serpentine and to constitute as much as 12 per cent of the rock in places.

Union of South Africa.[1]—Important deposits of asbestos occur in several localities in the Union of South Africa. The principal types of asbestos which have been produced are crocidolite and amosite, but chrysotile is also worked and will probably become of increasing importance.

Transvaal possesses important deposits of chrysotile, crocidolite, amosite and tremolite.

Amosite is found only in a belt in northeastern Transvaal between Lydenburg and Pietersburg. This belt, which is about 60 miles long by an average of 6 miles wide, contains three groups of interbedded, cross-fiber veins, varying in width to a maximum of about 12 inches. The veins are worked by underground mining. The principal mines are the Egnep and Amosa, situated near the farms Penge and Streatham, which furnish about four-fifths of the total output.

In the Carolina district chrysotile of good quality is mined principally in the Diepgezet and Goedverwacht areas.

High-grade, pure-white chrysotile occurs near Kaapsche Hoop about 28 miles northwest of Barberton. Here the percentage of fiber is very high, averaging about 40 per cent fiber and 60 per cent rock. Moreover, over

[1] The best work on the asbestos deposits of the Union of South Africa, is by HALL, A. L., work cited, 152 pp. See also HALL, A. L., "On the Asbestos Occurrence near Kaapsche Hoop in the Barberton District," *Trans. Geol. Soc. S. Africa*, vol. 24, pp. 168–181, 1921. (Abstract in *Eng. Mining Jour.-Press*, vol. 113, No. 13, p. 524 April 1, 1922.) The account here given is taken largely from Hall's work as abstracted in "Asbestos" (1913–1919), work cited, pp. 14–16.

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25 per cent of the fiber is over 1 inch long, compared with less than 1.5 per cent in Canada.

In *Cape Province* crocidolite is the only variety of asbestos worked. It occurs in interbedded cross-fiber veins in a belt extending from the farm Lovedale, 20 miles southeast of Prieska, in a northerly direction as far as Mashowing River in British Bechuanaland, with a possible extension into the districts of Vryburg and Mafeking.

In *Natal* chrysotile of inferior grade occurs somewhat sparingly.

Rhodesia.[1]—Rhodesia is the most important source of asbestos in British South Africa. Both chrysotile and amphibole asbestos occur abundantly in many localities in southern Rhodesia. The largest production comes from the Shabani fields in the Belingwe district and from the Mashaba area in the Victoria district. In both areas chrysotile of excellent quality is found in veins of the cross-fiber type. The Shabani field, so far as it has been explored, is about 6 miles long by 1 mile wide. The fiber varies from ⅛ to 2 inches in length. The Mashaba area seems to be smaller and the fiber is rarely over ¾ inch in length. The yield of asbestos fiber in the Mashaba area is said to range from 1 to 1.5 per cent of the rock broken, and in the Shabani area from 1.5 to 3 per cent.

Asbestos also occurs, and has been prospected to some extent, in the Lomagundi and Bulawayo districts.

Russia.[2]—While Russia before the World War was the second largest producer of asbestos, recent detailed descriptions of Russian deposits are not available. A general description of these deposits was given by Diller[3] in 1908, from which the following is taken:

> Russian asbestos is much harsher to the touch than Canadian, and less suitable for spinning, but before the World War the production was large and growing.
>
> There are two general districts in which asbestos has been produced. The first, and by far the largest and most important, is in the Perm district of the Urals in which there were 25 mines in operation in 1905. The principal mines are 51 miles north of Ekaterinburg, where a zone about 18 miles long by 2 to 3 miles wide has been developed, but other localities are known nearly to Orenburg. The other developed district is in the Minusinsk district on the Yenisei River in Siberia, but many other undeveloped deposits are reported in the Altai mountains region and to the southward.

Before the war most of the Russian asbestos was exported to Germany. For several years after the Russian revolution no asbestos production was reported, but a small production was noted in 1922.

[1] See Mennell, F. P., *S. Africa Jour. Ind.*, vol. 1, p. 1411, 1918. Also anonymous articles in *S. Africa Mining Eng. Jour.*, sp. ed., pp. 82–89, December, 1920. The description given here is from "Asbestos" (1913–1919), work cited, pp. 11–12.

[2] See Cirkel, F., work cited, pp. 222–229.

[3] Diller, J. S., "Asbestos," *Mineral Resources of the United States*, part 2, pp. 702–703, U. S. Geol. Survey, 1908.

United States.[1]—Both spinning-fiber chrysotile and non-spinning anthophyllite occur in the United States, but the former is not found in large quantities, and production, compared to that of Canada, has been very small. While deposits of asbestos have been reported in many states, production has resulted from but few deposits. Arizona has been the only important producer of chrysotile, but a small production has come at various times in the past from Vermont, Wyoming and California. Anthophyllite has been produced mainly in Georgia, but Idaho, Maryland and Californa have also been producers.

Arizona.[2]—Chrysotile asbestos occurs in several localities in Arizona, but it is mined chiefly in two regions: in the Grand Canyon, and in the field 24 to 40 miles in a direct line north and east of Globe. The production in the Grand Canyon district has been small and not continuous. The Globe field is about 50 miles in length and 20 miles in width in a deeply cut mountainous region along Salt River and covers an area of of about 700 square miles. Most of the mines in the Globe region are in four districts; (1) near Chrysotile on Ash Creek, about 41 miles from the railroad shipping point; (2) near Salt Bank on Salt River; (3) near the summit of Coon Creek Butte, at the south end of the Sierra Ancha; and (4) near the head of Sloane Creek, a branch of Canyon Creek.

The asbestos, which is of the cross-fiber type, occurs in veins in limestone chiefly near the upper contact with intruded sheets of diabase. Arizona chrysotile differs chemically from Canadian chrysotile in the very small amount of iron oxide which the former contains (Arizona usually 1 per cent or less of FeO and Canada usually 2.5 per cent or more of FeO). A part of the Arizona fiber is very soft and silky and a part is harsh and splintery. These two phases often occur in the same vein with no visible boundary between, and are hard to distinguish. This necessitates very careful sorting and milling if a high-grade fiber is to be produced. While spinning fiber of good grade and length can be produced, users state that the highest grades are so fine and silky that there is a high loss in spinning. Fiber lengths up to 4 inches sometimes occur but lengths less than 2½ inches are most common.

Vermont.[3]—Asbestos deposits occur at four localities near Lowell, in northern Vermont, connected with the serpentine belt which contains the great asbestos mines of Canada. The asbestos is chrysotile of both

[1] See Diller, J. S., "The Types, Modes of Occurrence and Important Deposits of Asbestos in the United States," *Bull.* 470, pp. 505–524, U. S. Geol. Survey, 1911. See also *Mineral Resources of the United States*, U. S. Geol. Survey, annual, for various years, particularly since 1907.

[2] See *Mineral Resources of the United States*, U. S. Geol. Survey, part 2, pp. 342–347, 1913; pp. 96–99, 1914; pp. 197–201, 1917; pp. 546–551, 1918; pp. 300–304, 1919; pp. 313–316, 1920; pp. 136–138, 1921.

[3] See Richardson, C. H., *Seventh Annual Report*, Vermont Geol. Survey, pp. 315–330, 1909–1910.

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the cross-fiber and the slip-fiber types, but it is so short that only mill fiber can be produced. Several unsuccessful attempts have been made to work these deposits at various times.

Wyoming.—Deposits of cross- and slip-fiber chrysotile asbestos occur in Wyoming in several localities and fiber has been produced in small quantities at various times in the past. These deposits are located (1) on Caspar Mountain, 8 miles south of Caspar; (2) on Smith Creek, 20 miles southeast of Caspar; (3) 28 miles south of Lander; (4) near Berry Creek in Lincoln County, on the north side of Forellen Peak, 35 miles from the nearest shipping point at Ashton, Idaho.

Some of the Wyoming fiber is 1 inch long, but most of it is much shorter and but a very small porportion is of spinning grade.

California.—While asbestos, of both the chrysotile and amphibole varieties, has been found in at least twelve counties in California and a small production obtained from a few properties, no large deposits of high-grade spinning fiber have been developed. Most of the deposits are apparently small or of low grade, and production has been only a few tons a year.

Georgia.[1]—Mass-fiber anthophyllite asbestos has been produced for many years in Georgia. While occurrences have been noted in many counties forming a belt across the northwestern part of the state from Rabun to Harris counties, the most important deposits are in White and Habersham counties. The chief deposits that have been worked are 3 miles southwest of Sall Mountain in White County and near Hollywood in Habersham County. In the best portions of the deposits the whole rock is fibrous and as much as 95 per cent of the rock quarried is recovered as fiber. The rocks of the region in general are deeply weathered and the workings are confined to open cuts or quarries in the weathered rock. At greater depths the rock is harder and less fibrous. While the fiber is long, it is so brittle that it is valueless for spinning purposes. It has been used chiefly for making fireproof paints and cements.

Idaho.—Anthophyllite asbestos, similar to that at Sall Mountain, Georgia, occurs about 14 miles southeast of Kamiah, Lewis County, Idaho. The fiber is short and brittle, and therefore suitable only for low-grade uses. A small tonnage was produced annually for a few years, and the fiber shipped to Spokane, Washington, where it was used for paints, cements, pipe covering, plaster and other local purposes.

Maryland.—Slip-fiber anthophyllite asbestos occurs in the softened and weathered portions of gneissoid schists a few miles north of Pylesville, Hartford County, Maryland. The veins are generally small and the usable portions limited to the disintegrating residual material within

[1] See Hopkins, O. B., "The Asbestos Talc and Soapstone Deposits of Georgia," *Bull.* 29, pp. 75–189, Ga. Geol. Survey, 1914.

10 feet of the surface. A small annual tonnage has been produced for several years. The fiber has been cleaned and prepared for filter purposes.

Other States.—Small deposits of amphibole asbestos have been reported near Dalton, *Massachusetts;* New Hartford, *Connecticut;* Cumberland, *Rhode Island;* Pateros, *Washington;* Bedford City and Rocky Mount, *Virginia;* Cane River, *North Carolina;* and Llano, *Texas.* A small output of low-grade asbestos (variety not noted) was produced in 1918 a few miles north of Mount Vernon, Grant County, *Oregon.* Chrysotile has been reported on the head waters of East Mile Creek, *Montana;* and near Great Falls, *Virginia.*

Cyprus.—Large deposits of asbestos occur on the Island of Cyprus and production has been important. Both chrysotile and anthophyllite are found, the former at Amianods, near Troodos in the Limasol district. The best grades come from Paphos. Much of the material produced is short-fibered, but some is of a grade that may be mixed with Canadian fiber.

Italy.—Italy is a small producer of asbestos, most of which is apparently of the amphibole variety. There are three asbestos districts in Italy: (1) in the Susa Valley near Mount Cenis; (2) in the Aosta Valley, from Ivrea to Chatillon; (3) and in the Valtellina district of Lombardy near Sondrio. Italy does not produce sufficient spinning fiber for her own needs, but imports chiefly from Canada and Africa.

Other Countries.[1]—Asbestos deposits, of both the chrysotile and amphibole types, are known in many other countries, and from some of them have come small and irregular productions, but none of them are of great present importance. This may be due to small size of deposits, low grade of fiber or remoteness from transportation and markets.

Some of the countries in which deposits of asbestos have been worked or have been reported are: *Australia, China, Japan, India, Finland, Switzerland, Greece, Turkey, Portugal, Spain, France, Germany, Norway* and *Great Britain.*

Production and Consumption. *World Production.*—The production of asbestos in the principal asbestos-producing countries in the world is shown in the following table prepared from statistics collected from various official sources.

It will be noted from this table that Canada is by far the largest producer of asbestos. The figures given, however, are somewhat misleading, in that much of the Canadian production is of the lower grades of mill fiber, shingle stock, etc., while most of the asbestos produced in Rhodesia and in the Union of South Africa is of high-grade spinning fiber. The local consumption of asbestos in these latter countries is very small and hence there is little local demand for the lower grades of fiber. These lower grades command too low a price to justify the expense of transpor-

[1] See Cirkel, F., work cited, pp. 214–244. "Asbestos" (1913–1919), work cited, pp. 8–32.

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World's Production of Asbestos 1913–1921
Metric tons

	1913	1914	1915	1916	1917	1918	1919	1920	1921
Australia:									
New South Wales	......	......	......	......	5	......	145	675	[illegible]
South Australia	......	......	......	......	......	......	......	5	2
Tasmania	......	......	......	......	275	2,900	[illegible]		
Western Australia	......	......	......	......	......	......	[illegible]	280	[illegible]
British South Africa:									
Rhodesia	263	442	1,823	5,586	8,675	7,778	8,839	17,076	17,716
Union	873	1,080	1,940	4,224	5,642	3,333	3,567	6,462	4,846
Canada	124,239	87,580	100,826	121,053	122,925	128,334	124,070	162,028	84,181
China	......	......	......	......	278	242	[illegible]	5	18
Chosen	......	......	......	......	......	......	122	*	*
Cyprus	......	......	......	......	1,088	232	1,352	910	*
India	......	......	......	......	150	263	294	1,847	221
Italy	175	171	182	82	85	60	98	166	430
Philippine Islands	......	......	......	......	......	70	375		
Russia	17,494	16,691	9,779	8,192	......	*	*	1,478	2,804
United States	998	1,131	1,590	1,342	1,778	905	1,063	1,495	784
Approximate total	144,042	106,095	116,100	140,479	140,997	144,215	140,282	192,336	113,800

* Figures not yet available.

tation for long distances. The distribution of Canadian (Quebec) production by grades in 1920 is shown in the following table from *Mineral Industry:*

Production of Asbestos in the Province of Quebec for 1920

Shipments and sales			Average value per ton	Stock on hand, Dec. 31, 1920	
Designation of grade	Tons	Value		Tons	Value
Crude No. 1	1,026	$ 1,513,457	$1,475.10	446	$ 659,259
Crude No. 2	2,830	2,295,927	811.28	854	829,438
Spinning fiber	13,983	3,915,562	280.02	1,929	653,115
Shingle fiber	16,784	1,852,210	110.36	1,306	172,476
Paper stocks and others	142,982	5,097,416	35.65	18,826	118,060
	177,605	$14,674,572	$ 82.62	23,361	$2,432,348
Asbestic	19,716	$ 43,559	$ 2.20	125	$ 274
Totals	197,321	$14,718,131	....	23,336	$2,432,622

Quantity of rock mined during the year, 3,099,122 tons.

United States.—The United States is the largest consumer of high-grade asbestos in the world and the largest manufacturer of asbestos goods. Domestic production furnishes only a very small proportion of the requirements for crude asbestos. While imports come chiefly from

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Canada, South African and Rhodesian asbestos is being used in important and increasing amounts.

The following table published by the U. S. Geological Survey shows the domestic production of asbestos in recent years:

DOMESTIC ASBESTOS MARKETED IN THE UNITED STATES, 1913–1921

Year	Chrysotile		Amphibole		Total	
	Short tons	Value	Short tons	Value	Short tons	Value
1913	......	....	1,100	$11,000	1,100	$ 11,000
1914	22	$ 5,450	1,225	13,515	1,247	18,965
1915	316	65,148	1,415	11,804	1,731	76,952
1916	808[a]	167,683[a]	830	13,311	1,638[a]	180,994[a]
1917	1,391[a]	279,270[a]	567	11,744	1,958[a]	291,014[a]
1918	392[a]	101,059[a]	606	17,628	998[a]	118,687[a]
1919	502	229,265	659	19,000	1,161	248,265
1920	1,245	661,907[a]	403	16,324	1,648	678,231[a]
1921	438	313,268	393	23,700	831	336,968

[a] Revised figures.

In recent years most of the domestic chrysotile fiber produced has come from Arizona and most of the amphibole from Georgia.

Imports and exports of crude and manufactured asbestos are shown in the following table:

UNITED STATES IMPORTS AND EXPORTS OF ASBESTOS[1]
In long tons

Year	Imports			Exports		
	Unmanufactured		Manufactured	Unmanufactured		Manufactured
	Quantity	Value	Value	Quantity	Value	Value
1912	63,860	$1,456,012	$363,759	...	....	$ 601,701
1913	86,737	1,928,705	389,664	...	....	754,102
1914	64,166	1,407,758	368,344	...	....	513,037
1915	83,541	1,981,483	137,320	...	....	764,050
1916	103,716	3,303,470	135,064	279	$ 6,133	1,209,076
1917	119,739	4,521,172	65,096	632	116,580	1,932,551
1918	122,946	6,337,585	27,476	622	51,053	2,493,325
1919	129,777	7,389,685	257,381	999	157,416	3,529,348
1920	149,605	9,120,253	619,054	549	141,071	4,431,132
1921	64,698	2,918,802	379,858	464	101,618	2,606,426

[1] Bureau of Foreign and Domestic Commerce.

Great Britain.—Great Britain produces practically no asbestos, but is the second largest manufacturer of asbestos products. Raw asbestos is imported chiefly from Canada, Rhodesia and South Africa.

Mining and Milling. *Canada.*[1]—*Mining methods* used in the Quebec districts may be divided into three general classes; (1) open pits; (2) "glory holes" and shrinkage stopes; and (3) combined open and underground workings. Methods used in mining slip-fiber differ from those used at cross-fiber deposits, for in the latter type the long fiber ("crude") must be carefully separated from the mill fiber before milling, while in the slip-fiber deposits no such care is necessary and nearly the entire output of the mine is milled.

The earliest workings were all of the open-pit type and such operations are still the most common today.

The overburden, consisting of clays, sands and gravels, varies from practically nothing to as much as 60 feet. Methods of stripping vary from simple hand methods, where the overburden is light (5 to 10 feet, as at Broughton), to steam-shovel and hydraulic methods for very heavy overburden (up to 60 feet or more, as at the King mine at Thetford).

After the rock is stripped, the pits are carried downward in benches 20 to 75 feet high (average about 40 feet). Drilling is now usually done with compressed-air hammer or piston drills, ranging in size from light hammer drills to heavy submarine-type drills which will drill 3-inch holes to a depth of 75 feet. After the ore is shot down, it is further reduced in size by block-holing or mud-capping. Slip-fiber rock is then loaded directly into buckets, pans or quarry cars by hand or by small steam shovels. Cross-fiber rock is first carefully sorted and rough-cobbed to remove all the crude grade, and the mill rock is then loaded into pans for hoisting. The crude grade is recobbed, re-sorted, graded and packed in bags for shipment.

In small pits hoisting may be done by derricks, but in large operations very large cableway systems are used. At one mine narrow-gage cars are hoisted through an inclined tunnel to mill bins or waste-rock dumps.

At the surface large bin storage for mill rock is often provided, to facilitate continuous mill operation during the winter months.

Where the open pits have become too deep for efficient operation, or where the overburden is too heavy to be removed economically, underground or combination methods are used. In some mines tunnels are driven under the pits and the ore milled down through raises into cars below (glory-hole system). A typical shrinkage-stope method is used by at least one company. Another mine is developed by a three-compartment, vertical shaft 515 feet deep. In this mine the ore is recovered by

[1] One of the best recent articles on asbestos mining and milling in Canada is that by BuKeysза, W. A., "Asbestos Mining and Milling in Quebec;" *Eng. Mining Jour.-Press*, vol. 113, Nos. 15 and 16, pp. 617–625 and 670–677, Apr. 15 and 22, 1922.

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glory holes extending to the surface or to the bottoms of old pits. Some mines are worked partly by ordinary open-pit methods and partly by glory-hole methods.

Milling methods, used at the various mills, vary in detail, but they are nearly all identical in principle. The objects of milling are to recover as much of the fiber as possible free from dirt and adhering rock and to handle the ore as gently as possible in order to minimize the reduction of fiber length by attrition. The general methods used are: coarse-crushing; drying; recrushing in stages, each stage being followed by screening, during

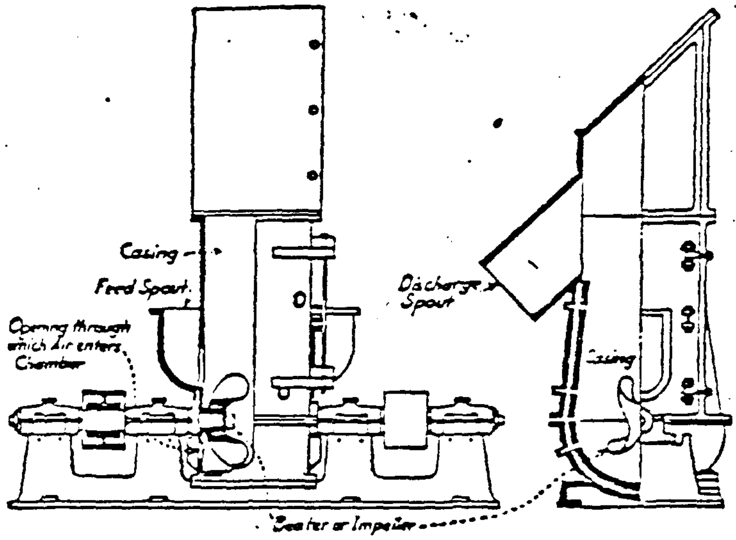

FIG. 2.—Sketch of "Laurie Cyclone."

which air suction effects the separation of the fiber from the rock gangue; collection of the fiber; cleaning of adhering dust and rock particles by rescreening; grading; and, finally, bagging for shipment.

Primary crushing is usually done in jaw crushers, and drying in direct or indirect-heat rotary driers. Secondary crushers may be of either the jaw or the gyratory type. The screening at this stage is usually done on long, flat, shaking, screen tables, which serve to remove fine rock waste and spread out the ore so that the freed fiber may be removed by suction. The final stages of crushing or grinding are done in special types of pulverizers, known as "Cyclones" and "Jumbos," developed in the asbestos industry. RuKeyser,[1] in describing these machine, states:

The desired effect in the reduction of the asbestos-bearing rock is one of straight impact and disintegration, permitting the freeing of the fiber and at the same time "fluffing" it. A minimum of grinding or shear action is desired.

[1] RuKeyser, W. A., work cited, pp. 674–675.

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The "Cyclone" (see Fig. 2) consists essentially of two cast-steel impellers shaped like a ship's screw, weighing approximately 1,000 pounds each and made to revolve at a high speed (2,000 to 2,200 r.p.m.) in an inclosed chamber lined with manganese-steel plates to withstand the impact of the rock hurled against it. If a lesser action is desired, the impellers may be made to revolve in the same direction, but in the usual practice they are rotated in opposite direction to each other. It is claimed by many that the "Cyclone" produces a great amount of attrition, injuring the fiber; is of low capacity, wasteful of power and necessitates frequent and costly repairs. The impellers must often be changed every two days, owing to the high speed at which they are revolved, and must be balanced on their shafts with extreme care.

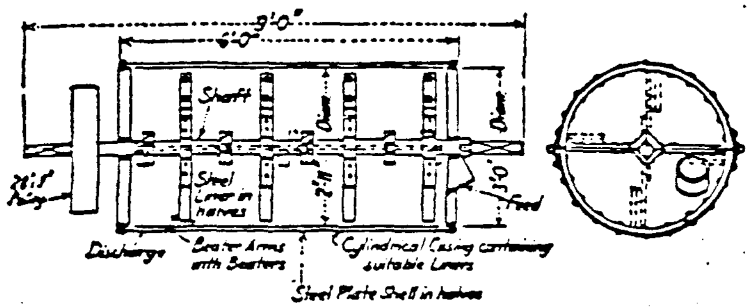

Fig. 3.—Sketch of "Jumbo."

The above considerations led to the development of the "Jumbo," a machine, better mechanically, which has for some time replaced the "Cyclone" on the Broughton rock. Within the past two years much experimentation has been done using the "Jumbo" on the harder Thetford and Black Lake rocks, and the machine is finding a great deal of favor with some operators who have discarded the "Cyclone." The "Jumbo" (see Fig. 3) is really a modification of the ordinary pulverizer, consisting primarily of a horizontal shaft fitted with a series of arms, these in turn carrying "beaters." The whole is caused to revolve at from 400 to 800 r.p.m. (as the nature of the rock dictates) in a cylindrical casing lined with suitable plates. The rock, fed from above at one end, is made to pass through the machine by a deflection of the beaters, and drops out at the other end.

From the "Jumbos" or "Cyclones" the ore again passes over a series of screen tables until the fiber is all removed from the rock by suction. The fiber is collected in conical steel-tank collectors, passed through a series of rotary or shaking-table screens, to remove dust and rock particles, and then to graders. Graders are slowly revolving hexagonal or octagonal screens, which separate the asbestos into the commercial lengths of fiber. The products from the grades go to their respective bins from which they are packed, in 100-pound bags, by hand or by semi-mechanical packers.

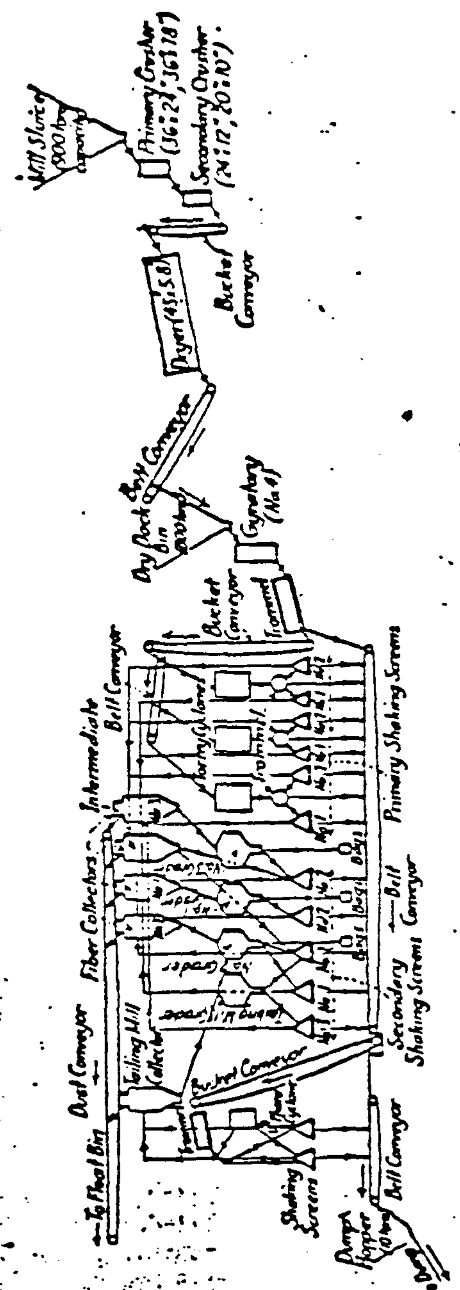

Fig. 4.—Typical flow-sheet of a cross fiber mill.

The accompanying flow sheets (Figs. 4 and 5) after RuKeyser are said to be typical, one of cross-fiber milling at Thetford and the other of slip-fiber practice at Broughton.

An approximate estimate of the proportions of the various grades of fiber produced at a modern Canadian mine and mill as noted by Dustan[1]

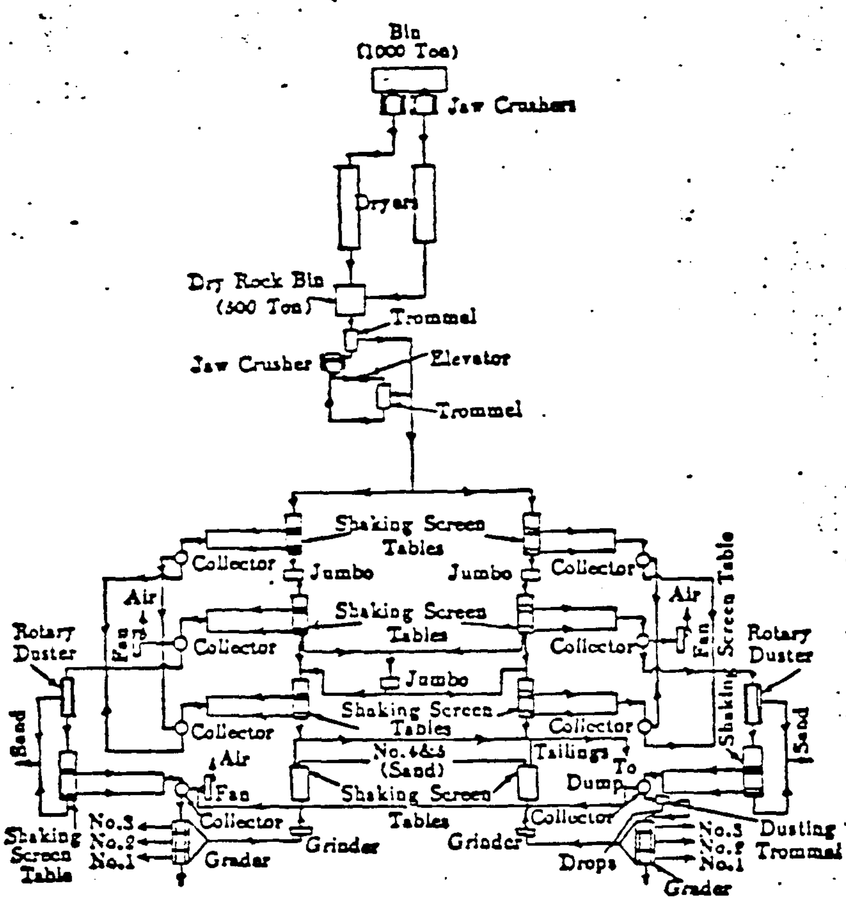

Fig. 5.—Typical flow-sheet of a slip-fiber mill.

is given below. The figures given are not averages and individual mills probably show considerable variations from these estimates; for example, the percentages of mill fiber shown are higher than recent averages for all operations in Quebec.

[1] Dunstan, B., "*Queensland Govt. Mining Jour.*," p. 372, Sept. 15, 1920.

ASBESTOS MINE AND MILL PRODUCTS

Unmanufactured grades and their approximate percentages in mine and mill rock

Products and Waste	General Range of Percentages, Per Cent
From the rock mined:	
Crude asbestos	
Grade I (over 1 inch)[a]	0 to 0.3
Grade II (average ¾ inch)[a]	0.3 to 0.9
Milling rock	30 to 60
Mine waste	40 to 70
From the rock milled:	
Mill stock	6 to 12
Mill fiber, No. 1 (average ⅜ inch)[b]	0.5 to 2
Mill fiber, No. 2 (average ⅜ inch)[b]	1.5 to 4.5
Paper stock (average ¼ inch)[b]	4.0 to 8.0
Mill waste (or)	88 to 94
Asbestic powder and sand[c]	44 to 60
(and) Mill waste	34 to 44
Contents of total asbestos:	
Crude asbestos (grades Nos. 1 and 2)	3.0 to 8.0
Mill stock:	
Mill fibers, Nos. 1 and 2	20 to 40
Paper stock	60 to 80
Total mine and mill product from rock:	
Total asbestos (all grades except asbestic)	3.6 to 7.4
Crude asbestos (grades Nos. 1 and 2)	0.3 to 0.9
Mill stock (fibers Nos. 1 and 2)[a]	1.5 to 2.9
Paper stock (mill fiber No. 3)[b]	1.8 to 3.6
Asbestic (powder and sand)[c]	20 to 30
Total waste rock (mine and mill)	67 to 97

[a] Spinning quality varies from ¾ to over 1 inch.
[b] Quality suitable for manufacture of paper, sheet, board, etc.
[c] Suitable for paint, plaster, etc.

United States.—The chrysotile asbestos in Arizona is obtained chiefly by underground mining methods, usually by tunneling along the asbestos veins. In 1918, the Ash Creek mine was reported to have about 10,000 feet of underground workings arranged in four levels, of which the longest tunnel reached a point about 600 feet into the mountain. Nearly all the Arizona asbestos has been marketed as hand-cobbed crude, as no mills have been erected.

In California both underground and open-pit methods of mining have been used, but production has been very small. In 1921 two mills were built, adopting the principles and machines used in Quebec.

In Vermont, mining has been done by open-cut methods, but there has been no commercial production in recent years. Several mills have

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been built at various times, the latest completed in 1922, following the methods used in Canadian slip-fiber mills.

South Africa and Rhodesia.—In the various sections of the Union and of Rhodesia both open-pit and underground mining methods are used. Often the open-pit workings are small and irregular, but in the larger and deeper underground mines more systematic methods are used. For example, in the southern sections of the crocidolite area of Cape Province a system of overhand stoping is used without timber. The ore is roughly hand-cobbed underground and the waste is allowed to accumulate in the workings, so as to keep the floor within working distance of the roof.

Milling methods have usually been very simple in the past. In most cases the ore has been hand-cobbed, screened in hand sieves or simple mechanical screens, graded and bagged. At some of the operations in Rhodesia more elaborate methods of preparation are reported to be in use, but no descriptions are available.

Specifications, Grades and Tests.—Since, for most important commercial uses, strong, flexible fiber is needed, the brittle anthophyllite type of asbestos needs little mention here. The chief exception is that of filter-fiber asbestos. For this purpose a fairly strong fiber is needed and the asbestos must be of such chemical composition that it is practically unaffected by common acids and alkalies. Tremolite is often used for this purpose.

Some of the physical properties which good asbestos fibers must possess for various uses are as follows: good fiber length, good flexibility, fine fibers, silkiness, high tensile strength, resistance to acids and alkalies, resistance to sea water and moist air, high melting point, resistance to heat, high heat-insulating value, high electrical-insulating value, good "spinnability" (that is, capable of being easily spun into products of good quality without undue loss and breakage of fiber). There are now so many and such diversified uses for asbestos that not all of these properties are necessary for any single use. Thus, short fibers may be used for asbestos-paper and asbestos-cement shingles, while long fibers are needed for asbestos textiles. For some purposes two or more types of asbestos with different physical properties (for example, crocidolite and chrysotile) may be mixed advantageously.

A comparison of some of the physical properties of crocidolite, chrysotile and amosite is given in the following table:

COMPARISON OF PROPERTIES OF CHRYSOTILE, CROCIDOLITE AND AMOSITE[1]

Property	Chrysotile	Crocidolite	Amosite
Fiber length (usual maximum)	1½ to 2 inches	1½ to 2 inches	7 inches
Tensile strength	High	Higher than chrysotile	Good
Flexibility	High	High	Good
Fineness of fiber	Very fine	Fine	Fine
Resistance to heat	Good, but becomes brittle	Poor; fuses to a glass	Good, but becomes brittle
Resistance to acids, alkalies and sea water	Poor	Good	Good
Electrical-insulating value	Fair to good	Good	
Heat-insulating value	Good	Good for moderate heat	Good
Spinnability	Excellent	Fair	Fair

[1] The properties noted above apply to best grades of each type.
Authorities, Cirkel and Hall, works cited.

For spinning purposes, Canadian chrysotile is considered the best in the world. Arizona chrysotile is good, but is apt to be lacking in uniformity and to contain harsh, brittle fibers. Some users state that the fiber is so fine and silky that there are large losses in spinning. Crocidolite is not in high favor in the United States, because it is rather difficult to fiberize properly; it is rather dirty and dusty compared with Canadian chrysotile; and its fusion point is low. Crocidolite and amosite, usually mixed with some chrysotile, however, are used much more extensively in England and Europe. Amosite fiber is harsher than chrysotile, and is rather dirty and dusty to handle; it has been used but little in the United States.

Asbestos is often erroneously called a refractory material, but it cannot properly be so classed. Crocidolite fuses at a relatively low temperature to a black glass. Both chrysotile and amosite lose their water of composition at a moderate temperature and become inflexible and very brittle. Nor has asbestos alone a high heat-insulating value, compared with such materials as basic magnesium carbonate. Asbestos is non-combustible and capable of being woven into fabrics, and these are the properties upon which much of the value of high-grade asbestos depends.

The quality of asbestos and its suitability for most uses may be easily determined by a few simple tests. Length, color, silkiness, flexibility and, to some extent, fineness of fiber and tensile strength may be determined by inspection. A sample of asbestos should be fiberized by rubbing or crushing between the fingers. Single fibers may then be tested for flexibility and tensile strength by bending and breaking. Several fibers may be twisted into a strand or yarn and again tested for flexibility and strength. Asbestos of good quality should be easily fiberized, soft, silky, strong, flexible and easily twisted into a strong yarn. Fibers ¼ inch or more in length and otherwise of good grade are of commercial interest.

The grading of asbestos for market varies in different districts and at different plants. In Canada there are two main grades, crude and fiber, each of which are divided into subgrades, in each case based on length of fiber. Crude, produced entirely by hand picking and cobbing, consists of all cross-fiber asbestos over ⅜ inch long. No. 1 crude consists of fiber over ¾ inch long (average 1 inch). No. 2 crude consists of fiber from ⅜ to ¾ inch long (average ⅝ inch).

Mill-fiber grades have not been well standardized. They are based on screen tests, but different producers use different classifications. Screen tests are made in a standard testing machine, which consists of four trays, 24 by 14 by 4 inches, fitting one on top of another. The top or No. 1 tray is fitted with a screen bottom of 2 mesh (No. 11 wire); No. 2 screen is 4 mesh (No. 17 wire); No. 3 screen is 10 mesh (No. 18 wire); the bottom tray is a solid pan. The nest of screens is fastened to a frame, so arranged that it may be vibrated horizontally with a 1½-inch throw, by an eccentric revolving at 300 revolutions per minute. In making a test, 1 pound (16 ounces) of fiber is placed in the top tray and shaken for exactly 2 minutes. The residue on each screen and in the bottom pan is weighed separately and the weight recorded in ounces. Thus, a fiber testing 0-8-6-2 (total 16 ounces) is one of which 8 ounces is retained on the second screen, 6 ounces on the third and 2 ounces of shorts in the pan.

While grades made by different Canadian producers vary somewhat, Marcuse[1] states that the following fiber tests may be taken as averages:

Long-spinning fiber	2-8-4-2
Medium-spinning and compressed-sheet fiber	0-8-6-2
Pipe-covering fibers	0-5-8-3
Shingle stocks	0-1½-9½-5
Paper and millboard stocks	0-0-10-6
Cement stocks	0-0-5-11

Shorts are not sold on length but according to color and cleanliness. Color is of prime importance. *Asbestic* is finely ground asbestos sand mill tailings.

[1] Marcuse, B., "The Marketing of Asbestos," *Eng. Mining Jour.-Press*, vol. 114, No. 7, p. 278, Aug. 12, 1922.

Grades of South African and Rhodesian asbestos vary somewhat, but seem to range about as follows:

Grade	Length of Fiber
D	Over 1¾ to 2 inches
C	1¼ to 1¾ or 2 inches
B	¾ to 1¼ inches
A	⅜ to ¾ inches
S	Up to ⅜ inch
X	Siftings
DA	Discolored fiber up to ¾ inch
DB	Discolored fiber longer than ¾ inch

Markets[1] and Prices.—The United States is the largest consumer of asbestos and manufacturer of asbestos products, with the United Kingdom standing second. Before the war the chief international marketing point was Hamburg, but during and since the war New York has taken the lead. Much of the South African and Rhodesian asbestos is marketed in London. Some of the largest manufacturers of asbestos products own mines in Canada or elsewhere which partly or wholly supply their needs for raw asbestos. Smaller consumers buy either directly from the producers or from dealers and agents.

Asbestos crudes and fibers are packed in 100-pound bags and sold at a price (including cost of bags) per 2,000-pound ton, usually f.o.b. cars mines. Crudes bulk about 40 cubic feet per 2,000-pound ton and fibers 60 to 90 cubic feet per ton. Sand and shorts are sold by the net ton and shipped either in bags or in bulk. Most producers have certain brand or grade marks (thus X, XX and C grades), but, while the same marks may be used by different producers, the grades do not necessarily correspond. Most asbestos is sold on sample and test.

Prices on all grades of asbestos increased greatly during and after the war, reaching a peak early in 1921. In 1913, No. 1, crude sold for $320 to $350 per ton, and early in 1921 it was quoted at over $3,000 per ton. The average value of all grades of Canadian asbestos sold increased from $26 in 1909 to $80 in 1919. After the peak, reached in 1921, prices began to fall rapidly until pre-war levels were nearly reached. In May, 1923, the following prices were quoted in the *Engineering and Mining Journal-Press:*

Asbestos.—Crude No. 1, $500; No. 2, $250 to $325; long-spinning fibers, $135 to $200; magnesia and compressed sheet fiber, $100 to $150; shingle stock, $65 to $85; paper stock, $35 to $42; cement stock, $20 to $25; shorts, $9 to $14—all per short ton, f.o.b. mines, Quebec, Canada.

Utilization.[2]—The uses for asbestos are so many and so varied that a simple enumeration of all of them cannot be given here. The main

[1] See Marcuse, B., "The Marketing of Asbestos," work cited.

[2] See Cirkel, F., work cited, pp. 245–289; also anonymous, "Asbestos," Tariff Information Survey N-20, 56 pp., U. S. Tariff Commission, 1921.

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uses for asbestos fall into a few fairly well-defined groups, namely: (1) asbestos yarns, cordage, cloth and similar textile products; (2) asbestos paper, compressed sheets, blocks, etc; (3) asbestos-cement products, such as asbestos shingles, lumber, corrugated siding, etc.; (4) heat-insulating cements; (5) boiler and pipe coverings (asbestos plus basic magnesium carbonate) and corrugated asbestos paper; (6) as an ingredient in paints and roofing cements (shorts, asbestic, ground anthophyllite, etc.); (7) asbestos fibers used as such for filtering, packing, etc.

From primary manufactured products, such as asbestos yarns, cordage and paper, a multitude of secondary finished products are produced, such as automobile brake-band linings, steam packing and pipe coverings. It should be noted that, while very long spinning fiber is essential for some purposes, the bulk of the asbestos marketed is for use in products in which much shorter mill fibers may be used.

Brown[1] has given a very good summary of the principal uses of asbestos.

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[1] Brown, J. Coggin, work cited, pp. 9–12.

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From – "Industrial Hygiene and Toxicology" Vol. I
By – Patty
Pub. By – Interscience Publishers, Inc., N.Y. 1948

Common External Marks of Occupation or Occupational Diseases or Other Diseases (continued)

Mark or sign	Probable cause	Significance	Comment
		Skin, continued	
Pathological sweating.	Many nonindustrial causes, but sometimes seen in lead poisoning.	Unusual sweating may be localized, odoriferous, colored, excessive. Sometimes found in heart disease, rickets, syphilis, palsy, tuberculosis, goiter, etc.	In arsenic or lead poisoning, abnormal sweating usually local to parts involved in neuritis.
Brick red (warm weather). Plum colored (cold weather).	Polycythemia (pathologic increase in numbers of red blood cells).	May be a manifestation of repeated exposure to carbon monoxide in relatively low concentrations. R. M. I.	Engorgement and congestion of superficial blood vessels. Most prominent on face. May involve conjunctivae.
Paroxysmal face and head flushing.	Chiefly associated with the menopause, this type chiefly limited to women 40 to 50.	May be associated with mental depression, excessive perspiration, weakness, insomnia, emotional instability.	Not occupational.
Lymphangitis.	Infection.	Red streak up arm or leg. Alarming indication of extension of localized pyogenic infection. R. M. I.	Frequently associated with "kernels" such as in axilla or groin.
Keratosis (farmer's warts).	Excessive sunlight, ultraviolet light, etc.	Represent warty, flat, or horny, persistent overgrowth of outer layers of skin. Characteristic of past middle age life; usually limited to exposed parts of skin; characteristic of many trades including farmers, sailors, fishermen, gardeners, trappers.	Rarely become cancerous; readily removed by electrocauterization, by x-ray and by electric needle; less well by keratin solvents. Quite common both in and out of industry.
Asbestos warts.	Mechanical penetration by asbestos fibers; possibly chemical action akin to production of silicotic nodules.	Condition usually limited to fingers and hands.	Similar condition with glass fiber workers, but in that case always mechanical.
Tumors (on skin).	Several types, both benign and malignant. Commonest variety, epithelioma.	Apart from nongrowing warts and obvious abscesses of skin, any enlarging mass on or in skin should be investigated. R. M. I.	Pigmented moles are prone to become malignant.
Tumors (beneath skin).	Frequently harmless, fatty tumors (lipomas). Attain to large size.	Because of uncertainty, every mass beneath the skin should be investigated by a physician.	Skin over lipomas, if squeezed, becomes dimpled, "orange peel" sign. See next item.

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of aluminum by physicians for therapeutic or prophylactic purposes, makes only metallic aluminum available. Some investigators, notably Hannon,[77] have reported marked success in the treatment of patients with severe disability. However, when purely objective criteria have been used to measure disability the results have been somewhat less striking. Gardner, Dworski, and Delahant[74] have suggested that variations in response to aluminum therapy may be due in part to the nature of the dust that has caused the silicosis. They suggest that dust which is primarily free silica may react with aluminum more readily than dust which contains high percentages of iron. The use of aluminum generally in industry for the therapy or prophylaxis of silicosis should be contemplated only with the utmost caution.

I. ASBESTOSIS

Asbestos is a hydrated magnesium silicate. More than 90 per cent of the raw mineral used in this country and Great Britian is produced in the Canadian chrysotile mines. Asbestos is used in two general types of manufacturing processes. It may be used either by itself or mixed with other insulating materials such as diatomaceous earth for fireproofing, packing, or insulating; or it may be combined with cotton and woven as a textile for fireproof and heat-resistant clothing and other substances. Lanza[77] estimates that there are about 10,000 persons exposed to asbestos in the United States. Most observers feel that the incidence of asbestosis in American asbestos workers is quite low. Asbestosis has, however, been reported more frequently in England and Canada.

Lanza, McConnell, and Fehnel[78] concluded from their study of asbestosis that: Prolonged exposure to asbestos dust causes pulmonary fibrosis different from that produced in silicosis and demonstrable by roentgenogram. Clinically it appears to be milder than silicosis.

Definite cardiac enlargement frequently was found to be associated with asbestosis.

A predisposition to tuberculosis, due to asbestos dust, was not indicated although it was not known to what extent asbestosis may add to the mortality from pneumonia and acute nontuberculous pulmonary infections.

Symptoms. The onset of asbestosis, as of silicosis, is slow although symptoms are apt to be somewhat more marked than in silicosis. In silicosis there may be marked x-ray findings with little complaint of symptoms, whereas the opposite is likely to be the case in asbestosis. As in silicosis, dyspnea is the cardinal symptom. Anorexia occurs frequently in advanced stages, and cyanosis and clubbing of the fingers are apt to appear with greater constancy in asbestosis.

Pathology. The fibrosis in asbestosis is diffuse and tends to predominate in the basal portions of the lungs in contrast to the generalized nodular fibrosis of silicosis

[75] J. W. G. Hannon, *Trans. Can. Inst. Mining Met.*, 48, 180 (1944).
[76] L. U. Gardner, M. Dworski, and A. B. Delahant, *J. Ind. Hyg. Toxicol.*, 26, 211 (1944).
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By - Patty
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with a predominance in the upper portions of the lung. Bronchiectasis and bronchiolectasis are frequent, especially in the more fibrous portions. Whereas the proliferation of fibrous tissue is caused by chemical action in silica exposure, it is induced by mechanical action in asbestos exposures. Gardner[77] found that the fibrosis-producing character of asbestos could be almost eliminated by grinding the fibers so that no particles more than 2 μ in length were present. As previously mentioned, asbestos is classified among the inert dusts.

Microscopic Anatomy. Johnstone[78] described the microscopic appearance of the lungs somewhat as follows: in the early phases of the disease there is thickening of the alveolar septa which results from fibroblastic proliferation. The alveolar spaces contain numerous phagocytes. With progression of the disease fibrosis becomes more marked; the alveolar structure gradually disappears, and in its place there is now dense fibrous tissue. The few alveoli that remain in the area of fibrosis are lined with low cuboidal epithelium giving them an almost glandular appearance.

Scattered throughout the lung in both the diseased and healthy parts are spindle-shaped structures described first by McDonald.[79] These bodies are 20 to 100 μ in length and are bulbous on one or both ends so that they appear club- or dumbbell-shaped. They are brownish in color, do not stain, and give a Prussian-blue reaction for iron. Simson[80] has produced these bodies in guinea pigs by experimental exposure to atmosphere containing asbestos. Lynch[81] concludes that these "curious bodies" signify exposure to asbestos dust but do not necessarily indicate asbestosis.

X-Ray Examination. For an excellent review of roentgenographic findings in both silicosis and asbestosis the reader might well refer to Pendergrass.[82] Characteristic differences in the roentgenographic findings in silicosis and asbestosis are tabulated below:

Asbestosis	Silicosis
Fibrosis diffuse (film may have ground glass appearance from pleural involvement).	Fibrosis nodular.
Findings may be either bilateral or unilateral.	Findings characteristically bilateral.
Lesions largely in the lower one half or two thirds of the lung fields.	Lesions predominately in the upper two-thirds of the lung fields.
Emphysema in upper portion of lung fields.	Emphysema in lower portion of lung fields.

Control. Prevention of asbestosis depends entirely upon preventing exposure to concentrations of dust sufficiently high to produce the characteristic reaction.

[77] L. U. Gardner, *Ind. Med.*, *9*, 45 (1940).
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[81] K. M. Lynch, *J. Am. Med. Assoc.*, *103*, 1947 (1936).
[82] E. P. Pendergrass, "Roentgen-Ray Diagnosis in Silicosis and Asbestosis," in A. J. Lanza, *Silicosis and Asbestosis.* Oxford Univ. Press, New York, 1938.

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Dreessen, DallaValle, Edwards, Miller, and Sayers[83] have found evidence to indicate that 5,000,000 particles per cubic foot of air is a satisfactory figure for the maximum permissible atmospheric concentration of asbestos to which workers may be exposed. Definite permissible standards, however, have not been established.

VI. Dust Causing Minimal Fibrosis or No Fibrosis

Gardner[77] has pointed out that any known inorganic dust other than free silica and the asbestos silicates may produce nonspecific dust reactions, as described on page 486. X-ray markings may be found in other conditions such as chronic infection and heart disease. No interference with pulmonary function or disability is produced by dust of this type and there is no influence on susceptibility to tuberculosis.

A. SILICATES

McCord,[84] from a number of sources, has compiled a list of the commonly used silicates, which is presented here:

Olivine—a magnesium silicate widely present in all basic rocks. Many varieties of this stone are known.

Calcium silicate—nonexistent in nature, but a common product of industry; may be found at blast furnaces and in production of cement and hydrated limes. Other silicates of calcium are known.

Willemite—a zinc silicate (rare).

Sodium silicate (meta)—the well-known water-soluble silicate, commonly called water glass. This is widely used in industry, notably as a filler in soaps. This is the only crystalline silicate of sodium, the others being amorphous glass.

Tremolite—a magnesium-calcium silicate.

Asbestos—tremolite, actinolite, chrysotile, or amianthus, all of which are essentially magnesium silicates.

Jade—another form of magnesium-calcium silicate.

Crocidolite—"blue asbestos." It is a sodium iron silicate.

Talc—a hydrated magnesium silicate with extensive industrial application.

Soapstone—a form of talc.

Agalite—a variety of talc resembling asbestos. It is used in the coating of paper, and as a paper filler.

Meerschaum—also called sepiolite. It is closely akin to talc.

Serpentine—hydrated silicate of magnesium. It is a common building stone.

Sillimanite—aluminum-containing silicate. The source of many stone tools of the stone age

Topaz—a semiprecious stone of silicate origin. Chemically it is an aluminum fluosilicate.

Fuller's earth—a hydrated silica-aluminum compound, associated with ferric oxide.

Kaolin (kaolinite)—many related silicates of mixed constituency.

Clays—hydrated aluminum silicates containing iron. Titanium, quartz and mica, are likely to be present in clays.

[83] W. C. Dreessen, J. M. DallaValle, T. I. Edwards, J. W. Miller, and R. R. Sayers. *U.S. Pub. Health Bull.* No. *241* (1938).
[84] C. P. McCord, *Ind. Med.*, *2*, 4 (1933).

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Fire clay—refractory clays, low in alkalies, but high in iron and titanium.

Ultramarine—a silicate of aluminum. It is widely used as a pigment, and there are many varieties, including blues, reds, greens, yellows, violet, and white.

Mica—a large group of silicates of different chemical constituency. All are characterized by their well-known tendency for cleavage into thin sheets. It is extensively used in industry, such as in electrical work for insulation.

Garnet—complex silicates of aluminum, iron, calcium, and magnesium. Besides being a semiprecious gem stone, garnets are used as watch bearings, in gem cutting, polishing, etc.

Feldspar—a large group of aluminum silicates entering into many minerals, for example, granite.

Permutite—a sodium-aluminum silicate of complex structure, much used in water softening.

Lava—mixed silicates of volcanic origin.

Pumice—volcanic, glassy, spongy lava. It is primarily used as a polishing agent.

Shale—a loose term applied to clays and other silicates that have been subjected to high pressures in the earth.

Slate—a substance of clay or shale origin, that has been subjected to high pressure and has metamorphosed. It contains or may contain much free silica.

Slags—Products of metal blast furnaces that contain native impurities as well as minerals such as dolomite introduced as fluxes, etc. Almost all forms of silicates may be included. Free silica may be present.

Silicon carbide—carborundum, a synthetic mineral.

Silundum—another form of synthetic silicate, akin to carborundum in chemical structure.

Fibrox—silicon oxycarbide. It closely resembles carborundum and is somewhat similarly made.

It may be stated with some certainty that none of these dusts, unless in combination with free silica, will produce nodular fibrosis; and proof of disability from breathing such dusts is lacking.

B. NONSILICEOUS DUST

Nonsiliceous dusts such as calcite, calcium carbonate, gypsum, limestone, Portland cement, and pyrolusite dusts have been listed in the classification of Miller and Sayers[58] as among those causing an absorptive tissue response and, accordingly, are not considered as producers of pneumoconiosis.

Apparent X-ray Nodulation without Fibrosis. Only brief mention will be made of baritosis and siderosis. Pendergrass[57] reports having seen several patients exposed to barium dust with widespread dense nodulation typical of that seen in simple silicosis. The individuals examined were symptom-free and not incapacitated. Sander[58] has described a similar condition caused by the inhalation of iron oxide fumes at welding operations. Exposure to iron dust or fume may produce an x-ray picture characterized by generalized nodulation. Autopsy specimens have revealed that the nodules are collections of iron with no tissue reaction or fibrosis.

[58] J. W. Miller and R. R. Sayers, *U.S. Pub. Health Repts.*, 56, 264 (1941).
[58] O. A. Sander, *J. Ind. Hyg. Toxicol.*, 26, 79 (1944).

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ant treatment is as good as anything that can be offered for these tragic results of past ignorance.

Asbestosis. The pathologic changes produced by asbestos are not like those of silicosis. The asbestos fibers group about the neck of an alveolus and stimulate the formation of a diffuse fibrosis. There is no definite migration or transportation of the dust particles to the lymph nodes and no formation of the fibrous nodules shown in Fig. 16a. As the fibrosis increases, the reduction in lung area causes serious dyspnea. Lanza (273) suggested that the enlarged hearts noted frequently in his cases of second-stage asbestosis may be the result of the increased work of the heart resulting from this condition; it takes more work to pump blood through the asbestotic than through the normal lung.

Gardner stated (175, 170): "On grinding these fibrous minerals to a very fine state of subdivision they do not become more irritating but practically lose all power to provoke tissue reaction . . . ." Vorwald *et al.* (433) continued the animal work initiated by Gardner and concluded: "The duration of exposure required to develop the pulmonary reaction to inhaled asbestos dust is inversely proportional to the concentration of long fibers in the atmosphere; as the concentration is increased, the reaction develops in shorter time."

In silicosis it seems to be a general rule that, after a certain point, the victim's condition grows worse even if his exposure to dust has ceased. But Wood and Gloyne (455) stated that they have seen patients with asbestosis "whose condition appears to have remained stationary since stopping work in the factory," but they advised definitely that the individual with asbestosis be removed from his dusty job. Merewether (311) and Lanza were less certain on this point.

Asbestosis Bodies. In the lungs of patients who have died after prolonged exposure to asbestos dust and in the sputum of men with considerable asbestos-dust exposure are found what first were called *curious bodies* and later *asbestosis bodies* (Fig. 18) (140). While somewhat similar bodies can occur in the lungs of coal workers and even of normal persons, it is admitted that asbestosis bodies in sputum are characteristic of asbestosis. Stewart (402) gives considerable diagnostic weight to their presence as do Sparks (397) and Gloyne and Merewether (184).

From "INDUSTRIAL DUST"
BY- DRINKER + HATCH
PUB, BY- McGRAW-HILL 1954

Asbestosis and Lung Cancer. The British require autopsies of persons who have allegedly died as a result of industrial exposures such as cause asbestosis or silicosis. The 1947 report of the Chief Inspector of Factories (25) states that, of 235 cases of asbestosis autopsied between 1924 to 1946, 31 or 13.2 per cent were complicated by carcinoma of the lungs or pleura. This figure should

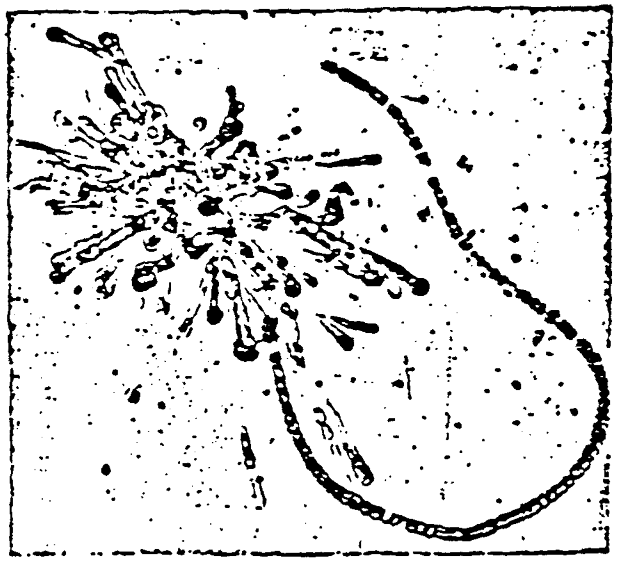

FIG. 18. Asbestosis bodies in sputum. (*After Ellman, Ref. 140; courtesy J. Indust. Hyg.*)

be compared with that of their cases of silicosis of whom 6884 were autopsied over the same period and in which 1.32 per cent showed cancer of the lungs. This latter is about the rate reported in the 1946 census in the United States (13 per cent of all deaths were from cancer and 1 per cent from cancer of the respiratory tract).

We do not imply that our American pathologists and our hospitals are less careful than the British in collecting data from autopsies. For example, Vorwald and Karr (434) at the Saranac Laboratories reviewed such data from their own experience and concluded that "inhaled dusts," except those containing recognized carcinogenic substances, "cannot in general be considered as etiological factors in the development of pulmonary carcinoma." But we still are a bit envious of the tidy way in which the British assemble their industrial data on morbidity and mortality.

C. RECOMMENDED CONTROL PROCEDURES: To prevent exposure to high concentrations of amorphous silica dust, process ventilation and/or enclosure are the best means of control. For some operations a dust respirator approved by the U. S. Bureau of Mines may be satisfactory.

IV. Specific Procedures

A. FIRST AID: None.

B. SPECIAL MEDICAL PROCEDURES:

(1) Preplacement: Clinical and chest radiographic examinations should be made on all persons prior to job assignment.

(2) Periodic: Since there is only limited information about the harmful effects of amorphous silica in industry, exposed personnel should have careful periodic medical examinations, including chest x-ray. Pulmonary function testing may be useful.

(3) Treatment: No satisfactory treatment other than removal from exposure, and therapy for any complicating infection.

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Asbestos

I. Hygienic Standards

A. RECOMMENDED MAXIMUM ATMOSPHERIC CONCENTRATION (8 hours): 5 million particles per cubic foot of air (MPPCF).[3]

(1) Basis for Recommendation: Experience in industry,[2,4,6,12,13] and animal experiments.[2,7]

B. SEVERITY OF HAZARDS:

(1) Health: Long continued inhalation of asbestos dust results in a form of pneumoconiosis known as asbestosis. The primary effect of inhalation is an interstitial pulmonary fibrosis. The disease is characterized by asbestos bodies in the lungs and sputum. Based on roentgenological examinations, asbestosis can be classified as minimal, moderate, and advanced. It is a serious disease in some instances, but more frequently it remains nondisabling for many years, even without appreciable symptoms, as long as some other serious disease does not supervene to cause death.[9] Chie. symptoms of advanced asbestosis are variable cough, dyspnea, substernal chest pains, decreased chest expansion, weakness, emaciation, clubbed finger tips, and curved fingernails. Any appreciable decrease in the amount of asbestos dust in the breathing atmosphere will cause a decrease in the incidence and severity of asbestosis. Individual suceptibility varies.[9] There have been reports of an increased incidence of lung cancer in persons with asbestosis.[8]

(2) Fire: None.

C. SHORT EXPOSURE TOLERANCE: Not applicable.

II. Significant Properties

A fibrous magnesium calcium silicate which occurs in various combinations as white, greyish or greenish masses, either compact or of long silky fibers, flax-like and readily separated. About 95% of commerical asbestos is chrysotile, which is derived from serpentine, and is a hydrous magnesium silicate containing from 12 to 14 per cent water of crystallization.

III. Industrial Hygiene Practice

A. RECOGNITION: The spinning and weaving of asbestos, in combination with other textiles for fire proof and heat resistant cloth, results in dust exposure. It may be used by itself or combined with other materials for valve packings, gaskets, boiler lagging and pipe covering, protective clothing, shielding materials, and as automotive brake linings. In the building industry it is used in the manufacture of asbestos cement products, heat insulating, and fireproofing materials.

B. EVALUATION OF EXPOSURES: Asbestos dust may be sampled with the electrostatic precipitator or by the impinger method using alcohol or alcohol and water, as the collecting medium,[5,6] and dust counts made by the standard light field technique.[5] The recommended maximum atmospheric concentration of 5 MPPCF is based upon the impinger sampling procedure.

C. RECOMMENDED CONTROL PROCEDURES: Prevention of asbestosis depends entirely upon preventing exposure to concentrations of dust sufficiently high to produce the characteristic reaction. Enclosure or local exhaust ventilation are the principal means of dust control. U. S. Bureau of Mines approved dust respirators may be worn as protection for some operations.

IV. Specific Procedures

A. FIRST AID: None.

B. SPECIAL MEDICAL PROCEDURES:

(1) Preplacement: Clinical and radiographic chest examinations prior to job assignment.

(2) Periodic: Exposed personnel should have periodic clinical examinations for signs and symptoms of asbestosis. These should include examination of the sputum for asbestosis bodies, and chest x-rays of good quality.

(3) Treatment: No satisfactory treatment other than removal from exposure and therapy for any complicating infection.

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