Bureau of Mines
Information Circular 7880

ASBESTOS

A MATERIALS SURVEY

BY OLIVER BOWLES

United States Department of the Interior—1959

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OFFICE OF THE DIRECTOR

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF MINES
WASHINGTON 25, D. C.

September 15, 1958

Hon. Leo A. Hoegh
Director
Office of Civil and Defense Mobilization
Washington 25, D. C.

Dear Mr. Hoegh:

The Materials Survey on Asbestos, originally published in February 1952, under an agreement with the National Security Resources Board, has been revised. Copies are being forwarded to you.

This is the first Materials Survey to be revised under the terms of the April 15, 1955, agreement between the Department of the Interior and the Office of Defense Mobilization, which assigned responsibility to Interior for preparation and revision of Surveys covering 45 mineral commodities.

Manuscript revisions proposed by reviewing officials of the Office of Civil and Defense Mobilization have been incorporated in the Survey.

Sincerely yours,

Thos. H. Miller
ACTING
Director

Foreword

Materials Surveys are designed to bring into a single document all the fundamental data needed by war or defense personnel with major responsibilities with respect to Survey subjects. The Surveys dealing with metals and minerals summarize the demand-supply position in the United States and include information on production, imports, consumption, exports, capacity, interchangeability, substitutes, possibilities for expansion, and pertinent history, usually in some detail back to 1935. The properties of the commodity are described. Exploration, mining, milling, and processing methods and domestic and foreign resources and reserves are discussed. An extended presentation of the structure of the industry covering major corporations, transportation service, processing facilities, interrelationship to other industries, pertinent laws and taxation policies, tariffs, Government controls, special labor problems, and history of wartime control experiences is included. Other special data are presented for particular commodities.

The first edition of Materials Survey—Asbestos, prepared by the Bureau of Mines, was published in February 1952. The present report, prepared in the Division of Minerals under the direct supervision of G. W. Josephson, Chief, Branch of Construction and Chemical Materials, is a revision of the earlier Survey, made in accordance with the agreement between the Office of Defense Mobilization and the Department of the Interior dated April 15, 1955, that revisions of the Surveys should be made periodically. Such revisions are essential because conditions governing production and consumption are constantly changing. New deposits may be discovered and exploited while other deposits may be depleted. Changing economic factors may curtail production in certain areas and expand it in others. Thus, production patterns may shift, the emphasis varying from point to point, from country to country, and even from continent to continent.

Similarly, in the field of utilization, substitution of alternate materials for a mineral commodity may increase; on the other hand, new and wider uses for the mineral may be developed. New equipment designs or new processes may increase or diminish the quantities of the mineral needed for specific uses. Changes in specifications or results of research may contribute to modifications in the use pattern.

Copies of the original Asbestos Survey were sent to many competent reviewers with a request for comments or corrections. Numerous respondents in the United States and in several foreign countries furnished supplemental or corrective data that have been incorporated in the revision. The revised manuscript was reviewed in whole or in part by specialists in the Bureau of Mines, the Geological Survey, the Department of Defense, and industry. Grateful acknowledgment is made to the reviewers of both the original and the revised report for their cordial and constructive response.

CHARLES W. MERRILL,
Chief, Division of Minerals.

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ASBESTOS[1]

A MATERIALS SURVEY

BY

OLIVER BOWLES[2]

Summary and Introduction

"Asbestos" is a name applied to a group of naturally fibrous minerals. Because it has the fibrous characteristics of silk or cotton and at the same time will not burn and has other advantageous properties as well, asbestos has specialized uses for which no adequate substitutes are yet available. Asbestos furnishes a major raw material for a great variety of essential products, the manufacture of which constitutes a vast industry.

Asbestos generally occurs in irregular veins scattered throughout rock masses. Most of the fiber-bearing rock is mined in huge open-pit or underground workings. The fibers are separated from the rock and sorted into groups, according to length, in large, complex mills. The longer fibers are shipped to textile plants, where they are further fiberized and prepared in special machines and are used for spinning into yarn and weaving into unburnable cloth that has many important uses. The shorter fibers, which are much more abundant than the long ones, are used in asbestos-cement building materials in heat-insulating products and for a multitude of other applications. These processes and uses are covered in considerable detail in later sections of this report.

This report gives primary consideration to the types and grades of asbestos that are of greatest importance in the program of military preparedness—namely, the spinning grades of chrysotile, both foreign and domestic, and the amosite and crocidolite obtained only from foreign sources.

ESSENTIALITY OF ASBESTOS

The United States has developed the greatest asbestos-products industry in the world. The value of such products manufactured in 1953 was $345 million and in 1954, $323 million. These products are not only vital to building construction and industry but are absolutely essential to certain other important fields of use. For example, virtually all brake lining and clutch facings of automobiles, trucks, or other mobile equipment used in peace or war consist essentially of asbestos. Hence, a shortage of asbestos used in friction materials would tend to immobilize highway transport. Also, there is no known substitute for asbestos used in steam packings. Accordingly, a shortage of such products would interfere seriously with many lines of industrial activity. Satisfactory replacements for the amosite variety mined only in South Africa for felted insulation of marine turbines can be obtained only at exorbitant prices. Crocidolite (blue asbestos), mined in Africa and Australia, is regarded as a necessary constituent of asbestos-cement pipe.

[1] Work on manuscript completed January 1958.

[2] Former consultant commodity specialist, Bureau of Mines (deceased).

Many other examples might be cited to indicate the essentiality of asbestos to our modern way of life and to any program of military preparedness.

SHORTAGE OF DOMESTIC SUPPLIES

This great asbestos-products industry has been built up under conditions of overwhelming dependence upon foreign supplies of raw asbestos. Domestic mines furnish only 6 to 8 percent of our requirements of all grades and an even smaller percentage of the important strategic grades. Canada and Africa are the principal foreign sources. Canada supplies most of the short-fiber demands of the United States and a major part of the longer textile-grade fibers. Africa formerly supplied a low-iron asbestos essential to important military needs where fireproof electrical insulation is involved, but such supplies are now obtained chiefly from British Columbia, Canada. Africa is our only source of the asbestos variety amosite, which is of first importance as light-weight insulation on ships and airplanes. Africa is the principal source of crocidolite (blue asbestos), which has certain special uses. Bolivia supplies small quantities and is the only source of crocidolite in the Western Hemisphere.

UPWARD TREND OF BOTH WORLD DEMAND AND SUPPLY

The asbestos-products industries of the United States are expanding greatly to pace growing industrial activity; therefore the domestic demand for raw asbestos is increasing steadily. British and continental European needs are also expanding. Central European asbestos-products industries, stagnant during World War II, have revived, and increasing quantities of African and Canadian fibers are being shipped to European markets. Australian demands are also rising substantially. Canadian and African production facilities recently have been greatly enlarged, and further increases are expected. Supplies of fiber adequate to meet growing world needs appear to be ample for the near future, but the long-term prospect is less definite.

ADEQUATE INFORMATION AN IMPERATIVE NEED

The procurement of necessary supplies is a problem of worldwide scope, and in every war emergency asbestos assumes top priority among strategic minerals. It is of paramount importance, therefore, that a thorough knowledge should be gained of the composition and properties of asbestos, its uses and requirements for each use, grades and specifications, the degree of essentiality of each application, the nature and extent of sources of supply throughout the world, mine and mill capacity, reserves, transportation facilities, political and commercial control, world requirements by countries, import and export data, allocation of supplies, fiber beneficiation, possibilities of synthetic asbestos manufacture, use of substitute materials, past war controls, war history, and various other problems that may appear. The purpose of this report is to furnish information on as many as possible of these pertinent questions.

CHAPTER 1. VARIETIES AND COMPOSITION OF ASBESTOS

VARIETIES

There are several varieties of asbestos, differing considerably in composition and physical properties. The most important commercially is chrysotile, which constitutes about 95 percent of total world production. Its wide use is due to the fact that its fibers are generally strong and flexible and therefore can be applied to many uses, such as manufacture of textiles and steam packing, for which weak and brittle fibers are not adapted.

Species of asbestos other than chrysotile fall in the amphibole group of minerals. The only varieties having significant use are anthophyllite, tremolite, amosite, and crocidolite. Fibers of anthophyllite and tremolite are generally weak and brittle, and their uses are limited. Sales are small, and only small quantities of these materials enter international trade. Amosite and crocidolite are mainly African varieties exported to the United States and other countries in considerable quantities for specialized uses.

CHRYSOTILE ASBESTOS

Chrysotile is a hydrous magnesium silicate having a composition represented by the chemical formula $3MgO \cdot 2SiO_2 \cdot 2H_2O$. It is a fibrous form of the mineral serpentine. Antigorite is a platy form of serpentine of no commercial value.

In recent work Shaw (*5*)[3] indicates that both OH, the hydroxyl radical or water of constitution, and H_2O, the water of crystallization, are present in chrysotile. To indicate the dual nature of the water content, he writes the chemical formula $(OH)_6Mg_6Si_4O_{11}H_2O$. He claims also that in fibers from different locations the proportions of these two forms in which water occurs may vary. Thus, in Canadian chrysotile a greater part of the hydration is water of crystallization, while in the Rhodesian chrysotile the hydration is due largely to the hydroxyl radical. He expresses the view that such a difference in chemical constitution may explain in part the superior electrical resistance of the Rhodesian fiber.

The composition of chrysotile, however, is not rigidly fixed according to either of the formulas given above. Minor quantities of iron, nickel, manganese, or aluminum may replace part of the magnesium. Such small replacements may result in some modifications in the physical properties of the fibers. Furthermore, these properties are influenced to some extent by the presence of impurities; but, in general, chrysotile is more constant and dependable in quality than other varieties of asbestos. Chemical analyses of representative samples of asbestos are given in Bureau of Mines Bulletin 552 (*7*).

AMPHIBOLE ASBESTOS

The amphibole group of minerals was formerly believed to consist of anhydrous silicates of magnesium, calcium, iron, and other elements. However, in 1916 Schaller (*2*), using five exact analyses of tremolite, showed, by calculating the molecular ratios, that water was an integral part of the composition of tremolite and derived the formula $2CaO \cdot 5MgO \cdot 8SiO_2 \cdot H_2O$, which is now the recognized composition as contrasted to the widely published formula $CaO \cdot 3MgO \cdot 4SiO_2$. When X-ray studies of minerals were begun in the early 1920's, Schaller's findings were confirmed, and it was further learned that all amphiboles contained water of crystallization. Only in textbooks of mineralogy published since about 1940 will the definite statement be found: "All amphiboles contain hydroxyl." The water content of amphiboles is low—only 1 or 2 percent—whereas chrysotile contains about 13 percent water.

AMOSITE

There is some doubt that amosite is a distinct mineral species. Rabbitt (*4*) found by X-ray analysis of two amosite samples from South Africa that both were monoclinic in crystallization and therefore were not anthophyllites. The chemical composition of one indicated that it was probably actinolite, and the other was probably cummingtonite. Vermas (*6*) concludes that amosite is a fibrous form of the monoclinic amphibole grunerite $(FeMg)_7Si_8O_{22}(OH)_2$. However, it seems desirable to retain the name amosite in commercial usage where it serves a useful purpose.

Amosite may contain as high as 40 percent iron oxide, but, as it is monoclinic in crystallization it is not a true anthophyllite, although

[3] Italicized numbers in parentheses refer to items in the bibliography at the end of this chapter.

it is commonly classed as a high-iron anthophyllite. Amosite, unlike the true anthophyllites, which are almost invariably weak and brittle, consists commonly of long, fairly strong fibers that have certain specialized uses. It is mined only in Africa.

ANTHOPHYLLITE

The composition of anthophyllite is now generally expressed by the formula $Mg_7(Si_4O_{11})_2(OH)_2$, sometimes written $7MgO \cdot 8SiO_2H_2O$. The magnesium may be replaced in part by certain other elements, but complete replacement is not possible because the anthophyllites possess only limited isomorphism. Ferrous iron may replace magnesium up to 26.53 percent, but such an anthophyllite would still contain as much as 11.48 percent MgO. When the ferrous iron content exceeds 26.53 percent, the mineral ceases to be anthophyllite, as it becomes monoclinic in crystallization whereas all anthophyllites are orthorhombic.

The MgO content of anthophyllite is said to range from 5 to 50 percent. A series of 46 chemical analyses of anthophyllites assembled by Rabbitt (*4*) shows a maximum of 31.53 percent and a minimum of 11.48 percent. The one with the maximum MgO content contained 5.6 percent FeO. The CaO content of anthophyllites is very low; it averages about 0.5 percent and rarely exceeds 2 percent.

Aluminum is a more important constituent of anthophyllites than is commonly supposed. Of Rabbitt's 46 tabulated analyses, 14 show more than 10 percent Al_2O_3, and 20 show more than 5 percent. Aluminum may replace magnesium or silicon.

TREMOLITE

In tremolite the calcium may be replaced in small part by sodium. The magnesium is replaceable by iron in considerable quantities and by aluminum to a lesser degree. Also, a small part of the silicon may be replaced by aluminum. Tremolite usually consists of gray to white silky fibers, which are for the most part weak and brittle, although fibers of considerable strength and flexibility are found at times. Both tremolite and anthophyllite are superior to chrysotile in resistance to chemical reaction.

CROCIDOLITE

Crocidolite or blue asbestos belongs to the hornblende group of amphiboles. Its simplest chemical formula is $3Na_2O \cdot 6FeO \cdot 2Fe_2O_3 \cdot 16SiO_2 \cdot H_2O$. Considerable variation in composition has been noted. Sodium may be replaced by potash, ferric and ferrous iron by magnesium or manganese, and ferrous iron by aluminum. Mineralogists now regard crocidolite as identical with riebeckite, being merely a fibrous form of that mineral. Crocidolite therefore bears the same relation to riebeckite that amosite bears to grunerite and that chrysotile bears to massive serpentine. Blue asbestos is produced chiefly in South Africa, but substantial quantities are now obtained in Western Australia, and a small output is obtained in Bolivia. Except for those in Bolivia and a recently discovered occurrence in New Quebec, Canada, no commercial deposits of blue asbestos are known in the Western Hemisphere. In Bolivian blue a large part of the iron is replaced by magnesium. The magnesium content of African blue asbestos is somewhat lower.

ERRATIC CHARACTER OF AMPHIBOLE FIBERS

As may be observed from the foregoing discussion, the replacement of one element by another in varying proportions is a prevalent characteristic of the several varieties of amphibole asbestos. This variation in composition results in corresponding changes in their physical properties. These properties may also be influenced by the presence of impurities. The somewhat erratic and unpredictable physical characteristics of the amphibole fibers have a profound influence on their use. An anthophyllite from one locality may give satisfactory service for some specific use, while one from another deposit, although appearing to be exactly the same, may be unsatisfactory. Thus, problems in amphibole asbestos procurement are much more difficult and complex than the procurement of mineral products like iron or copper, which, when pure, have constant properties, irrespective of the part of the world in which they may originate.

IMPORTANCE OF PHYSICAL PROPERTIES

The outstanding physical characteristic of asbestos is its fibrous structure. Other important fibers found in nature are those of animal origin, such as wool and silk, and those of vegetable origin, such as cotton and flax. Incombustibility is one of the striking differences between asbestos and the fibrous products of animal or vegetable origin. Of perhaps equal importance is the difference in structure. Each filament of cotton, wool, or silk is of measurable and fairly constant diameter and is indivisible into finer sizes. On the other hand, fibers of chrysotile asbestos can be divided and subdivided until a fineness is attained that is limited only by the delicacy of the machinery used and the skill of manipulation. The ulti-

mate fiber size is presumably the size of the ultimate molecule or crystal lattice of asbestos. In other words, fiberization is a cleavage process, and cleavage in minerals is defined as a tendency to split in a certain direction, that is, to separate along and between layers of molecules.

With respect to use, fiber size is important, and the size will depend upon the degree of fiberization attained in milling. Fibers obtained from different deposits vary in the ease with which they may be fiberized. Thus, two samples of chrysotile asbestos, given exactly the same mill treatment, may furnish products differing considerably in fiber diameter, because one of them separates or fiberizes more easily than the other. Such differences may have great practical importance because an asbestos that is difficult to fiberize may require such intense milling to reduce the fibers to desirable fineness that they may be broken into undesirable short lengths. Ease or difficulty of fiberization is therefore an important property of asbestos.

The use to which a chrysotile asbestos may be applied is governed largely by fiber length. The longest fibers command the highest prices and the shorter grades progressively lower prices. Apparently, therefore, primary attention must be given to milling processes that will separate the fibers from the parent rock and will fiberize them adequately with a minimum of fiber breakage.

The heat resistance of asbestos is important in many applications. Some users of asbestos confuse nonflammability with refractoriness. Nevertheless, many substances that will not burn will melt or decompose at relatively low temperatures. The fireproof property of asbestos is one of its chief assets; but, although unburnable, it will decompose and lose its essential physical properties at moderately high temperatures. Some students of the subject have conceived the idea that asbestos is a highly refractory substance by reading the statement made by Cirkel (*1*) that it can withstand temperatures of 2,000° to 3,000° F. easily, while some varieties can be subjected to a temperature of 5,000° F. with no apparent visible effects. With due respect to Dr. Cirkel, who wrote a splendid pioneer volume on a mineral of which little was known at that time, he was in error regarding the heat resistance of chrysotile.

Brandenberger and coworkers (*3*), who have made a comprehensive study of temperature effects on chrysotile at the Mineralogical Institute of the University of Zurich, state that the so-called adsorbed water of chrysotile is driven off at about 300° C. Between 550° and 600° C. all of the water of crystallization is driven off, and the mineral gradually alters to olivine. Accompanying this dehydration is a pronounced change in physical properties. At 400° C. there is a notable deterioration in fiber quality; and above 550° C., with more or less complete dehydration, chrysotile is completely decomposed. The amphibole varieties of asbestos will withstand somewhat higher temperatures than chrysotile. However, crocidolite, although having a low water content, is easily fused into a black magnetic mass.

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CHAPTER 2. DESCRIPTION OF DEPOSITS

Asbestos deposits of commercial value are widely distributed throughout the world. The most important are in Canada, Southern Rhodesia, Union of South Africa, and Soviet Russia, but there are deposits in many other countries. The locations of known commercial deposits are indicated in figure 1, prepared by the Department of Geography, University of Maryland, in cooperation with the Bureau of Mines.

DOMESTIC DEPOSITS

VERMONT

The Vermont chrysotile asbestos deposits near Hyde Park are regarded as a southern extension of the well-known Canadian belt. They differ in character, however, in that most of the asbestos so far obtained is of the slip-fiber type. Some of the slip fiber is long and is adapted for certain spinning and textile uses. Minor quantities of crossfiber occur in veins that are rarely more than three-fourths inch wide. Accordingly, Vermont is a predominantly short-fiber-producing area. The output of spinning-grade asbestos is about 3 percent of total production. These fibers are used to some extent for spinning, but chiefly for filters in electrochemical cells. The remaining groups, in order of abundance, are group 6D and groups 5, 7, and 4. (See Canadian grading and classification in a later section.) The principal uses of the shorter fibers are for asbestos-cement products, asbestos paper, molded brake linings, and pipe and boiler covering and as a paint constituent. The sole producer is Vermont Asbestos Mines, subsidiary of the Ruberoid Co. A new, modern mill was built in 1949.

Although the Vermont deposits have great commercial value, they are less important strategically because there is a small output of the spinning-grade fibers, which are of greatest strategic importance at this time. Furthermore, the fibers, like those in Quebec, cannot be classed as low-iron.

ARIZONA

Chrysotile asbestos occurs in Arizona in numerous localities over an area 60 miles long and 25 miles wide in the Salt River and Cherry Creek Basins, Gila County. The region is more easily accessible than in earlier years. The nearest railway station is Globe, which is 40 miles or more from most of the deposits. Hard-surfaced roads from Globe reach the vicinity of the deposits, and good access roads connect the main highways with most of the mines. Access to some of the undeveloped claims is difficult. Arizona asbestos differs in origin and occurrence from the deposits of Canada, Rhodesia, and Soviet Russia. In Arizona the fibers occur in serpentine in veins parallel to the bedding of limestone in proximity to diabase intrusions. The veins are generally confined to more or less horizontal zones several inches in thickness. They may become lean or vanish within relatively short distances or may become richer.

Some of the Arizona fiber is soft, flexible, and of excellent quality, but other occurrences are harsh or semiharsh. The scattered character of the fiber veins, the high cost of mining, the presence in places of harsh fiber, and long distance from markets have tended to discourage production. Table 1 shows production by years through 1944.

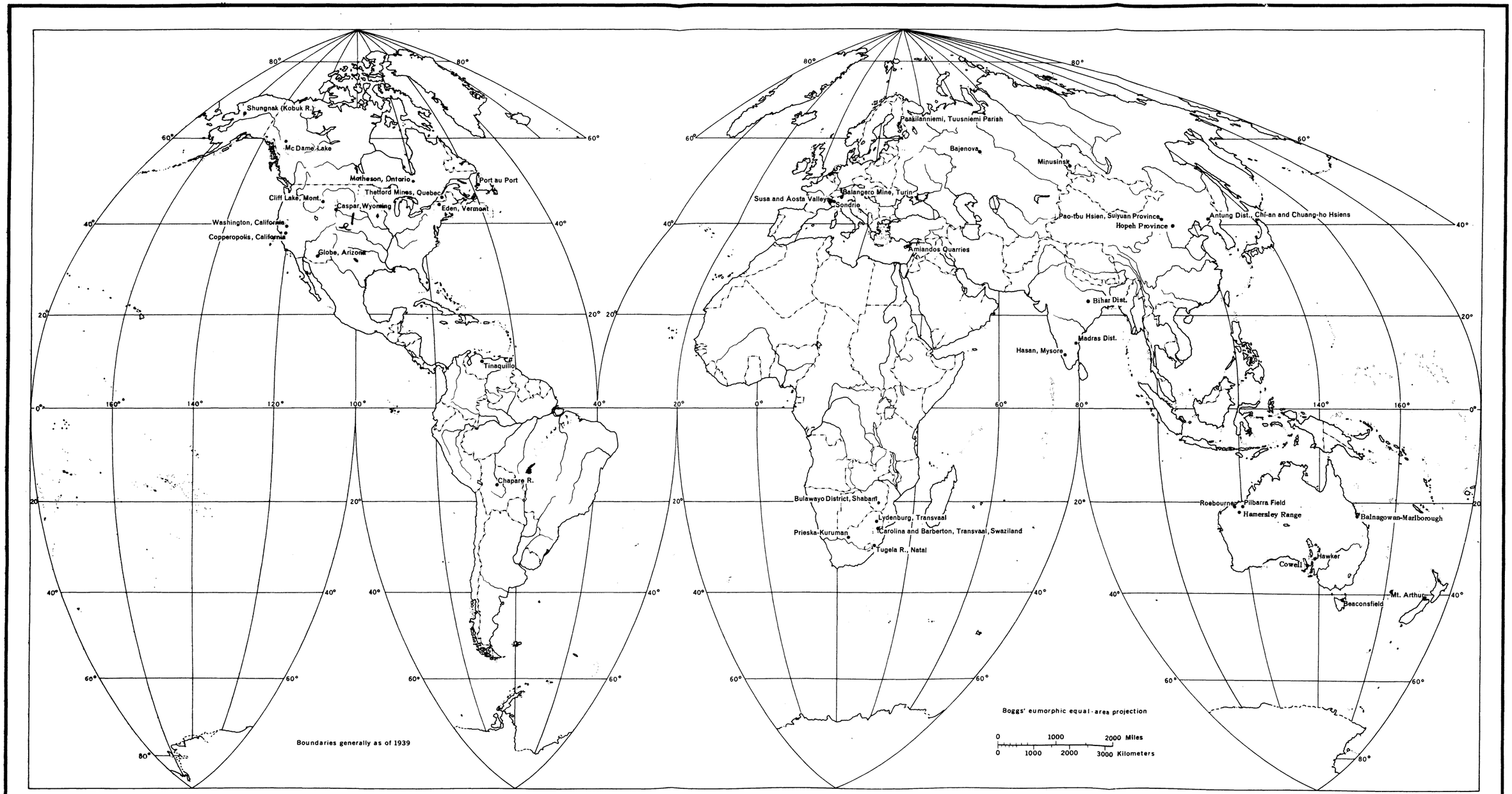
TABLE 1.—*Sales of asbestos in Arizona, 1914–45*

Year	Short tons	Year	Short tons
1914	50	1931	184
1915–18, inclusive	[1] 1, 900	1932–34, inclusive	[1] 34
1919	423	1935	-------
1920	1, 200	1936	464
1921	413	1937	648
1922	93	1938	942
1923	4	1939	904
1924	[1] 132	1940	1, 197
1925	[1] 80	1941	2, 574
1926	100	1942	1, 742
1927	[1] 1, 250	1943	1, 459
1928	[1] 1, 500	1944	696
1929	934	1945	-------
1930	683		

Note.—Data for 1914–44 compiled by Arizona Bureau of Mines. Figures for 1945 and following years are confidential but were somewhat higher than in the early 1940's.

[1] Estimated.

As discussed elsewhere, low-iron chrysotile has great strategic importance for electric insulation products, such as electrical tapes and cable coverings. Until the Cassiar Asbestos Corp. mine in northern British Columbia, Can-



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BUREAU OF AGRICULTURAL ECONOMICS

FIGURE 1.—Map of major world asbestos deposits.
(Courtesy of Prentice-Hall, Inc.)

ada, began to produce in 1953, the C & G grades of Rhodesian chrysotile constituted virtually the sole source of supply of these highly important fibers. Arizona fiber, however, contains little iron, and the soft varieties are eminently suitable for electrical insulation uses; the Arizona deposits are, in fact, the only domestic low-iron chrysotile deposits worked up to 1956.

During the early stages of World War II it seemed desirable to stimulate production in Arizona as a safeguard against shortage of supply from Rhodesia. To determine the possibilities of the Arizona area, the Bureau of Mines undertook an exploratory project in 1943, the results of which have been published (*4*).[1] Mining was conducted in five locations that were regarded as most favorable. Exploratory work failed to indicate extensive reserves, but some commercial material was found at two of the locations. Mining operations extending from one exploratory drift uncovered a large area of fiber-bearing rock of much higher quality than that which appeared in the preliminary drift. In three of the locations no significant discovery was made. Usually the occurrences were found to be erratic, noncontinuous, and limited in area by rather exacting conditions, such as small folds and bedding-plane faults in limestone in proximity to diabase sills and dikes.

Another handicap is lack of a profitable market for the shorter grades, the disposal of which is discouraged by the high cost of transportation. Because of the uncertainty of the occurrences and the high cost of mining, only a moderate increase in production is to be expected even when stimulated by high prices.

The Arizona deposits have been described in detail in recent reports (*5*, *6*).

OTHER OCCURRENCES

Small quantities of asbestos are or have been produced in several other States. Amphibole asbestos is produced in North Carolina, Georgia, and California, and small quantities have been mined in Alaska, Idaho, Maryland, Montana, Oregon, Virginia, and Washington. Chrysotile occurs in many counties in California, and a small output has been reported at times, but the history of development is disappointing. The quality of the fiber in some of the deposits appears to be adequate, but no deposits large enough for sustained production have yet been developed. During 1950 several promising deposits of chrysotile of textile quality were found in a large serpentine belt in Shasta, Trinity, and Siskiyou Counties. Milling and processing tests on a large sample from one of these deposits gave such promising results that a program of exploration is fully justified. California may yet prove to be a valuable source of supply.

A small output of chrysotile has been recorded from near Casper, Wyo., and occurrences have been noted in Alaska, Montana, Oregon, and several other States. No deposits that bear promise of substantial output have been found in any of these locations.

FOREIGN DEPOSITS

CANADA

QUEBEC

The most extensive asbestos operations in the world are in the eastern townships of the Province of Quebec. The asbestos area, which is about 70 miles long and 5 or 6 miles wide, lies between Danville and East Broughton. Within this section are six producing centers—East Broughton, Robertson, Thetford Mines, Black Lake, Coleraine, and Asbestos. The asbestos is chrysotile of high quality, occurring chiefly as crossfiber veins in a serpentine and peroditite formation of post-Ordovician age. In the map of the Quebec asbestos region (fig. 2) the areas indicated as consisting of serpentine also include areas of gabbro and pyroxenite; hence, the areas of host rock are not as extensive as the map indicates. The Quebec deposits have been described in considerable detail by Ross (*1*) and Cooke (*3*).

Most of the output of the Black Lake, Thetford, and Danville areas is derived from crossfiber veins ranging in width from hairlines to 4 or 5 inches across. The bulk of the output is obtained from veins less than one-fourth inch across. The length of the fiber is governed primarily by the width of the vein. Slip fiber originating in fault planes is the chief product of the East Broughton area.

The proportion of fiber recovered averages 6½ to 7 percent of the rock mined and 8 to 8½ percent of the rock milled, according to a recent estimate. In early years it was estimated that 7.8 percent of the fiber produced was of spinning grade; in 1928–32 the spinning grade averaged 6 percent. With increasing utilization of shorts, the percentage is now somewhat lower.

The following companies were operating in the Quebec area in 1956: Asbestos Corp., Ltd., Johnson's Co., Bell Asbestos Mines, Canadian Johns-Manville Corp., Nicolet Asbestos Mines, Ltd., Quebec Asbestos Corp., and Flintkote Mines, Ltd. The following companies were conducting exploratory or development work

[1] Italicized numbers in parentheses refer to items in the bibliography at the end of this chapter.

on new properties in Quebec in 1955 and 1956: Lake Asbestos Co. (subsidiary of American Smelting & Refining Co.), Golden Age Mines, New Lafayette Asbestos Co., Ltd., Derogan Asbestos Corp., Quebec Asbestos Corp., International Asbestos Co., National Gypsum Co., and Eastern Asbestos Co.

The locations of the mines are indicated in figure 2, prepared by the Department of Geography, University of Maryland, in cooperation with the Bureau of Mines.

A low-iron chrysotile deposit, similar to those of Arizona, occurs north of Buckingham, Quebec, about 45 miles from Ottawa. Eastern Asbestos Co., of Montreal, has conducted a drifting and core-drilling program, which has established reserves of considerable extent. A small mill was under construction early in 1956.

ONTARIO

The Johns-Manville Corp. has developed a large property—the Munro Mine—which began production in April 1950. The mine is 12 miles east of Matheson, Munro Township, district of Cochrane. The chrysotile asbestos occurs in crossfiber veins in a nearly vertical serpentinized sill 500 to 900 feet wide. The sill is cut by later dikes and displaced by crossfaults. The maximum width of the veins is about 1 inch. The deposit furnishes a large proportion of the group 4 grades but little or no fibers of spinning grade. Fiber persists to a depth of several hundred feet. The rock has been mined by open-pit methods, but an underground system was being developed in 1954 and 1955. Several thousand tons of fiber are obtained from this source annually.

BRITISH COLUMBIA

Cassiar Asbestos Corp., Ltd., has developed a new low-iron chrysotile asbestos deposit on a spur of McDame Mountain, northern British Columbia. Reserves are large, and the proportion of spinning fibers is exceptionally high. Sales exceeded 20,000 tons in 1956; 35 percent of the material sold was of spinning grade. Forty-two percent of total fiber sold was exported to the United States, 49 percent of which was of spinning grade. Because of the high transportation cost to consuming centers, the shorter, relatively low-priced grades, such as are sold in large quantities in Quebec, cannot be marketed profitably and therefore are not produced. This discovery is one of the most significant recent developments in the asbestos industry, but operation is hampered to some extent by severe climatic conditions and difficult transportation.

NEWFOUNDLAND

A deposit of chrysotile asbestos has been found in the Lewis Brook area in Newfoundland. Fiber of good quality and spinning length is available, but its commercial possibilities are still undetermined. Difficulties of access and transportation are probably the chief handicaps to development. This deposit constitutes a potential reserve.

Discovery of a large asbestos deposit on the north coast of Newfoundland between White Bay and Notre Dame Bay was reported in 1956. The fiber is said to be a good-quality chrysotile predominantly of the shorter grades. The deposit probably can furnish only very small quantities of spinning fibers.

SOUTHERN RHODESIA

Southern Rhodesia ranks next to Canada in international trade as a world source of chrysotile asbestos. The Russian deposits are doubtless larger, but the Russian output is applied principally to domestic uses; only fluctuating and uncertain quantities enter international trade.

The most important producing area is the Shabani, about 80 miles south of Gwelo and 120 miles east of Bulawayo. Here the asbestos occurs in an ultrabasic dunite-serpentine complex intruded by granite gneiss. The deposits, which are lenticular in the workable sections, have been proved by drilling to considerable depths. The workable zones are large; the strike length of the zone at section 170 of the Shabani mine is 2,000 feet and the width 200 to 300 feet. Other important sections of the Shabani mine are the Birthday, section 177, and Nil Desperandum. Crudes and spinning and shingle fibers are produced at a rate of about 5,000 tons a month. Owing to lack of local outlets and distance from foreign markets, the paper, plaster, and other short fibers are now wasted. Transportation was at first difficult, but since 1928 the fiber has become much more easily available to foreign consumers because of completion of a 63-mile railway from Shabani to Somabula.

The Mashaba district, another important mining area, is about 40 miles east of Shabani. The principal mines are the Gaths, King, and Temeraire. There are also several smaller producers. Shingle fibers are the principal products.

Several mines are operating in the Filabusi district, about 60 miles west of Shabani, notably the Croft, Pangani, and Wynnes. The Vangard, Ben, and Peak mines are in the Belingwe district and the Lanninhurst mine, a small but steady producer, is farther south at West Nich-

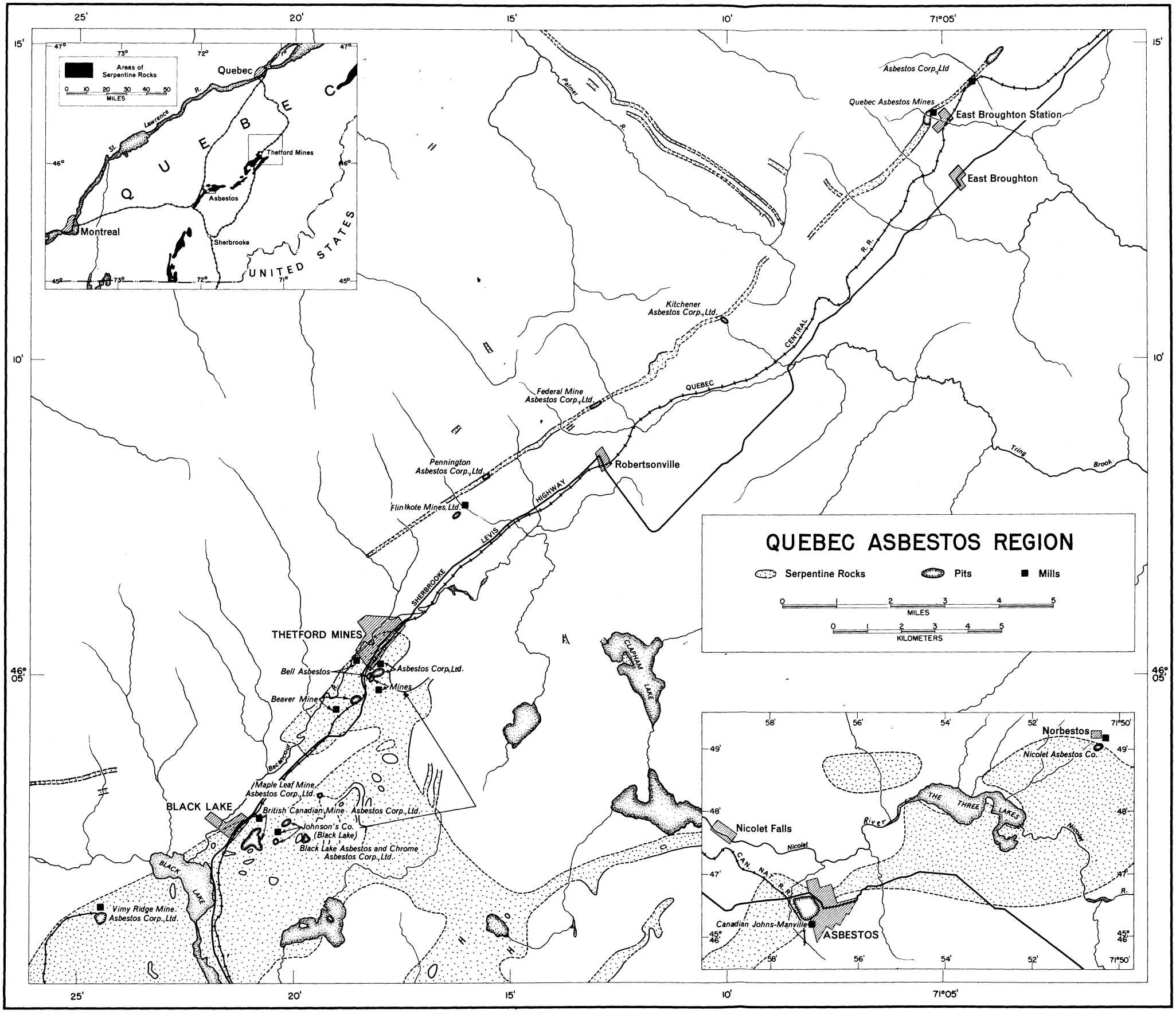

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FIGURE 2.—Map of Quebec asbestos region.
(Courtesy of Prentice-Hall, Inc.)

olson. On the Great Dyke, a major ultrabasic feature extending about 320 miles across the Colony, the only asbestos deposit now being worked is the Ethel mine in the Umvukwe Hills, about 60 miles northwest of Salisbury.

Other occurrences of chrysotile are known in Southern Rhodesia, and some have produced at times. In view of the complex treatment involved in producing the well-known C & G grade fibers in the Shabani area, it is difficult for small operators to produce acceptable grades.

The proportion of long fibers of strategic grade is relatively high in Rhodesia. It has been estimated that 25 to 30 percent of the Shabani fiber may be classed as spinning grade, whereas only 4 to 6 percent of the Quebec fiber is of this grade. The preponderance of long fiber in the Shabani area, however, is overemphasized on a percentage basis by the fact that there is an enormous market for Canadian short grades, whereas the shorter fibers are recovered in relatively small quantities in Rhodesia because of the high freight rate to markets, the chief of which are remote from the mines.

Rhodesian asbestos was greatly in demand in the United States during World War II and for some time thereafter, because it contains little iron and therefore is well adapted for electric insulation uses. Owing to the recent availability of low-iron chrysotile from British Columbia, Canada, the Rhodesian fibers are now regarded as of minor strategic importance.

Rhodesian fibers are of particular value to the asbestos industry because they are well suited for blending purposes. The local market for the fibers has experienced a growth commensurate with the industrial development of the Federation and will continue to expand as this development continues. The bulk of the production, however, is exported, the main outlets being the ports of Beira and Lourenço Marques in Portuguese East Africa. Production now exceeds 100,000 tons annually.

UNION OF SOUTH AFRICA

CAPE PROVINCE

The largest deposits of crocidolite (blue fiber) known in the world occur in Cape Province in a belt of banded ironstones of sedimentary origin extending from a point 20 miles south of Prieska northward beyond Kuruman—an overall length of about 240 miles. The maximum width is about 30 miles. The lavender-blue crocidolite occurs in interbedded crossfiber veins widely but sporadically distributed throughout the belt. The dip and strike of the folded beds are variable, and adequate knowledge of the geology is essential to intelligent prospecting and development. The fibers range in length from less than one-half inch to 2 inches or more but rarely exceed 4 inches. The proportion of spinning fiber is high, ranging from 10 to 20 percent. The principal producer is the Cape Asbestos Co. (Cape Blue Mines (Pty.), Ltd.), which operates several mines north of Prieska. The New Amianthus Mines, Ltd., a subsidiary of Turner & Newall, the Griqualand Exploration & Finance Co., Ltd., and Kuruman Cape Blue Asbestos (Pty.), Ltd., operate mines in the northern section of the belt. Transportation is difficult, as the nearest railway is 20 to 130 miles from the workings. Production exceeded 48,000 tons in 1956.

TRANSVAAL

Four varieties of asbestos—chrysotile, crocidolite, amosite, and anthophyllite—occur in the Transvaal. Small quantities of the last variety are produced for local use. Chrysotile was first produced in the Carolina district from deposits in altered dolomite overlying a diabase sill. These seem to be similar in origin to the Arizona desposits. A second occurrence 47 miles from Carolina is the usual type of crossfiber veins in serpentine. Production from the Carolina district has never been large.

The Barberton district is again a fairly prolific producer after some years of low productivity. The Stoltzburg Asbestos (Chrysotile) Holdings, Ltd., Kalkkloof Asbestos Mine, Ltd., and several other companies are now producing moderate quantities of asbestos in the Carolina area, while African Chrysotile Asbestos and Barberton Chrysotile Asbestos companies are the chief producers in the Barberton field. Production exceeded 24,000 tons in 1956.

The only commercial deposits of amosite known in the world are in the Transvaal. As indicated in the introduction of this report, amosite does not appear to be a separate mineral species, but it has distinctive qualities that justify its continued consideration as a commercial type. The fiber occurs most prominently near Penge, about 30 miles north of Lydenburg in northeastern Transvaal. The amosite belt extends from the Steelport River northwestward along the basin of the Olifants River, thence westward to Chuniespoort. The asbestos occurs in crossfiber veins associated with diabase sills in a series of shales, slates, and quartzites that dip about 18°. The depth to which the asbestos veins persist down the dip has not been determined. The strike of the rock parallels the Olifants River; accordingly, the tributaries of the river cut across the strike and create favorable conditions for driving strike adits along the fiber veins.

The asbestos occurs in three bands. The upper band is 42 inches thick and contains 14 percent asbestos. Below it is 72 inches of waste rock, beneath which is the main band, 60 inches thick; about 25 percent of this is asbestos. A band of waste rock 108 inches thick lies below it, and beneath is the lower band, 30 inches thick; 11 percent of this is amosite fiber.

Four mines are located along the outcrop. The Amosa and Penge mines, adjacent to each other, are at Penge. The main milling facilities are at these mines. The Kremellanboog mine is about 8 miles southeast along the strike, and the Malips mine is 25 miles northwest of Penge. Each of these mines has its own milling and housing facilities. Many smaller mines are also worked.

Much of the fiber is 6 inches or more in length. It is of strategic importance and is in strong demand. Current plant capacity is about 50,000 tons per year, and an expansion of facilities to double the output is planned.

Crocidolite occurs with amosite in the western part of the belt. Production was small for many years, but since 1950 it has exceeded 15,000 tons annually.

NATAL

A small production of chrysotile is obtained at times from a deposit east of Kranz Kop, Zululand.

SWAZILAND

Development was begun in 1937 of an important deposit of chrysotile asbestos in an area in Swaziland about 12 miles south-southeast of Barberton in the Transvaal. The asbestos occurs as crossfiber veins in serpentine. The Havelock mine, owned by Turner & Newall, Ltd., began production in June 1939. The mine connects with the railroad at Barberton by means of an overhead cableway 12.6 miles long. This has become a major producing area, having an output of about 30,000 tons per year.

U. S. S. R.

The Russian asbestos deposits are generally regarded as ranking next in importance to the Canadian. The region providing the major part of Soviet production is known as the Bazhenovo region in the Urals (*2*). The industry is centered at Asbest, about 35 km. north of Bazhenovo and 85 km. northeast of Sverdlovsk. The asbestos-bearing serpentinized intrusion is about 21 km. long and 200 to 1,200 meters wide. It consists of peridotites bounded by schist or slate on the west and by granite on the east. The asbestos occurs in ellipsoidal masses of serpentine, which may attain a length of 3,500 and a width of 1,000 feet. The highest percentage of asbestos is in the central parts of these masses. The crossfiber veins generally run north and south and dip vertically. Slip fiber appears in places. Russian asbestos contains less iron than the Quebec fiber. Analyses of typical samples show an Fe_2O_3 content of Bazhenovo asbestos of 1.09 percent compared with 4.52 percent for a Thetford Mines sample. The FeO content of the samples was, respectively, 0.45 and 1.90. The overburden is comparatively shallow, and asbestos in the weathered rock is somewhat harsh and lacks silkiness. Below the 50-foot level it more nearly resembles Canadian fiber. The percentage of spinning fiber is said to be a little higher in the Russian than in the Canadian deposits, but the percentage of total recovery is about the same.

There are four major groups of mines in the district. The most northerly, known as the Proletariat, produces shorts almost exclusively. The October and the Ilyinsk, the two central districts, are the richest and are the major producers. The most southerly district is known as the Trudovoy Otdykh.

VENEZUELA

Chrysotile of the Quebec type occurs in the State of Cojedas, 5 to 7 miles from Tinaquillo and about 35 miles from Valencia. There are two major deposits, El Tigre and La Montanita, about 3½ miles apart. The latter is the larger and the more promising. The asbestos occurs in crossfiber veins attaining an occasional width of 1½ inches. A fair proportion of fiber of spinning length is available. In 1952 Amianto Venezuela Compania Anonima (AMVECO) of Caracas was organized to develop and mine these properties. A reconditioned mill at the El Tigre deposit began operating in 1953 and produced 1,700 tons in 1955. Fiber of shingle-stock grade is sold to an asbestos-cement products plant at Caracas, and an export trade is being developed for the longer grades. Several other deposits in the area may justify further examination.

BOLIVIA

Crocidolite (blue asbestos) has been mined in a small way in Bolivia for many years. The deposits are about 200 km. northeast of Cochabamba in the Mendoze Canton, Department of Cochabamba. The asbestos veins range from ½ to 30 cm. (12 inches) in width. They fill fractures and bedding planes in sandstone. The veins are fairly close together in places; 6 veins have been found in a cut 1 meter wide. The fiber-vein area is evidently very extensive. The fibers are weaker than the African or Australian blue but are superior to other blue

fibers for use in gas-mask filters. The material was therefore stockpiled for strategic use but, with the development of satisfactory fiberglass gas-mask filters, Bolivian blue is now of minor strategic importance. Because of its low tensile strength, there is little demand for it in the open market.

GREECE

A recently discovered occurrence known as the Zidani asbestos deposit, about 30 miles south of Kozani in northern Greece, was being developed in 1957 by Kennecott Copper Co., of New York, N. Y. According to reports, core drilling had established extensive reserves.

ITALY

Both tremolite and chrysotile are produced in Italy. The Balangero chrysotile mine in Torino, about 20 km. north of Turin, has been the chief producer during recent years. The fiber is said to be inferior to Canadian asbestos for spinning purposes. Although production of all kinds of asbestos reached 33,266 short tons in 1955, very little is exported to the United States.

AUSTRALIA

Small quantities of chrysotile are produced in Western Australia and New South Wales. The most important asbestos deposit is the crocidolite occurring in the Hamersley Ranges of Western Australia. Several thousand tons of blue fiber, comparable in quality with Cape blue, is produced annually, and 1,000 to 2,000 tons per year is imported into the United States. Crocidolite also occurs at Hawker, South Australia. Chrysotile occurs in the Roebourne and Pilbarra districts of Western Australia, near Cowell, South Australia, at Marlborough, Queensland, and in the Beaconsfield district of Tasmania.

NEW ZEALAND

Chrysotile asbestos in veins up to 3 inches wide occurs in a serpentine area, at least 3 miles long, near Mount Arthur in the upper Takaka district. The deposit is said to be extensive, but no production has been recorded since 1952.

CHINA

Several chrysotile deposits are known in China. The largest deposits in China Proper are in the Paotou Wuchuan and Kuyang districts, Suiyuan Province, and in Laiyuan district, Hopei Province. Neither province has produced extensively. It is estimated that production reached as high as 20,000 tons a year under Japanese stimulation in the early 1940's, but most of it during that period was obtained from the Antung area in Manchuria. No reliable production data are available.

JAPAN

Before 1939 a small production of asbestos was obtained from various scattered deposits, but after that date intensive exploration and development were undertaken, and a subsidized asbestos industry of moderate size was established. The most important mines are in the Hokkaido district, where about 94 percent of the chrysotile output originates. The other 6 percent is mined in southwestern Honshu district. In the Hokkaido district the chrysotile occurs in irregular veins in serpentine. Virtually the entire output consists of short fibers used chiefly in asbestos-cement products. The fiber is prepared in processing mills patterned after those in Quebec, Canada.

FINLAND

Finland is a steady asbestos producer, but the fiber is an amphibole type of little strategic importance. The principal output is from the commune of Tuusmiemi.

CYPRUS

The asbestos deposits of Cyprus occur at Amiandos, on Mount Troodos, in the west-central area. Short-fiber chrysotile occurs in irregular veins in serpentine. The maximum thickness of the veins is about half an inch. The asbestos content of the rock is only 1 to 2 percent. Milling is predominantly a short-fiber operation, and "shingle stock" is said to comprise about 90 percent of production. Although output exceeded 17,000 short tons in 1955, the material has little strategic value.

INDIA

Chrysotile asbestos of good quality occurs in Pulivendla Taluk (County), Cuddapah district, Andhra State, about 160 airline miles northwest of Madras. The asbestos-bearing zone lies in a serpentine-bearing magnesian limestone at contact with intrusive sills of trap-rock. Small tonnages of the fiber reach the United States market occasionally. Veins of chrysotile are worked at times near Gopalpura, Mysore district, and also in the Hasan district, Mysore State. Asbestos deposits of Singh-

bhum district of Bihar and Bara Bana in the Seraikela district of the same State consist chiefly of tremolite.

MOROCCO

In the early 1940's considerable interest was exhibited in the Bou Azzer asbestos mine located in desert country about 100 km. (62 miles) north of the Sahara Desert. The asbestos is chrysotile occurring at contact of a mass of greenstone with granodiorite. The fiber occurs in lenses, many of which are small. Samples of fiber sent to the Bureau of Mines were of good spinning quality, but only a small fraction of the fiber is of spinning length. The association of the asbestos with cobalt is unique. Up to 1944 about 500 tons of short fibers had been hauled by truck to Casablanca, where it was used in the manufacture of building materials. No activity has been reported since that date. Several other asbestos deposits have been worked in the vicinity of Bou Azzer.

OTHER COUNTRIES

Sporadic production from small deposits is reported from many other countries, but none appears to offer substantial supplies.

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CHAPTER 3. EXPLORATION

Exploration is a necessary preliminary step in the development and exploitation of asbestos deposits. Asbestos is usually associated with serpentine, a mineral easily recognized. Geologic mapping of serpentine and associated formations is of great assistance in prospecting. Exploration at depth may be conducted with diamond or shot core drills.

CURRENT PROGRESS IN EXPLORATORY WORK

Industry has conducted wide exploration, and Government, through the channels of the Bureau of Bines and the Geological Survey, has searched for new deposits for many years, but little success has been attained. Early in the postwar (World War II) era, when all types and grades of asbestos were in short supply, the Government recognized that a critical situation existed, not only for asbestos but for several other minerals, and the Defense Minerals Exploration Administration on February 20, 1951, allocated a $10-million fund to assist in the search for new deposits. The terms for asbestos exploration were of decided advantage to participating firms. The ratio of contribution originally was 90 percent by the Government and 10 percent by the operator. Late in 1953 the ratio was changed to 75 and 25 percent, respectively.

From the establishment of the DMEA program until March 1957, 19 asbestos contracts had been approved, most of them in Arizona, several in California and Vermont, and one each in Montana and Wisconsin. Four of the contracts led to certification of discovery, but three of the deposits so certified were too small to have significance in the overall situation. The fourth certification concerns an extension of the well-known large asbestos-bearing area in Vermont, the only large domestic reserve known at this time. The results are discouraging, but they might have given more promise had not the regulations under which DMEA has operated since early 1953 confined assistance to low-iron chrysotile discoveries, a regulation which has virtually limited applications to Arizona. The results of the DMEA program indicate that industry is prepared to cooperate with Government in exploration of areas that bear promise of containing valuable asbestos deposits, the investigation of which would involve too much risk to encourage unsupported private investment.

The Bureau of Mines and the Geological Survey are assisting in exploratory work insofar as their limited resources will permit. Some work is being done by State geological surveys. Several asbestos companies are conducting extensive exploratory work as a part of their regular development programs.

Government facilities for asbestos exploration are largely unused. No DMEA applications for assistance on asbestos prospects have been received for many months.

METHODS AND PROBLEMS OF EXPLORATION

Methods of exploration are governed to some extent by the nature of the deposit. Most of the commercial asbestos deposits of the world, like those in Quebec, Canada, are associated with massive serpentine, peridotite, and similar rocks that extend to great depths. Such deposits, which may be designated the three-dimensional type, require exploration both laterally and vertically. A less common type, like that in Arizona, consists of more or less horizontal fiber veins bedded in limestone. Such deposits are predominantly two-dimensional, the main problem being determination of the areas of the fiber-bearing zones. However, occasional vertical exploration may be desirable to determine the presence or absence of additional fiber veins at other levels or to trace fiber-vein displacement by faulting or folding.

The magnetometer has recently been applied with some success to prospecting for asbestos. Serpentine masses with which chrysotile is generally found can be detected with a magnetometer even though they may be blanketed deeply with overburden. The magnetometer will not detect asbestos, but it enables the prospector to delineate the areas where serpentine, the host rock of the asbestos, exists, and thus it narrows the field for later, more intensive prospecting. The magnetometer is less effective in prospecting the sheetlike deposits occurring in limestone.

If, by using the magnetometer or by other means, a promising area has been delineated, more detailed prospecting may be pursued. If the serpentine occurs in bare outcrop, a careful examination of the surface will permit a limited evaluation of the deposit. If the deposit is covered with shallow overburden, pits or trenches will permit examination of near-surface rock. Exploration at depth is best accomplished with diamond-bit core drills. Survey lines are commonly spaced at 100-foot intervals and in 2 parallel series at right angles to each other. Drill holes may be spotted at

the intersections of the grid thus formed. The spacing may, however, be greater or less than 100 feet, depending upon circumstances. The holes may be either vertical or inclined. A direction is chosen that will furnish the most useful information concerning the rocks intersected. A study of the cores will give information on the spacing and thickness of the fiber veins, the approximate percentage of fiber present, the length and quality of the fiber, and the depth of fiber-bearing rock available.

The proportion of fiber to rock may be determined by measuring the total width of fiber veins intersected. One method is to measure the veins by increments of one-sixteenth inch. A 5-foot section of core contains $^{960}/_{16}$; assumption of an even 1,000 is within the realm of approximate accuracy. Therefore, by adding the total number of sixteenths of fiber contained in a 5-foot section and dividing this number by 10 an uncorrected percentage of fiber content is obtained. This figure may be corrected according to the angle at which the veins intersect the axis of the core.

Another method of evaluating the fiber by grades is to crush the cores and screen out the fiber in a laboratory mill.

If the cores are badly broken as they commonly are in fractured and veined serpentine, a method of sampling the drill sludge has been devised. The findings of fiber content by the drill-core or sludge methods may be checked by determining the fiber content of representative bulk samples taken from outcrops or drifts. Laboratory or pilot-plant mills may be used for such determinations.

If a commercial mill is available, a test run of several hundred tons of average mill rock is the most reliable means of determining total recovery and recovery by grades that may be expected. However, each asbestos deposit has its characteristic features, and milling processes and equipment must be adapted to suit the prevailing conditions. A mill designed and adjusted to treat most efficiently the rock of a certain deposit may not be well suited to treat rock from another source. Therefore, the percentage recovery obtained on the sample may be lower than could be obtained when, as a result of experience, the mill is operating at maximum efficiency.

Length, strength, and flexibility of the fibers are of first importance. For fibers one-fourth inch long or longer a simple test is to hold a wisp of fiber firmly between the thumb and finger, using both hands, and to twist it by rotating the hands. Weak fibers will break readily under such treatment. If the asbestos can be twisted for some time without breakage it has high strength, and if the fibers are long enough they probably are suited for spinning uses. Fibers one-fourth inch long and longer are more valuable than the shorter grades. However, for weak fibers like those of most anthophyllites and tremolites, fiber length is of little significance because the fibers are easily broken into shorter lengths.

ESSENTIAL REQUIREMENTS OF NEW DISCOVERIES

Certain conditions must be satisfactorily met before successful commercial operation of a new chrysotile asbestos deposit can be reasonably assured.

Chrysotile fibers of commercial grade must be strong and flexible. Surface weathering tends to weaken the fibers; samples should therefore be taken below the weathered zone. Adaptability of the fibers to use is an important consideration; filtration properties, harshness, flexibility, and brittleness directly affect commercial application.

Some asbestos deposits are worked profitably even though virtually all of the fiber is below spinning grade because short fibers are used extensively. However, fiber of spinning length is highly desirable, especially in times of national emergency. Even a small proportion of fiber veins three-eighths inch or more thick is a favorable factor. Deposits yielding both spinning and nonspinning fibers are more likely to prove profitable than those producing short fibers only.

Normally the percentage of fiber recovery in commercial deposits ranges from 4 to 6 percent, but occasionally it may be higher or lower. Some deposits containing only 2 or 3 percent fiber are said to be operated profitably. A deposit with small yield might be workable if the fibers were of exceptionally high value, if, for example, the deposit yielded a substantial proportion of spinnable asbestos.

Asbestos milling is a costly process that requires a heavy investment in equipment. The investment is justified therefore only if the workable deposit is large enough to insure adequate supplies of commercial quality, fiber-bearing rock for at least 20 years of operation at an established rate and average profits. Prospect core drilling to determine the extent of reserves is a necessary forerunner of any asbestos mining and milling project.

Economic factors are important. Operating costs, power and water supply, transportation facilities, market demands, and availability of labor are important factors in determining minability.

CHAPTER 4. MINING METHODS

Asbestos deposits throughout the world differ widely in character, and as mining must be adapted to the prevailing conditions a great variety of methods is followed, including both surface and underground mining. Open-pit quarry methods, glory-hole, underground room-and-pillar, shrinkage-stoping, block-caving, and other methods are represented. A brief description of mining operations, by locality, follows.

ARIZONA

In Arizona there is no massive fiber-bearing rock, as in Canada. The serpentine with which the approximately horizontal asbestos veins are associated occurs in bands from a few inches to a few feet thick extending parallel with the Mescal limestone bedding. Many of the mines are entered from cliff faces or the steep sides of canyons. The veins pinch and swell irregularly and are so erratic in size and direction that development cannot be planned as definitely as in the mining of many other minerals. The fiber is mined in drifts and stopes, and conditions are most favorable where two or more veins of workable size are close enough to be worked in one drift. Modified room-and-pillar methods are followed. Mining costs per ton of recoverable asbestos are high.

VERMONT

The chrysotile-asbestos deposit of Vermont is on Belvidere Mountain approximately 15 miles from Hyde Park. Overburden is not heavy; and, as the asbestos veins occur in massive serpentine as in Canada, open-pit quarry methods can be followed to advantage. The quarry is operated on 3 benches, each about 600 feet wide and 125 feet high. A series of 7-inch blastholes is sunk with churn drills, and about 50,000 tons of rock is broken with each multiple blast. The rock is loaded with 3-yard electric shovels into 15-ton Euclid trucks, which dump into a 48- by 60-inch jaw crusher. The crusher will handle such large masses that very little secondary blasting is necessary. Secondary crushing is accomplished in Symons cones, which reduce the rock to walnut sizes. The product of the cones is carried on a conveyor belt about one-fourth mile to an open stockpile at the millsite. Material from the stockpile is conveyed to a drier and thence to a dry-storage bin, from which the mill feed is drawn.

CANADA

Canadian asbestos occurs in irregular veins in massive serpentine deposits that are extensive both laterally and at depth. Accordingly, well-ordered, large-scale mining operations have been developed. For many years asbestos rock was obtained from large, open-pit quarries served by massive overhead cableways. About 1927 methods were modified by the introduction of cranes or power shovels for loading, locomotives for hauling cars on the quarry floor, and cable cars for removing rock from the pits up inclined planes or through tunnels. Crudes were hand-cobbed on the quarry floor or removed from picking belts after the rock was crushed.

A later development was the introduction of shrinkage stoping, but the block-caving method first introduced in the King mine of the Asbestos Corp., Ltd., was found to be the most economical and is coming into more general use. It has been employed by the Johnson's Co. for some years, and the Canadian Johns-Manville Corp. has completed development of an extensive block-caving system that has been in progress for several years. Each block is 200 feet square. The crushing plant is on the 816-foot underground level and the loading facilities on the 950-foot level. The entire output of Bell Asbestos Mines is mined by block-caving methods. This rather complex system of mining has been described in several publications (*2*, *3*).[1]

[1] Italicized numbers in parentheses refer to items in the bibliography at the end of this chapter. Page references refer to pages in the item and not in this report.

SOUTHERN RHODESIA

The largest asbestos mines in Southern Rhodesia comprise the Shabani group. They are classed among the most important asbestos mines in the world. In early years mining was conducted from open-pit workings, most of which have now been replaced by completely mechanized underground methods. In the initial stages of underground work at the larger mines cut-and-fill and shrinkage stoping were used. Later these methods were superseded by a block-caving system similar to that used in Quebec, Canada. Mining methods vary according to the size of the operation and the nature of the deposit.

UNION OF SOUTH AFRICA

According to a recent report (*4, p. 124*), about three-fourths of the asbestos mined in the Union is recovered by underground methods.

Chrysotile is produced by about a dozen companies, but total output is relatively small. The operations are chiefly of the open-pit type, although underground workings have been developed at some of them. Both block caving and shrinkage stoping are employed.

The principal amosite mines, the Amosa and the Penge, controlled by the Cape Asbestos Co., have extensive underground workings. The fiber-bearing beds dip 20° to 25°, and the natural slope of the terrain exposes them in convenient position for driving adits, usually at 100-foot intervals. The adits are connected by winzes and raises to develop blocks of fiber-bearing rock that are commonly worked as breast stopes. Waste rock is used for backfilling. Mill feed is trammed to adit mouths and conveyed to central ore bins. As the workings are extended down the dip, shaft sinking is required.

Five major producing mines furnish most of the crocidolite obtained in the Petersburg field of the Transvaal. Mining methods are similar to those in the amosite area. Five smaller mines are also operating, but large quantities of fiber are won by individual miners on a contract basis.

About two-thirds of the crocidolite mined in the Cape Province originates in three mines controlled by the Cape Asbestos Co.—the Westerberg and Koegas in the southern end of the field and the Pomfret mine in the north. The balance is produced in many smaller workings. The asbestos occurs in three reefs or belts, the outer, main, and inner, which form a synclinal trough. In the principal mines various stoping methods are employed, depending upon local conditions. The longer fibers are hand-cobbed. Details are given by Sinclair (*4, pp. 135–142*).

SWAZILAND

The Havelock mine was first operated as an open pit, but since 1948 underground stoping methods have been followed. A shaft sunk to 1,280 feet at an angle of 40° serves 5 levels. Sorting is done underground, and only the fiber-bearing rock is brought to the surface. After being crushed, the fiber-bearing rock is passed through a rotating grizzly with 4-inch openings. The minus-4-inch product passes through a trommel with 2½-inch circular openings. The plus-4-inch product and the minus-4-inch plus 2½-inch product are carried on a picking belt, where fiber-bearing and barren rock are separated; the latter is carried to waste.

U. S. S. R. (*1*)

The asbestos deposits of the Bazhenovo district have a thin overburden. Hand methods of removal were first employed, but power shovels or hydraulic methods have superseded them to quite an extent.

More than 20 shallow, open quarries were worked for many years. Up to 1929 drilling was the only mechanical process used; all other operations were conducted with handtools. Owing to inadequate milling facilities, handpicking became an important concentration process, and only ¼ to ⅕ of the rock quarried was sent to the mill. The average fiber content of the rock mined was only about 6 percent; but, because of the concentration attained by handpicking, rock sent to the mill contained 20 to as high as 80 percent fiber.

The first steps toward more complete mechanization were taken in 1929, with installation of 2- to 4-ton-capacity overhead cableways with fixed foot towers and traveling head towers, supplemented by inclined haulageways served by electric hoists. The rock was blasted in benches 5 to 6 meters high and classified into crudes, mill feed, and waste.

In 1929 two shafts were sunk and connected with a haulage level at a depth of 50 meters. They were designed for glory-hole mining, which proved uneconomical. This method was supplemented and largely superseded in 1930 by electric-shovel loading in open pits; the rock is transported by locomotives to inclined haulageways, up which cars are taken by electric hoists.

OTHER COUNTRIES

The Cyprus mines are extensive; but, as the short chrysotile fibers produced have no strategic importance, a description of mining methods is not pertinent here. The same is true of the amphibole-asbestos mines of Finland. In Australia the crocidolite of the Hamersley Range, occurring in seams 2 to 6 inches thick, is mined by a room-and-pillar method. The Tinaquilla, Venezuela, deposits are worked as open quarries.

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CHAPTER 5. MILLING METHODS

DEFINITIONS

Asbestos fibers fall into two main groups—crudes and mill fibers. The term "crude" in Canada and Vermont is applied to fiber of spinning grade measuring three-eighths inch or longer that is hand-cobbed instead of being passed through a mill. In Arizona the term is used more loosely. There are four grades of Arizona crudes that include all fiber lengths. Although some are hand-cobbed, most of them are produced by simple mechanical cobbing and screening. In other countries, also, the term is used more loosely than in Canada. In both Soviet Russia and Africa it includes fibers prepared by hand-cobbing alone or in conjunction with simple mechanical crushing, disintegrating, and screening processes. Mill fibers are obtained by crushing and beating the fiber-bearing rock until the asbestos is freed and then removing the fiber from the rock by screening and air separation.

GENERAL FEATURES

Chrysotile, the principal asbestos of commerce, is a fibrous form of serpentine and is usually associated with massive fractured serpentine. The concentration process is therefore unusual in that it involves separation of a fibrous mineral from a massive form of the same mineral. Neither chemical composition nor specific gravity can therefore be used as a basis for separation. The property that makes mechanical separation possible is the fibrous structure, which permits it to be opened or divided into filaments that are amenable to separation from the gangue by air suction or screening.

The value of chrysotile asbestos depends largely upon the length of the fibers, the long fibers being worth several times as much as the short ones. A most important principle underlying asbestos milling is separation of fiber from rock with a minimum of fiber breakage. Unnecessarily rough treatment should be avoided. Modern mills are designed to remove the separated fiber after each crushing process. If fiber already freed from rock enters the next crushing unit along with sand and rock fragments, it may be broken into shorter grades. Asbestos milling consists essentially of coarse crushing, drying, and recrushing in stages, each step being followed by screening and air separation of fiber from rock.

The milling process fiberizes the asbestos and also separates rock fragments and dust from the asbestos. Spinning-grade milled fibers require considerable further processing at the asbestos textile-manufacturing plant. Crude asbestos to some extent retains the natural solid form in which it occurs in the veins, and several successive opening processes are required. These processes are conducted at the textile plant.

The development of improved processes, whereby fiberization may be accomplished with minimum breakage of fibers, is a profitable field for research. Some success has been attained by using dispersing agents to supplement or replace mechanical means. Impregnation with air at high pressure followed by sudden release of the pressure has been tried (*4*).[1] This is essentially the same process as that followed by the Masonite Co. for fiberizing wood. When applied to masses of crude asbestos, the method gave satisfactory fiberization but is said to be uneconomic.

The milling process not only breaks the longer fibers into shorter lengths but tends to weaken the fibers, and this also should be avoided as far as possible. Methods have been devised whereby the tensile strength of asbestos fibers can be tested and the results expressed in terms of pounds per square inch (*5*). Although this process is slow and tedious, it has at least one important application. Bundles of crude asbestos can be submitted to processing equipment, such as crushers, rolls, and hammer mills, and the tensile strength of the fiber can be tested before and after processing. By comparing the degree of weakening of the fiber, one can determine which type of equipment is best suited for opening the fiber with minimum effect on the fiber strength.

CANADA

Canadian milling practice is described first because it is the most complete and is the pattern followed in most asbestos regions.

Primary crushing is the first step in milling. Rock from the mines is dumped into a "sluice" having a railroad-rail grizzly bottom, which provides a bypass for fines. The primary-

[1] Italicized numbers in parentheses refer to items in the bibliography at the end of this chapter.

crusher feed from the sluice is controlled by finger gates, that is, suspended rails that may be moved up or down. A jaw crusher with a 36- by 24-inch opening set for a 4- to 6-inch discharge is the most popular primary breaker, but larger or smaller units may be used. The discharge from the crusher passes through a trommel screen, and the oversize in lumps 4 to 6 inches in diameter is fed to secondary crushers, usually of the gyratory or cone type. The crusher product and undersize from the trommel are conveyed to driers, and the dried rock is stored in bins having capacities of 25,000 to 150,000 tons each.

From dry storage the rock is carried through a third crushing stage in crushers of the gyratory or cone type. The crusher product is fed to shaking screens equipped with suction hoods for removing fiber. The suction hoods are 3 to 4 inches wide and extend across the full width of the screens at their lower ends. Large fans provide the suction that lifts the fiber from the screen and carries it to collecting cyclones. The rock that passes over the end of the screen and the undersize that passes through the screen are carried forward for further treatment. The rock is reduced in a fourth and last crushing stage to about one-fourth-inch size and is again passed over shaking screens to remove fiber and fines.

Up to this point, size has been reduced by crushing; for further reduction fiberizers are used. There is a marked difference in the action of crushers and fiberizers. Reduction by crushing is accomplished by a pinching or compressing force applied rather slowly. The fiberizer, however, is a high-speed hammer mill that breaks the rock by rapidly applied impact. Either method releases the fiber from the rock, but the impact method is more intense; to reduce fiber breakage to a minimum, the fiberizer ordinarily is not used until the longer, more valuable fibers have been separated.

The product of the fiberizers, like that of the crushers, is fed to shaking screens from which the fiber is collected by air suction, and the rock and screenings are carried forward for further treatment. This process may be repeated several times. Fiberizing, screening, and air suction are the three major steps in asbestos milling. The dust-laden air from the aspiration process is carried to dust chambers. The extremely short grades collected in the dust chambers are blended, bagged, and sold as "floats."

Fibers from the collecting cyclones are graded according to length in trommels 8 to 16 feet long and 26 to 60 inches in diameter, fitted with woven-wire cloth. Any number of grades may be made, depending upon the size of the screen openings. Special grades may be made by blending.

Further details on Canadian milling practice are given in several publications (*2*, *3*, *7*). Figure 3 is a picture of the largest asbestos mill in the world. It can handle 20,000 tons of asbestos-bearing rock a day.

A new type of mill (the aerofall) is claimed to offer certain advantages. The typical flowsheet for standard practice as indicated heretofore employs a series of successive hammer-mill reductions with removal of fiber at each stage to reduce fiber breakage. The aerofall mill feed of minus-4-inch stone is reduced in a single stage. It is air-swept and designed to remove the fiber continuously as soon as it is freed from the rock. Its effectiveness has not yet been thoroughly explored.

Some years ago a movement toward a much wider use of shorts for such products as asphalt floor tile was discerned in the Canadian asbestos industry. Some of these products contain 35 percent or more asbestos, which is said to impart exceptionally high qualities. Because of this new market outlet, all companies operating mills in Quebec introduced additional screens and suction facilities to recover part of the shorts formerly regarded as waste.

A pressure-packing process is now used in some mills. Instead of the conventional bagging machine, equipment has been designed whereby paper sacks are enclosed in steel and the fiber is packed under high pressure. Each rectangular sack containing 100 pounds occupies only about 2 cubic feet. Storage and shipping space are conserved when this sacking method is employed.

The dry process is universally used in asbestos milling. Wet methods were tried experimentally many years ago but were not adopted commercially. A few years ago, however, the Johnson's Co. erected a new wet-process plant for re-treating mill tailings to recover shorts. The process was developed by Selective Treatment Company, Ltd., under patents now expired. According to report, the process is no longer used.

A recent trend in Canadian milling is to prepare fibers to conform with exacting specifications regarding grading and dust removal. Equipment is being modified to manufacture products tailored more closely than in former years to the special requirements of the consuming industries.

CAPACITY

Table 2 shows the milling capacity of the Quebec asbestos industry, including new mill construction and other changes to the end of 1956. Fiber production from the mills reached a maximum of over 1 million tons in 1955.

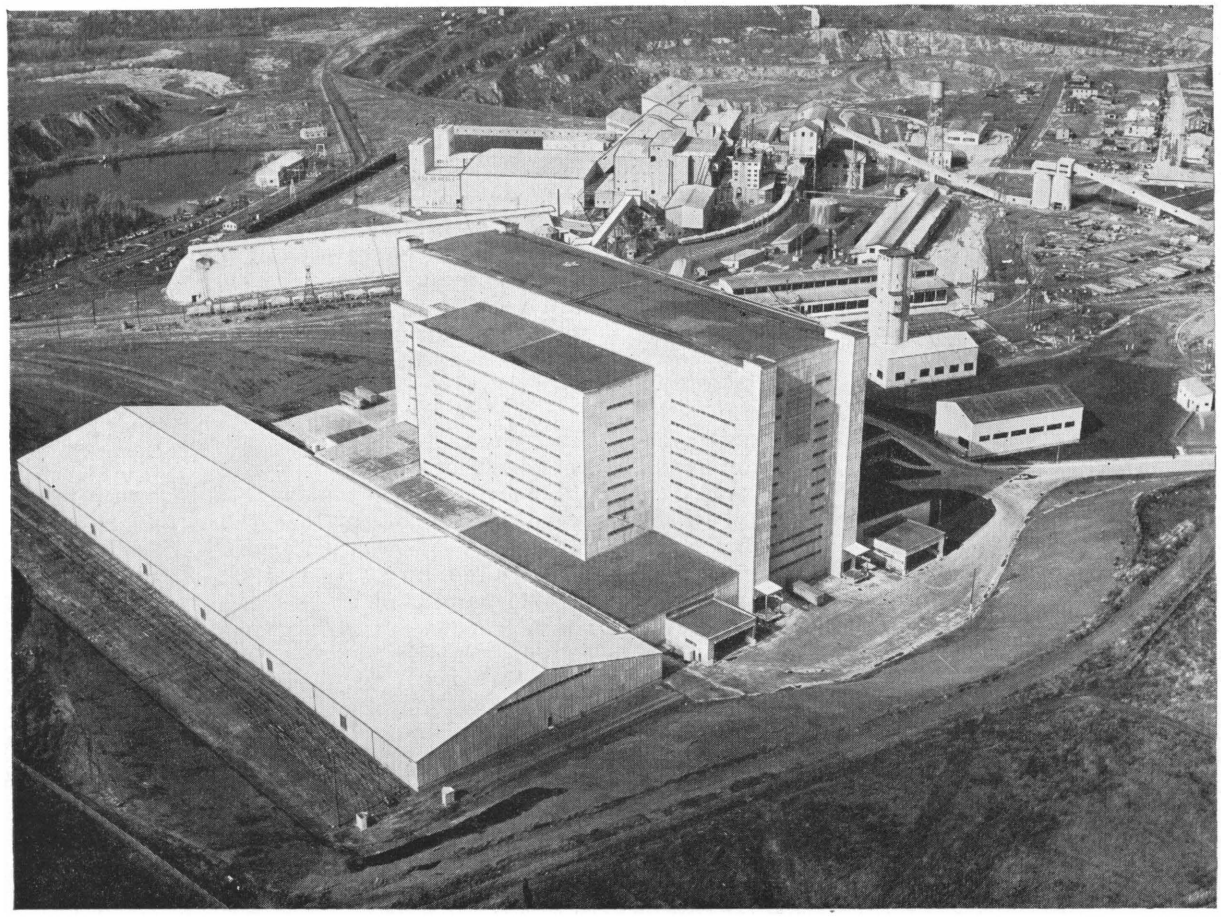

FIGURE 3.—The Largest Asbestos Mill in the World, Canadian Johns-Manville Corp. Mill, Asbestos, Quebec.

TABLE 2.—*Canadian milling capacity, 1956*

Company and mill	Daily rock capacity, short tons
Asbestos Corp., Ltd.:	
Beaver & King mills	7, 200
British Canadian mill	5, 000
Normandie mill	5, 000
Bell Asbestos Mines, Ltd. (Turner & Newall): Bell mill	1, 800
Cassiar mill (British Columbia)	600
Canadian Johns-Manville Co., Ltd.:	
Danville mill	20, 000
Munro mill	2, 000
Flintkote Mines (Flintkote Co.): Thetford Mines mill	1, 200
Johnson's Co.:	
Thetford Mines mill	2, 000
Megantic mill	4, 000
Nicolet Asbestos Mines, Ltd. (Nicolet Industries, Inc.): Danville mill	1, 500
Quebec Asbestos Corp., Ltd. (Philip Carey Manufacturing Co.): East Broughton mill	1, 500
	51, 800

ARIZONA

At least 10 mills have operated recently in Arizona. Most of them are for "cruding," a process that involves the use of jaw crushers and screens only. Asbestos fibers passing over a ½-inch mesh are designated as No. 1; those passing over a ¼-inch mesh and through a ½-inch mesh, as No. 2; and those passing through the ¼-inch-mesh screen, Grades 3 and 4. Several mills have equipment for further processing, including hammer-mill reduction followed by screening and air separation.

VERMONT

A mill built in 1949 about one-fourth mile from the quarry of the Vermont Asbestos Mines is said to be one of the most modern and complete asbestos mills in existence. (See fig. 4.) The rock, of walnut sizes, delivered to the mill by belt conveyor, is broken in a series of vertical hammer mills and the fiber separated by air suction at each stage. Ro-Tap table screens

FIGURE 4.—Mill of Vermont Asbestos Mines, Near Eden, Vt.

are used. The fiber is classified in regular graders, as in Canada. The major output falls in Groups 5 and 6 of the Canadian classification, although substantial quantities of 4 and 7 are produced. (See later section on Grading and Classification, Canada.) Limited quantities of Group 3 are obtained. Groups 4, 5, and 6 are used in the company asbestos-products plants and are supplemented by purchases from outside sources.

UNION OF SOUTH AFRICA

The milling of amosite and blue asbestos differs considerably from the milling of chrysotile. As the associated rocks consist largely of hard, banded ironstones and jaspers, as much as possible of the waste rock is removed by handpicking to obviate damage to the fiber and excessive wear on mill machinery. In early milling practice the demand for fibers in crude form made aspiration impracticable, but air-separation methods are followed in the more modern mills. General milling practice involves three stages: Hand-cobbing or mechanical treatment to recover the long fibers; the main milling operation to recover medium-length grades by crushing, screening, and aspiration; and separate treatment of the finer materials to separate the short-fiber grades.

In a typical crocidolite mill, rock from the mine is reduced in a jaw crusher and passed through a trommel. The oversize is carried on a picking belt for removal of crudes and waste rock, and the undersize goes to the short-fiber mill. Secondary reduction is accomplished in a gyratory crusher, the reduced product is screened to remove grit, and the fiber is air-lifted to cyclone collectors.

Because of its unusual fiber length, much of of the amosite produced is hand-cobbed. The fiber-bearing rock is passed through a series of rolls and disintegrators and then graded on shaking screens or trommels.

Details of South African practice are given in a recent report (*8*).

SOUTHERN RHODESIA

Many changes have been made in Rhodesian milling practice during recent years. The modifications were due in part to the larger tonnages of rock handled and in part to the change in mining methods to a block-caving system. Older methods of cobbing and sorting

in open pits have largely been abandoned, and modern mills have been built.

At the larger mines the rock is passed through primary crushers and screened. The fines are carried to driers, and the oversize passes to secondary crushers, the product of which joins the dried fines. Further reduction is accomplished chiefly by impact mills. The rock is passed through a complex series of fiberizers and screens, and the freed fiber is collected in cyclones. The fibers are further cleaned and classified into commercial grades. At Shabani some of the long fibers are cobbed and cleaned by hand to prepare a special product.

SWAZILAND

At the Havelock mine the minus-2½-inch product from the primary crusher is dried and the fiber removed by suction fans. The rock, with hand-sorted materials from the picking belt mentioned under Mining Methods, is crushed and the fiber removed in successive stages by air suction. Initial reduction is by a 16- by 10-inch jaw crusher, but the later stages of reduction are accomplished with least damage to the fibers by the use of edge runners. The longest fibers, known as HVL, correspond with the C & G grades from Rhodesia but are said to be of somewhat poorer quality.

U. S. S. R. (*1*)

At the Russian quarries most of the crude fiber is hand-sorted on picking belts after the rock is crushed. At one of the mills operating in the Urals some years ago the quarry rock was reduced to about 6-inch size with a No. 9 Gates gyratory crusher. It discharged to a picking belt, where 20 percent or more of the primary feed (consisting of rock too lean to justify milling) was thrown out as waste. The asbestos-bearing rock was reduced to 1½- to 2-inch size in two No. 7 Gates gyratory crushers discharging to heavy shaking screens. The oversize passed to picking belts, where more barren rock was eliminated. The good rock from the picking belt was reduced to about 1-inch size in a jaw crusher and joined the undersize from the shaking screens in a wet-storage bin. Moisture was reduced in three rotary driers, and the product was conveyed to a dry-storage bin.

The most noteworthy feature of the preliminary milling stage was the concentration on picking belts. Because the serpentine tends to break cleanly along the borders of the fiber veins, effecting a more or less distinct separation of barren and fiber-bearing rock, conditions particularly favor this method of concentration. Of the original mill feed, consisting of 2,400 tons a day, about 1,400 tons was eliminated as waste, leaving only 1,000 tons for the later milling processes. Thus, picking belts saved operators a great deal of useless milling.

In the more advanced milling stages the dried rock was passed over heavy shaking screens, from which four products were obtained: (1) Fiber removed by suction fans, (2) oversize rock conveyed to a set of rolls, (3) middlings that bypass the rolls and are carried to the next screen, and (4) fines conveyed to a Humboldt disintegrator. By means of a series of such rolls, screens, suction pipes, and disintegrators, virtually all of the fiber was recovered. Fiber from the collecting hoppers was sent to a series of shaking screens for cleaning. The cleaned fiber was collected again by suction fans and classified by length in slowly rotating grading trommels.

A large new mill, designed to handle 2 million tons of rock annually and produce 80,000 tons of fiber in 6 grades, was nearing completion in 1934. This mill, with other Russian facilities, would, it was estimated, provide the Nation with a total milling capacity of approximately 175,000 tons of fiber a year. Annual production in 1936 and 1937 was reported to be 125,000 metric tons and in 1938, only 86,000 metric tons.

SUPPLEMENTARY MILLING IN ASBESTOS TEXTILE FACTORIES

As pointed out earlier, the milling process is designed to remove impurities and to separate the fibers from each other (fiberize) effectively. Crude fibers are not milled before delivery to the user and are opened in the asbestos-products manufacturing plant. Even the milled fibers require considerable processing before they are in satisfactory condition for use.

The preliminary opening of crude fibers is generally accomplished in a pan crusher, also known as a chaser mill or edge runner. A steel wheel with a 14- to 18-inch face runs in a circle in a pan to which a batch of crude fiber is added. Scrapers push the fiber inward from the circumference and outward from the center to keep it under the roller. Conical rolls running in a circular trough are sometimes used to reduce the grinding action between the surface of the roller and the bottom of the pan. The running time required to complete a batch varies greatly, depending upon the ease or difficulty of fiberization of the particular asbestos being treated. It may range from 2 to 12 minutes on milled fiber and 12 to 20 minutes on crudes. The time of completion is determined by the operator who, by long experience, can judge the condition of the fiber by its feel. To

conserve fiber length and strength, excessive crushing and grinding are avoided. Separated impurities are removed by screening.

Some milled fibers, which have been more or less completely opened, do not require pan-crusher treatment; others require some degree of "pan softening." The extent to which pan treatment is needed depends entirely upon the character of the fiber. Some milled fibers may bypass the pan, while others bearing the same brand and grade may require "pan softening." Milled fibers that require no pan treatment are passed through a vertical opener or some other type of equipment that disintegrates the fibers. A rotating toothed cylinder may be used.

The next step in treatment beyond the preliminary pan crushing or other fiberizing machine is conducted in a grader. It consists of a sheet-metal enclosure with a horizontal rotating shaft in the center, equipped with steel paddles set at intervals in spiral positions. These paddles beat the fiber, separating iron minerals, rock particles, or dust as well as splinters of unopened fiber. The latter are returned to the openers for further treatment. The fluffy fiber is picked up by an air current and carried away for further treatment in ceiling condensers and breaker cards. Fiberization is one of the most critical operations in the textile plant, because it involves as complete separation of the fibers as can be accomplished without sacrificing their length or strength. These processes have been described in some detail (*6*).

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CHAPTER 6. GRADING AND CLASSIFICATION

CANADA

Canadian chrysotile asbestos is graded into nine major groups, most of which are divided into several subgroups. Group 1 consists of Crude No. 1 and group 2 of Crude No. 2, Crude Run-of-Mine, and Crudes Sundry. Groups 3 to 7, known as mill fibers, are classified according to tests made with a Quebec standard testing machine. This equipment and its operation have been described so fully in several asbestos reports that it seems unnecessary to enlarge upon them here. The machine consists of three screens—½-inch-mesh, 4-mesh, and 10-mesh—and a box for the shortest materials. The four-figure designation of the grade indicates the number of ounces from a total of 16 that collects in each of the four receptacles. Thus, a fiber designated 4–7–4–1 is one 4 ounces of which remains on the first screen, 7 on the second, and 4 on the third; 1 ounce passes through into the box. Groups 8 and 9 are graded on the basis of weight per cubic foot. "Crude" asbestos consists of hand-selected and hand-cobbed cross-vein material, essentially in its native or unfiberized form. "Milled" asbestos consists of all grades produced by mechanical treatment such as crushing, screening, and air separation.

"Shipping test" is the average, for each carload or small shipment, of tests of representative samples taken at the time of shipping. "Guaranteed minimum shipping test" is that below which the actual shipping test shall not fall.

Following is the Canadian standard classification as of January 1, 1949:

Group 1: Crude No. 1—Consists basically of crude ¾-inch staple or longer.
Group 2: Crude No. 2—Consists basically of crude ⅜- to ¾-inch staple.
Crude Run-of-Mine—Consists basically of unsorted crudes.
Crudes Sundry—Consists of crudes other than above specified.

Mill fibers

Standard designation of grades:	*Guaranteed minimum shipping test, Canadian standard testing machine*
Group 3:	
3F	7 – 7 – 1. 5 – 0. 5
3K	4 – 7 – 4 – 1
3R	2 – 8 – 4 – 2
3T	1 – 9 – 4 – 2
3Z	0 – 8 – 6 – 2
Group 4:	
4H	0 – 5 – 8 – 3
4K	0 – 4 – 9 – 3
4M	0 – 4 – 8 – 4
4R	0 – 3 – 9 – 4
4T	0 – 2 – 10 – 4
4Z	0 – 1. 5 – 9. 5 – 5
Group 5:	
5D	0 – . 5 – 10. 5 – 5
5K	0 – 0 – 12 – 4
5M	0 – 0 – 11 – 5
5R	0 – 0 – 10 – 6
Group 6: 6D	0 – 0 – 7 – 9
Group 7:	
7D	0 – 0 – 5 – 11
7F	0 – 0 – 4 – 12
7H	0 – 0 – 3 – 13
7K	0 – 0 – 2 – 14
7M	0 – 0 – 1 – 15
7R	0 – 0 – 0 – 16
7T	0 – 0 – 0 – 16
Group 8: 8S	Under 75 pounds per cubic foot loose measure.
Group 9: 9T	More than 75 pounds per cubic foot loose measure.

Following are the qualities and uses of the various groups:

Group 1 (Crude No. 1) is asbestos fiber longer than three-fourths inch. It should be silky and have enough tensile strength to permit its use for making asbestos yarn, tape, cloth, carded fiber, and other textiles.

Group 2 (Crude No. 2) is generally referred to as fiber that has not been milled and that is ⅜ to ¾ inch long. It must have good tensile strength.

Group 3 is generally considered as milled spinning or textile fiber and tests 0–8–6–2 and over.

Group 4, known as shingle fiber, includes fiber suitable for the manufacture of asbestos-cement products, such as pipe, shingles, and siding; compressed sheet packing; and 85-per-

cent magnesia and high-temperature molded pipe covering. These fibers are also used with portland cement in manufacturing asbestos corrugated and flat interior and exterior sheets, wallboard, switchboard panels, and other products. This grade tests below 0–8–6–2 and includes 0–1½–9½–5. The better known grades for asbestos-cement shingles are 4H, 4M, 4T, 6D, and 5R.

Group 5, known as paper stock, includes fibers testing below 0–1½–9½–5, including 0–0–10–6. They are used chiefly for manufacturing asbestos paper and millboard and sometimes are mixed with higher grades in manufacturing asbestos-cement shingles.

Group 6, known as stucco or plaster fiber, has only one grade, namely, 6D.

Group 7 includes all fibers having a minimum shipping test of 0–0–5–11 and below. These are known as refuse and shorts and are used in manufacturing asbestos boiler and roofing cements, roofing paints, and occasionally for making millboard. The suffix "F" designates "floats" in all subsections of this group. Floats consist of dust, collected in chambers and bagged. It may be sized by screening before bagging.

Groups 8 and 9 are known as sand and gravel and stone, respectively. They contain a preponderance of rock and sand. These materials are used chiefly in manufacturing asbestos flooring, wall tiles, and similar products.

BRITISH COLUMBIA

The principal grades of chrysotile asbestos currently marketed are 3K, spinning fiber, and 4K, shingle fiber. They correspond closely with the Quebec grades similarly designated. Two special grades are designated AAA and AC. The former is said to be equivalent to Rhodesian C & G 1, and the latter to C & G 3.

ARIZONA

Arizona chrysotile asbestos is graded by screening. The fiber-bearing rock is generally passed through a jaw crusher, and the crusher product is carried to shaking screens. Fiber which remains on a ½-inch screen is classed as No. 1; that which passes a ½-inch mesh and remains on a ¼-inch mesh, No. 2; through ¼-mesh and on ⅛-mesh, No. 3; and that which passes through the ⅛-inch mesh, No. 4. These products are classed as "crudes" in Arizona.

VERMONT

Vermont classification is the same as the Canadian.

UNION OF SOUTH AFRICA

CROCIDOLITE

Following is the classification of Cape blue (crocidolite) recognized by the Cape Asbestos Co., Ltd.

Grade:	*Length of fiber, inches*
X	Minus ¼.
No. 3 or S or MS	¼ to ⅜.
No. 2 or A	⅜ to ¾.
No. 1 or B	¾ to 1½.
Long or C, D, and E	Plus 1½.

Most of the United States imports are of Grade S or MS (mixed short).

Grades of Transvaal blue, as given by the Department of Mines, Union of South Africa, are as follows:

Crude Grade:	*Fiberized* Grade:	*Length of fiber, inches*
TX	TDX	Plus 1½.
T1	TD1	⅞ to 1½.
T2	TD2	½ to ⅞.
T3	TD3	¼ to ½.
T4	TD4	Minus ¼.

AMOSITE

The following classification was in effect until 1952. B–1 was the longest and best grade. The second grades were B–3 and D–3. They were virtually the same grade but came from different sources, the B–3 originating in the Penge mine and the D–3 in the Amosa mine. However, it has been stated recently that B–3 is no longer produced. Other designations that were applied to this grade are 3/B, 3/D, 3/BX and 3/DX. Another grade nearly as good as B–3 or D–3 was designated 3DMI. Although called 3DMI, it was really 3 D Mi, the "Mi" meaning "mixture." It consisted chiefly of D–3.

In 1952 the Mineral Development Office, Department of Mines, Geological Survey, Union of South Africa, reported a new classification as follows:

Symbol:	*Range of average fiber lengths, inches*	*Designation*
D3	2 –6	Long.
D11	½ –2	Medium.
MD	½ –2	Do.
DX	½ –2	Do.
M	½ –2	Do.
S2	3/16–1	Shorts.
R	⅛ – ½	Residue.
K3	½ –2	Medium.
SK	3/16–1	Shorts.
RK	⅛ – ½	Residue.
W3	½ –2	Medium.
SW	3/16–1	Shorts.
RW	⅛ – ½	Residue.
WEG	⅛ –3	Medium.

The fibers range in color from brown to gray.

CHRYSOTILE

Grading at the larger mines is said to follow Canadian standards to some extent, although many old independent designations persist. No classification for South African chrysotile has been standardized.

SOUTHERN RHODESIA

CHRYSOTILE

Milled fiber:
- C & G/1—high-grade textile fiber (equivalent to Canadian Crude No. 2).
- C & G/2—high-grade textile fiber (equivalent to Canadian 3F).
- C & G/3—shingle stock.
- C & G/4—shingle stock.
- VRA/2—comparable but not equivalent to C & G/2.
- VRA/3—comparable but not equivalent to C & G/3.
- VRA/4—comparable but not equivalent to C & G/4.

SWAZILAND

CHRYSOTILE

Havelock mine:
- Milled fiber:
  - HVL/1—long spinning fiber.
  - HVL/2—short spinning fiber.
  - HVL/3—comparable but not equivalent to C & G/3.
  - HVL/3XX—comparable to C & G/4 (by one manufacturer).

U. S. S. R.

CHRYSOTILE

Crude:
- AA—not less than 18 mm. in length.

Milled fiber:
- O–1—textile fiber (comparable to Canadian 3F or 3K).
- O–2—textile fiber (comparable to Canadian 3R).
- I–2—textile fiber (comparable to Canadian 3Z).
- G–3—textile fiber (comparable to Canadian 3Z).
- O–3—shingle fiber (comparable to Canadian 4H).
- O–4—shingle fiber (comparable to Canadian 4Z).
- I–4—shingle fiber (comparable to Canadian 4R).
- G–4—shingle fiber (comparable to Canadian 4Z).
- WS—shingle fiber.
- R–5—paper fiber (comparable to Canadian 6D).
- I–5—paper fiber (comparable to Canadian 6D plus).
- S–4—paper fiber (comparable to Canadian 5DO).
- R–6—shorts.
- I–6—shorts.
- 6–A—shorts.

NOTE: Grades S–4 and WS are completely opened fibers; grades marked "I" are soft but not completely opened; grades marked "G" contain more unopened crudes; grades marked "O" and "R" contain much hard, crude fiber.

INDIA

CHRYSOTILE

Crudes:
- Special A—comparable to Canadian Crude No. 1.
- Regular A—comparable to Canadian Crude No. 1.
- Regular B—comparable to Canadian Crude No. 1.

STOCKPILE GRADES AND SPECIFICATIONS

At the end of 1955 low-iron chrysotile, South African amosite, and Bolivian crocidolite or its equivalent were the only types designated for United States Strategic Stockpiling.

CHRYSOTILE

Chrysotile for stockpiling is the low-iron type. It must conform with National Stockpile Specification P–3–R1, dated June 10, 1953, and must be equal to that obtained at the Shabani mines, Southern Rhodesia. The Rhodesian grades designated are C & G 1, C & GP1, C & G 2, and C & GP2. The use of the letter "P" simply indicates a processed rather than a crude fiber. The fiber-length requirement of C & G 1 and C & GP1 is that a minimum of 15 ounces shall be retained on the first and second screens of the Quebec standard testing machine. The requirement of C & G 2 and C & GP2 is that a minimum of 13 ounces shall be retained on the first and second screens of the Quebec standard testing machine. Arizona Crude Nos. 1 and 2, as well as nonferrous crudes from other sources, are acceptable for stockpiling when strong and "silky."

Canadian fiber presumably will satisfy the specification if the iron content can be reduced enough. Accordingly, the fiber lengths of acceptable Canadian fibers are also specified as follows: Crude No. 1, consisting of fibers at least 85 percent of which shall be three-fourths inch in length or longer; Crude No. 2, consisting of fibers at least 90 percent of which shall be ⅜ to ¾ inch in length; spinning fibers of the following grades according to Canadian standard tests (see p. 24):

3F: 7–7–1.5–0.5
3K: 4–7–4.0–1.0
3R: 2–8–4.0–2.0
3T: 1–9–4.0–2.0

As regards the iron content, the acceptable fiber shall be commercially nonferrous and shall conform with the following limitations: Total iron, maximum percent by weight, 3.5; magnetic iron, maximum percent by weight, 2.0. The specification includes items on impurities, moisture content, sampling, methods of test, etc.

Five-pound samples shall be inspected by domestic commercial users whose combined manufacturing requirements represent at least 50 percent of the total United States consumption of the grades of asbestos covered by these specifications and, in any event, by not less than three such users. Acceptance shall be based upon written statements from the majority

(normally 2 out of 3) of these users that the lot of asbestos conforms to the applicable requirements.

AMOSITE

Amosite for stockpiling must conform with National Stockpile Specification P–4–R, dated September 14, 1953. The specification simply states that the material shall conform to the standard commercial Grade D–3 or DX or D–11. Inspection is made under the same conditions as specified for chrysotile.

CROCIDOLITE

Crocidolite (blue asbestos) shall conform with National Stockpile Specification P–80–R, dated April 17, 1952, which designates that the material purchased shall be Bolivian crocidolite asbestos or its equivalent. Three grades are covered, as follows: Crude No. 1, a minimum of 85 percent (by weight) of which shall be in fibers ¾ inch in length or longer; Crude No. 2, a minimum of 85 percent of which shall consist of fibers ⅜ inch to ¾ inch in length; and Run-of-Mine (crude or milled), a minimum of 90 percent of the lumps and fibers of which shall be retained on a No. 16 sieve. The material shall contain not more than 2 percent of moisture and not more than 5 percent of foreign matter. The specification includes items covering methods of test, etc. Details of sampling and inspection are omitted, as this material is no longer being purchased for the stockpile.

CHAPTER 7. WORLD PRODUCTION AND CONSUMPTION

WORLD OUTPUT

World output of asbestos during recent years appears in table 3. The proportions furnished in 1954 by each of the more important producing countries is shown graphically in figure 5.

The figures for total output are estimates, because Russian output is large but unrecorded. In 1955 Canada produced 62 percent of the total tonnage. A large part of the Canadian production, however, comprises the shorter grades, which find an extensive market in the United States but which are produced in smaller quantities in the other producing countries. United States production was only 3 percent of the world output. Figures for world production during earlier and later years are published by the Bureau of Mines (*2*).[1]

OUTPUT BY COUNTRIES

UNITED STATES

United States production, as indicated in table 3, is a relatively small factor in the world supply. Most of the United States fiber is of the shorter chrysotile grades. Table 4 shows domestic production over a period of years.

CANADA

Table 5 is an historic record of Canadian production, showing the remarkable growth of the industry since 1935. Canadian output was confined almost exclusively to the Province of Quebec until 1950, when shipments were first made from the Munro mine in Ontario. Shipments from the Cassiar mine in British Columbia were first recorded in 1953 and reached more than 20,000 tons in 1956.

Table 5 shows significant changes in the proportions of the various grades produced in Canada since 1935. The quantity of crudes produced has decreased greatly since 1943. During the period 1949 to 1955 it dropped to an approximately constant level, which was about one-third of the quantity produced annually from 1935 to 1943. This substantial decrease in the proportion of crudes is due chiefly to the change in mining methods. The modern block-caving system does not afford the opportunity for hand-cobbing that was carried on extensively when open-pit mining was pursued. Hence, much of the long-fiber asbestos formerly recovered and sold as hand-cobbed crudes now passes through crushers and mills and constitutes a part of the Group 3 spinning fibers.

Table 5 also shows that the quantity of shorts compared with fibers increased from a ratio of about 1 to 1 during 1935 to 1944 to a ratio approaching 2 to 1 during recent years. This pronounced increase in sale of shorts resulted from their growing utilization as components of products such as asphalt floor tile.

TABLE 3.—*World production of asbestos, by countries,*[1] *1947–51 (average) and 1952–56, in short tons*[2]

[Compiled by Helen L. Hunt]

Country[1]	1947–51 (average)	1952	1953	1954	1955	1956
North America:						
Canada (sales)[3]	760, 408	929, 339	911, 226	924, 116	1, 063, 802	1, 014, 249
United States (sold or used by producers)	39, 719	53, 864	54, 456	47, 621	44, 568	41, 312
Total	800, 127	983, 203	965, 682	971, 737	1, 108, 370	1, 055, 561

See footnotes at end of table.

[1] Italicized numbers in parentheses refer to items in the bibliography at the end of this chapter.

ASBESTOS

Percent of World Production for 1954

60.6 % CANADA

3.1% UNITED STATES

VENEZUELA

BRAZIL

BOLIVIA

ARGENTINA

0.5% FINLAND

15.7% U. S. S. R

YUGOSLAVIA

FRANCE 0.8% 1.7% ITALY

PORTUGAL SPAIN

MOROCCO

1.3% CYPRUS

KENYA

INDIA

KOREA 0.5% JAPAN

S. RHODESIA 5.2%

BECHUANALAND

7.1% 2.0% SWAZILAND

UNION of SOUTH AFRICA

0.3% AUSTRALIA

NEW ZELAND

LEGEND

100% 90 80 70 60 50 40 30 20 10 5 0

PERCENT SCALE

● UNDER 5,000 SHORT TONS

MILLION SHORT TONS

1.6 1.52 1.2 .8 .4 0

ALL OTHER SHOWN BY ●
AUSTRALIA
JAPAN
CYPRUS
SWAZILAND
S. RHODESIA
U. of S. AFRICA
FINLAND
FRANCE
I TALY
U.S.S.R.
UNITED STATES
CANADA

TOTAL WORLD PRODUCTION BY COUNTRIES FOR 1954.

463673—58 (Face p. 28)

FIGURE 5.—Map showing world production of asbestos, and production by countries.

TABLE 3.—*World production of asbestos, by countries*[1] *1947–51 (average) and 1952–56, in short tons*[2]—Continued

Country[1]	1947–51 (average)	1952	1953	1954	1955	1956
South America:						
Argentina	287	(4)	(4)	(4)	198	238
Bolivia (exports)	209	513	810	33	----	62
Brazil	1, 700	1, 439	1, 357	2, 816	3, 124	3, 739
Chile	277	(4)	(4)	(4)	(4)	(4)
Venezuela	237	434	185	743	1, 757	5, 041
Total	2, 710	[5] 2, 800	[5] 2, 800	[5] 4, 000	[5] 5, 300	[5] 9, 300
Europe:						
Bulgaria	(4)	(4)	992	1, 213	1, 323	1, 102
Finland [6]	11, 123	11, 464	12, 047	7, 853	18, 674	8, 282
France	3, 942	8, 338	11, 419	14, 449	10, 913	9, 370
Greece	26	26	1	2	3	6
Italy	18, 687	26, 387	22, 484	25, 955	33, 266	36, 459
Portugal	259	185	105	30	56	35
Spain	34	33	----	176	----	----
U. S. S. R. [5]	205, 000	240, 000	300, 000	375, 000	450, 000	500, 000
Yugoslavia	1, 025	2, 762	4, 131	3, 598	4, 305	4, 165
Total [1 5]	245, 000	290, 000	380, 000	435, 000	520, 000	565, 000
Asia:						
Cyprus	13, 145	18, 250	15, 881	15, 309	15, 306	[7] 15, 375
India	249	969	805	435	1, 564	1, 378
Iran [8]	----	55	----	----	110	39
Japan	5, 744	3, 370	4, 495	6, 916	6, 932	9, 914
Korea, Republic of	(4)	(4)	----	233	66	54
Taiwan (Formosa)	290	26	----	161	403	118
Turkey	226	----	----	50	259	634
Total [1 5]	20, 600	25, 000	27, 000	31, 000	36, 000	39, 000
Africa:						
Bechuanaland	----	528	548	729	1, 426	1, 356
Egypt	940	66	220	----	----	----
French Morocco	602	635	600	597	631	379
Kenya	532	390	166	224	152	170
Madagascar	4	3	8	----	----	----
Mozambique	----	----	----	196	301	202
Rhodesia and Nyasaland, Federation of:						
Southern Rhodesia	70, 328	84, 834	87, 739	79, 962	105, 261	118, 973
Swaziland	32, 397	34, 769	30, 103	30, 142	32, 613	29, 875
Uganda	----	----	----	7	2	2
Union of South Africa	68, 315	133, 839	94, 817	109, 151	119, 699	136, 520
Total	173, 118	255, 064	214, 201	221, 008	260, 085	287, 477
Oceania:						
Australia	1, 909	4, 546	5, 567	5, 279	5, 993	9, 857
New Zealand	192	764	----	----	172	368
Total	2, 101	5, 310	5, 567	5, 279	6, 165	10, 225
World total (estimate)[1]	1, 245, 000	1, 560, 000	1, 565, 000	1, 670, 000	1, 935, 000	1, 970, 000

[1] In addition to countries listed, asbestos is produced in China, Czechoslovakia, and North Korea. Estimates by author of chapter which appears in Minerals Yearbook, 1956, are included in the total.

[2] This table incorporates a number of revisions of data published in previous Asbestos chapters. Data do not add to totals shown owing to rounding where estimated figures are included in the detail.

[3] Exclusive of sand, gravel, and stone (waste rock only), production of which is reported as follows: 1947–51 (average), 34,167 tons; 1952, 39,664 tons; 1953, 21,118 tons; 1954, 26,429 tons; 1955, 28,582 tons; 1956, 45,428 tons.

[4] Data not available; estimate by author of chapter which appears in Minerals Yearbook, 1956, included in total.

[5] Estimate.

[6] Includes asbestos flour.

[7] Exports.

[8] Year ended Mar. 20 of year following that stated.

TABLE 4.—*Asbestos sold or used by producers in the United States, 1925–56*

[Bureau of Mines, Minerals Yearbook]

Year	Short tons	Value	Year	Short tons	Value
1925	1, 258	$51, 700	1941	24, 391	$725, 753
1926	1, 358	134, 731	1942	15, 481	498, 857
1927	2, 981	336, 882	1943	6, 014	334, 815
1928	2, 239	351, 178	1944	6, 667	380, 334
1929	3, 155	351, 004	1945	12, 226	446, 045
1930	4, 242	289, 284	1946	14, 075	504, 761
1931	3, 228	118, 967	1947	24, 035	918, 558
1932	3, 559	105, 292	1948	37, 092	1, 806, 261
1933	4, 745	130, 677	1949	43, 387	2, 614, 416
1934	5, 087	158, 347	1950	42, 434	2, 925, 050
1935	8, 920	292, 927	1951	51, 645	3, 912, 500
1936	11, 064	314, 161	1952	53, 864	4, 713, 032
1937	12, 079	344, 644	1953	54, 456	4, 857, 359
1938	10, 440	247, 264	1954	47, 621	4, 697, 962
1939	15, 459	512, 788	1955	44, 580	4, 487, 428
1940	20, 060	674, 508	1956	41, 312	4, 742, 446

TABLE 5.—*Production (shipments) of asbestos in Canada, 1935–56, in short tons*

[Dominion Bureau of Statistics]

Year	Crudes	Fibers	Shorts	Total
1935	2, 278	102, 270	105, 919	[1] 210, 467
1936	3, 440	133, 288	164, 559	301, 287
1937	3, 846	200, 247	205, 933	401, 026
1938	2, 911	163, 097	123, 785	285, 793
1939	3, 121	193, 992	167, 359	364, 472
1940	2, 076	181, 890	161, 615	345, 581
1941	2, 845	223, 767	251, 234	477, 846
1942	2, 890	199, 829	236, 741	439, 460
1943	2, 016	217, 889	247, 291	467, 196
1944	1, 547	190, 233	227, 485	419, 265
1945	981	219, 767	246, 148	466, 896
1946	742	228, 234	329, 205	558, 181
1947	958	222, 196	438, 667	661, 821
1948	977	241, 953	473, 839	716, 769
1949	652	194, 583	379, 671	574, 906
1950	904	305, 194	569, 246	[2] 875, 344
1951	748	333, 001	639, 449	[3] 973, 198
1952	741	351, 644	576, 954	[4] 929, 339
1953	781	326, 340	584, 105	[5] 911, 226
1954	725	326, 653	596, 738	[6] 924, 116
1955	724	395, 096	667, 982	[7] 1, 063, 802
1956	717	392, 982	620, 529	1, 014, 229

[1] Virtually all of the production in 1935–49 was from the Province of Quebec.
[2] Includes 10,519 tons from Ontario; balance from Quebec.
[3] Includes 26,588 tons from Ontario; balance from Quebec.
[4] Includes 23,116 tons from Ontario; balance from Quebec.
[5] Includes 27,238 tons from Ontario and British Columbia; balance from Quebec.
[6] Includes 29,823 tons from Ontario and British Columbia; balance from Quebec.
[7] Includes 41,810 tons from Ontario and British Columbia; balance from Quebec.

Table 6 shows Canadian output by grades in more detail. This table indicates that spinning fibers (Groups 1, 2, and 3) constitute only a small proportion of the Canadian output (about 4.1 percent in 1955), but the total output of asbestos has been so high that production of the spinning grades has ranged from 33,000 to more than 43,000 tons annually during recent years.

The overall capacity of the Quebec mills to produce spinning fibers is much greater than the production figures in table 6 for Group 3 fibers indicate. New mills are under construction or are being planned. The Quebec Asbestos Mining Association estimated in 1954 that the Quebec mills would have the capacity to produce 54,000 tons of the spinning grades

in 1955 (*1*). In addition to the Quebec output, the Cassiar Asbestos Corp. in British Columbia produced nearly 7,000 tons of spinning grades in 1956, and supplies from this source are likely to increase moderately. If, however, an abnormally heavy demand for Quebec spinning-grade asbestos should develop, disposal of an excessive supply of the shorter grades, which are coproducts of the spinning fibers, might create a serious problem.

TABLE 6.—*Production (shipments) of asbestos in Canada, by grades, 1950–56, in short tons*

	1950	1951	1952	1953	1954	1955	1956
Crudes: Groups 1 and 2	904	748	741	781	725	724	717
Mill fibers:							
Group 3	33, 955	33, 136	35, 932	35, 970	35, 208	43, 081	33, 929
Group 4	164, 861	188, 130	198, 506	187, 466	192, 285	234, 998	246, 295
Group 5	106, 378	111, 735	117, 206	102, 904	99, 160	117, 017	112, 759
Group 6	175, 743	223, 471	204, 091	175, 171	168, 960	172, 339	168, 042
Group 7	363, 179	386, 823	340, 721	379, 218	396, 639	469, 149	428, 149
Group 8	30, 324	29, 155	32, 142	29, 716	31, 139	26, 494	23, 438
Total	875, 344	973, 198	929, 339	911, 226	924, 116	1, 063, 802	1, 014, 229

UNION OF SOUTH AFRICA

Table 7 shows production in the Union of South Africa for the period 1935–56, by varieties. South African production has special importance because it includes the entire world supply of amosite and the principal world supply of crocidolite (blue asbestos).

TABLE 7.—*Production of asbestos in the Union of South Africa, by kinds, 1935–56, in short tons* [1]

Year	Amosite	Blue	Chrysotile	Total
1935	4, 684	2, 541	15, 483	22, 708
1936	4, 823	4, 264	16, 149	25, 236
1937	6, 531	5, 247	16, 855	28, 633
1938	8, 793	8, 810	5, 573	23, 176
1939	11, 299	10, 127	612	22, 038
1940	17, 767	8, 901	646	27, 314
1941	19, 211	7, 352	1, 658	28, 221
1942	24, 924	7, 641	1, 917	34, 482
1943	23, 189	10, 344	2, 034	35, 567
1944	22, 848	9, 666	2, 014	34, 528
1945	16, 737	9, 671	1, 765	28, 173
1946	9, 838	8, 691	1, 666	20, 195
1947	18, 780	9, 079	2, 253	30, 112
1948	30, 372	10, 909	4, 441	45, 722
1949	41, 974	21, 180	7, 609	70, 763
1950	42, 393	30, 598	14, 334	87, 325
1951	54, 053	33, 659	19, 509	107, 221
1952	63, 280	44, 735	24, 970	132, 985
1953	35, 258	37, 707	18, 840	91, 805
1954	45, 922	43, 746	19, 373	109, 041
1955	50, 137	48, 842	20, 535	119, 514
1956	50, 097	62, 087	24, 336	136, 520

[1] A small output of anthophyllite is omitted because it has no strategic importance.

SOUTHERN RHODESIA

Table 8 shows production in Southern Rhodesia for a 21-year period. The chrysotile is of the low-iron type much in demand for electrical insulation uses. Rhodesia was the major source of such fiber in the world until British Columbia, Canada, began production of similar fiber in 1953.

Production was begun in Swaziland in 1939, with the opening of the Havelock mine, which has become an important producer of chrysotile (see table 3, p. 29).

TABLE 8.—*Asbestos production in Southern Rhodesia, 1935–56*

[Annual Report: Chief Government Mining Engineer and Chief Inspector of Mines, Southern Rhodesia]

Year	Short tons	Year	Short tons	Year	Short tons
1935	42, 598	1943	58, 146	1950	71, 527
1936	56, 346	1944	58, 293	1951	77, 663
1937	57, 014	1945	56, 293	1952	84, 834
1938	58, 811	1946	55, 872	1953	87, 739
1939	58, 313	1947	54, 094	1954	79, 962
1940	57, 891	1948	68, 897	1955	105, 261
1941	44, 134	1949	79, 638	1956	118, 973
1942	55, 803				

U. S. S. R.

An important asbestos industry exists in Soviet Russia; production in the late 1930's exceeded 100,000 tons a year during some years. Table 9 is of historic value.

TABLE 9.—*Asbestos production in U. S. S. R.*

[Economic Review of the Soviet Union and other sources]

Year	Metric tons	Year	Metric tons	Year	Metric tons
1913	17, 494	1922	3, 215	1931	64, 674
1914	15, 691	1923	[2] 4, 780	1932	59, 800
1915	9, 779	1924	[2] 8, 456	1933	71, 700
1916	8, 192	1925	[2] 12, 330	1934	92, 500
1917	[1]	1926	[2] 18, 334	1935	95, 500
1918	[1]	1927	[2] 21, 156	1936	125, 117
1919	[1]	1928	[2] 26, 492	1937	125, 000
1920	1, 478	1929	[2] 29, 520	1938	86, 000
1921	2, 604	1930	54, 083	1939	[3]

[1] Data not available.
[2] Year ended Sept. 30.
[3] No figures available for 1939 or later years. Estimated recent annual production is 220,000 metric tons.

WORLD CONSUMPTION

Consumption of asbestos for any given region is more difficult to determine than production because supplies may be obtained from various sources. The figures in table 10 (except those for the United States and Canada) have been compiled from data on shipments into the various countries or regions from the principal production centers, namely, Canada, Southern Rhodesia, the Union of South Africa, and Swaziland. The output of those regions, together with United States production (the figures for which are used in determining United States consumption), account for nearly 95 percent of total world consumption, excluding that of U. S. S. R. Consumption in the United States and Canada has been determined with fair accuracy, but the figures for other countries or regions given in this table are approximate only. For example, shipments from the U. S. S. R. into continental Europe east of the Soviet orbit are not included because figures for such shipments are not available. However, the figures given account for 90 to more than 95 percent of the total annual consumption.

TABLE 10.—*Consumption of asbestos, by countries or regions, 1950–55, in short tons*

	1950	1951	1952	1953	1954	1955
United States	527, 002	796, 992	752, 609	743, 625	724, 117	782, 216
Canada	45, 365	30, 884	27, 281	32, 696	36, 388	60, 124
United Kingdom	129, 690	148, 371	148, 412	122, 509	118, 784	150, 184
Other European countries [1]	93, 160	130, 027	160, 373	238, 821	145, 732	186, 111
Latin America	34, 879	38, 413	34, 452	38, 726	39, 029	49, 267
Australia	26, 758	29, 183	34, 607	28, 872	40, 766	41, 482

[1] Continental Europe east of Russian orbit.

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2. MINERALS YEARBOOK, Statistical and economic compilation published each year since 1931 by the Federal Bureau of Mines: before 1932 published as Mineral Resources of the United States; chapter on asbestos each year.

CHAPTER 8. WORLD RESERVES

IMPORTANCE OF RESERVES

Current production throughout the world is an important element in the asbestos supply situation, but consideration of the availability of asbestos fibers cannot be confined merely to the present. Even though immediate supplies may be adequate, the question inevitably arises: What are the prospects for obtaining equal or larger quantities of suitable fiber in the years to come? The answer depends largely upon the extent of reserves of commercial fiber in the various asbestos-producing areas of the world. Knowledge of reserves is so important in planning future operations that the larger companies have spent vast sums on geologic surveys and prospect drilling so that adequate reserves may be definitely established as a solid basis for investment in mining and milling facilities. Unfortunately, much of the information thus assembled is confidential. However, all the available data on reserves that could be found are recorded here.

UNITED STATES

The Geological Survey and the Bureau of Mines estimated in 1944 that United States reserves of all grades of chrysotile fiber totaled about 750,000 short tons. Since that time considerable prospect drilling has been conducted in the deposit at Eden, Vt., to a depth of about 800 feet, and a 20-year supply at the current or even an enlarged production rate seems to be assured. This would imply a reserve of at least 800,000 to 1 million tons of fiber in that area. A large proportion of the asbestos mined in Vermont is of the shorter grades, but recent exploration has uncovered deposits said to have a larger proportion of spinning fibers.

The discovery of new deposits would supplement reserves already known. Prospect drilling by a private company was conducted on a chrysotile deposit north of Redding, Shasta County, Calif., during 1950 but was discontinued, presumably because the deposit proved to be too small to justify large-scale operations. Core drilling near Copperopolis, Calaveras County, has established the presence of a deposit of considerable extent. Promising deposits of spinning-grade chrysotile have been found in several places in Shasta, Trinity, and Siskiyou Counties, Calif., in an extensive serpentine area that merits exploration. Deposits are known in many other counties. It is possible that commercial deposits of considerable size exist in California.

Long chrysotile fibers of good spinning quality are available in Arizona, but the known reserves are small.

Known United States reserves of asbestos that can be classed as strategic are small, but there is some basis for expecting more promising developments in the future. There are no known reserves of either amosite or crocidolite.

CANADA

Estimates of Canadian reserves are incomplete. A great deal of prospect drilling has been done, but many of the results are not available. Asbestos Corp., Ltd., the second largest producer in Quebec, has published reserve data in its annual reports. The company estimates its rock reserves as of 1955 as follows:

	Thousand short tons
King mine	7,300
Beaver mine	7,400
British Canadian mine	58,400
Normandie mine	34,400
Other properties	15,400
Total	122,900

Reserves are more than 35 million tons greater than those estimated in 1950. Assuming a 5-percent fiber recovery, this would indicate a fiber reserve of more than 6 million tons. Drill exploration at the King mine shows asbestos-bearing serpentine to a depth of 1,700 feet. Johnson's Co. has increased its reserves greatly by diamond drilling. Bell Asbestos Mines has purchased a new property in Range 4, Thetford Township, on which it has developed a high-grade 2,000- by 800-foot deposit at least 300 feet deep.

The Johns-Manville Corp. has conducted extensive prospect drilling for many years. From information supplied by drill cores, the company has constructed large models of its undeveloped areas showing the quantity and grade of fibers, both laterally and vertically, as a guide to future development. The comprehen-

sive data thus assembled have enabled the company to estimate that it has, within its present holding, enough available fiber to last at least 100 years at the present rate of mining. These extensive deposits at Asbestos are predominantly short-fiber occurrences.

The overall picture of reserves in the Quebec area is indefinite. The heavy investment in facilities and their expansion indicates that the principal producers have assured themselves of reserves adequate for continuous operation at the current rate or on an enlarged scale for at least 25 or 30 years. As current production exceeds 1 million tons of asbestos a year, a reserve of at least 30 million tons for the Quebec area seems to be assured simply on the basis of expectations implied by capital investment and current rate of production. In view of the supplies available for a much longer period of extensive operations established by exploration by the largest producer, together with probable reserves in unexplored areas, the figure of 30 million tons could easily be doubled or trebled.

Of greatest immediate interest are the reserves of crudes and spinning fibers. In 1948, 1949, and 1950 these groups comprised about 4 percent of the total fiber output. Accordingly, if total reserves are tentatively estimated at a minimum of 60 million tons of all types of fibers, the reserves of crudes and spinning fibers would appear to be about 2,400,000 tons. Production by grades is not available for the period 1933–47. In 1928–32 the proportion of crudes and spinning fibers to total fiber production averaged about 6 percent. Although the figure of 4 percent for 1948–50 indicates a decline, this is more apparent than real because of the recent great increase in recovery and sale of the very short fibers.

From the foregoing, it may be concluded that Quebec reserves are adequate for a half century of production, even at an increasing rate.

The new development in Munro Township, Ontario, provides a supplementary supply. The reserves are probably extensive but not of the magnitude of those in Quebec. This development has not produced grades and qualities of fiber suitable for textiles. Reserves at the Cassiar property in British Columbia are estimated at nearly 7 million tons of rock carrying about 7 percent asbestos. These reserves are of special interest because about 35 percent of the production in 1956 was of the strategic spinning grades.

U. S. S. R.

Reserves of chrysotile asbestos in the U. S. S. R. are extensive. It has been estimated that the reserves as of January 1, 1937, exceeded 19 million tons of fiber, excluding the shorter grades (less than 0.7 mm. long). Reduction in reserves as a result of mining since that date is said to be more than offset by new discoveries (*2*).[1]

Figures from another source indicate that reserves in 1939 were about 18 million metric tons (*1*).

SOUTHERN RHODESIA

According to an estimate made in 1928, the reserves of asbestos in Southern Rhodesian deposits amounted to about 7 million tons. During the ensuing 22 years about 1 million tons was mined, which would reduce the reserves to about 6 million tons; however, the rate of depletion probably has been reduced to some extent by enlargement of established reserves through prospect drilling. The 170 and Birthday fiber-bearing rock masses, which are approximately 2,000 feet long and 100 feet wide and dip 250°, have been proved by drilling to a vertical depth of 1,000 feet. One diamond-drill hole in the Birthday section intercepted rock of good grade at a depth of 2,300 feet. The Nil Desperandum deposit has been proved to a depth of 850 feet.

The proportion of spinning-grade fiber produced in the Shabani area is exceptionally high. An estimate as high as 25 or 30 percent has been made, but in 1949 it was said that 20 percent of the output would satisfy United States National Stockpile specifications, which call for Grades C & G Nos. 1 and 2. As the largest Rhodesian reserves are in the Shabani area, a reserve of spinning fibers exceeding 1 million tons may be assumed.

UNION OF SOUTH AFRICA

TRANSVAAL

The rich chrysotile mines of the Barberton area (New Amianthus and Munnick-Myburgh) are virtually exhausted, although steps have been taken to reopen them. Moderate reserves of chrysotile occur in other mines of the Barberton area, such as the Stoltzburg and Doyershock. Recent exploration mentioned under Swaziland disclosed that the serpentine belt extends at least 14 miles into Transvaal from the Swaziland border, indicating new possibilities for chrysotile occurrences.

Amosite deposits cover a wide area, and the fiber veins show remarkable continuity over

[1] Italicized numbers in parentheses refer to items in the bibliography at the end of this chapter.

long distances. Hence, it is inferred that the reserves are extensive. Crocidolite occurs with amosite in the Pietersburg district in the western part of the amosite belt. The reserves are probably less extensive in this area.

CAPE OF GOOD HOPE

The crocidolite deposits of the Cape extend over an area 240 miles long and up to 30 miles wide. The area is so large and the fiber veins are distributed so generally throughout it that the reserves are probably extensive.

SWAZILAND

The reserves at the Havelock mine are said to comprise 14 million tons of rock carrying 4 percent asbestos. This would indicate over half a million tons of fiber. Much larger reserves may be developed than these estimates indicate, because recent exploration has revealed an extension of the serpentine belt from the Havelock mine south-southwest to the Transvaal border, a distance of 17 miles.

CHINA

China may have large reserves of asbestos. It was estimated in 1935 that Hopei Province had a reserve of 400,000 tons.

AUSTRALIA

As the crocidolite-bearing rocks of the Hamersley Range, Western Australia, extend over an area 180 miles long and 20 to 30 miles wide, the prospective reserves are very large. They may even exceed those of the Union of South Africa.

WORLD ESTIMATE

The following estimates of world reserves (table 11) have recently been made (*3*).

TABLE 11.—*Asbestos reserves of chief producing countries, thousand short tons*

Country	Variety			
	Chrysotile	Amosite	Crocidolite	Probable life in years[1]
Australia	25	--------	100	30
Canada	50, 000	--------	--------	75
Southern Rhodesia	10, 000	--------	--------	75
Swaziland	500	--------	--------	20
Union of South Africa	250	1, 500	1, 000	30
United States	1, 500	--------	--------	50
U. S. S. R.	25, 000	--------	--------	100

[1] "Life" is based on the continuance of the 1946–52 rate of world production.

SUMMARY

The world as a whole appears to have adequate asbestos reserves for at least 25 or 30 years at current or moderately increased rates of output. United States reserves of the shorter fibers are small compared with domestic needs. Of the longer grades, the reserves are very small. The chief suppliers of the United States markets—Canada and Africa—appear to have adequate reserves for long-range planning. The Soviet Union probably has reserves large enough to supply its domestic economy in war or peace for many years. To provide for a possible downward scaling of reserves or for a greatly enlarged consumption, the discovery and development of new deposits, especially in the United States, are highly desirable.

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CHAPTER 9. POLITICAL AND COMMERCIAL CONTROL

SIGNIFICANCE OF INDUSTRY CONTROL

Asbestos deposits of commercial importance are not abundant and are widely scattered over the earth. The demand for this mineral has increased greatly; therefore, both political and commercial control of asbestos deposits has primary interest, not only to individual consumers but to national governments, because it is regarded as a mineral of strategic importance.

POLITICAL CONTROL

The U. S. S. R. deposits are under absolute control of the State. All other producing areas of primary importance—Canada, Southern Rhodesia, Union of South Africa, and Swaziland—are within the political orbit of the British Commonwealth. Moderately important deposits in Cyprus, Australia, and New Zealand are also within the British sphere. Deposits of moderate importance outside the British Commonwealth are in the United States, Venezuela, Italy, Finland, India, China, and Japan. Relatively small deposits are controlled politically by Argentina, Bolivia, Portugal, France, Turkey, French Morocco, and several other countries.

COMMERCIAL CONTROL

The only large asbestos producer in the United States—Vermont Asbestos Mines—is a subsidiary of the Ruberoid Co. of New York City and is controlled by United States capital. All of the small United States companies are similarly controlled.

Commercial control of the Canadian asbestos industry is diverse. The largest operation in Quebec, Canada—in fact, the largest operation in the world—that of Canadian Johns-Manville, is a subsidiary of the Johns-Manville Corp. of New York City. This company also is operating a property—the Munro mine—near Matheson, Ontario, which began production in 1950. The Quebec Asbestos Corp., Ltd., is a subsidiary of the Philip Carey Manufacturing Co. of Cincinnati, Ohio; the Nicolet Asbestos Mines, Ltd., of Nicolet Industries, Inc., 70 Pine Street, New York City; and Flintkote Mines, Ltd., of the Flintkote Co. of New York City.

British capital also is represented. The Bell Asbestos Mines, a large producer, is a subsidiary of Turner & Newall, Ltd., of Manchester, England. Asbestos Corp., Ltd., the second largest producer in the Quebec area, and the Johnson's Co., one of the pioneer operators, are reported to be financed by Canadian capital.

Cassiar Asbestos Corp., Ltd., operator of a new mine in British Columbia, is a subsidiary of Con-West Exploration Corp., a Canadian firm. However, substantial blocks of stock in the Cassiar Asbestos Corp. are owned by Turner & Newall, Ltd., of Manchester, England, and by Raybestos-Manhattan, Inc., of Manheim, Pa.

Two British companies, Turner & Newall, Ltd., and the Cape Asbestos Co., control most of the asbestos production in Southern Rhodesia, the Union of South Africa, and Swaziland. These companies have extensive asbestos-products manufacturing plants whose raw-material needs claim first priority. Also, European and Australian buyers are preferred customers at times. Accordingly, the position of United States buyers of the important fibers originating in Africa is somewhat uncertain.

The one company operating in Cyprus is controlled by British capital. The Australian mines are controlled by British and Australian interests. Most of the production of blue asbestos in Bolivia has come from Bolivian-owned mines. A French company was reported to have held a 48-percent interest in the Venezuelan asbestos industry at Tinaquillo, but in 1953 the property was taken over by a new company controlled by Venezuelan capital. The State controls, both politically and commercially, the activities of the asbestos industry of the Russian Urals.

CHAPTER 10. INTERNATIONAL TRADE

EXTENT OF INTERNATIONAL TRADE

The Soviet Union stands alone with respect to its position as a large producer as well as a large consumer of asbestos. Southern Rhodesia and the Union of South Africa have had small asbestos-products manufacturing industries but are attaining increasing importance. According to a consular report received in 1956, there are 13 asbestos-products plants in the Union of South Africa and 2 in Southern Rhodesia. Canada is becoming an important manufacturer of asbestos products. In 1954, 16 plants made products which were sold for nearly $24 million, compared with 15 plants producing goods valued at about $8 million in 1948. Canadian consumption of asbestos ranges from 3 to 5 percent of total sales.

Countries that are normally the important asbestos consumers outside the U. S. S. R.—the United States, England, France, Germany, Belgium, Netherlands, and Japan—produce no asbestos or only relatively small quantities. Because nearly all important asbestos-producing countries are minor consumers and nearly all important consuming countries have limited domestic asbestos resources, a large proportion of all asbestos mined enters international trade, and all the principal nations are profoundly interested in foreign sources of supply and their availability in times of emergency. Figure 6 presents a general picture of the export and import situation throughout the world for three recent years.

As the United States depends so extensively on foreign supplies, international trade in asbestos and its products merits careful scrutiny. Furthermore, the trade of the principal asbestos-producing countries with the United States and other importers is likewise significant, because it indicates the proportion that each consuming country receives from year to year.

FOREIGN TRADE OF THE UNITED STATES

CONSUMPTION

The United States is the largest consumer of asbestos in the world. Consumption during the 22-year period 1935–56 is indicated in table 12. Imports comprise 92 to 96 percent of the annual requirements. These imported supplies constitute the major part of the raw materials employed by more than 100 asbestos-products plants that manufactured goods valued at more than $344 million in 1953. Importations into the United States are hampered in no way by tariff regulations because unmanufactured asbestos is imported duty free.

TABLE 12.—*Apparent consumption*[1] *of asbestos in the United States, 1935–56*

[Bureau of Mines Minerals Yearbook]

Year	Short tons	Year	Short tons
1935	174, 655	1946	459, 752
1936	250, 922	1947	616, 194
1937	316, 263	1948	675, 746
1938	187, 150	1949	532, 708
1939	255, 547	1950	727, 002
1940	262, 199	1951	796, 992
1941	438, 741	1952	752, 609
1942	433, 949	1953	743, 625
1943	445, 902	1954	724, 117
1944	389, 241	1955	782, 216
1945	378, 030	1956	727, 396

[1] Production plus imports minus exports.

IMPORTS

Table 13 shows United States imports of asbestos by years for a 22-year period, 1935–56, by leading countries of origin. Over 90 percent on a tonnage basis ordinarily is imported from Canada, but a large part of it consists of the shorter, nonstrategic grades. Of greatest significance in times of emergency are the imports of crudes and spinning fibers designated as strategic grades. Imports from Canada of these grades for the 12-year period 1945–56 are indicated in table 14. As these grades have generally been scarce in times of emergency, the proportion of total Canadian output that reached United States markets during the postwar era is significant. Such figures, available only since 1948, are shown in table 15. In the early part of the post-World War II period the demand for these grades was greater than the supply. In 1948 the United States received 68 percent of the total supply and in 1949, only 59 percent. From 1950 to 1952, the proportion ranged from 67 to 72 percent but was considerably lower in 1953, 1954, and 1955. The recession was, however, due to depressed markets for spinning grades rather than to inability to obtain them.

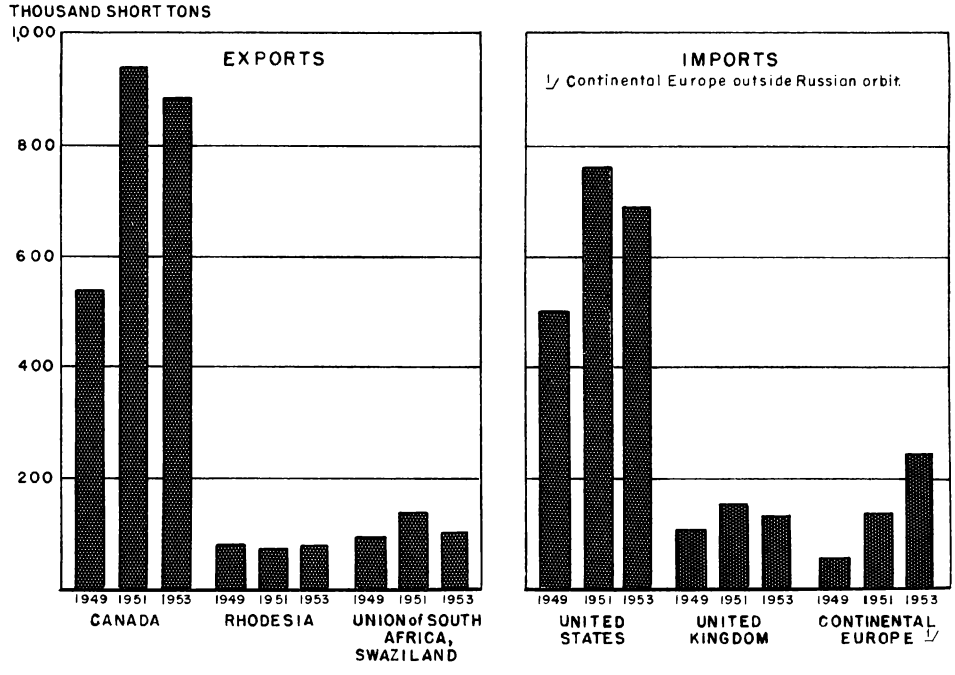

FIGURE 6.—Asbestos Exports and Imports, by Countries, for 1949, 1951, and 1953.

TABLE 13.—*Imports of asbestos into the United States, by principal countries of origin, 1935–56, in short tons*

[U. S. Department of Commerce]

Year	Africa			Australia	Canada	U. S. S. R.	Other	Total
	Southern Rhodesia [1]	Union of South Africa	Swaziland					
1935	1, 183	945	(2)	----------	154, 236	4, 813	5, 408	166, 585
1936	3, 266	2, 080	(2)	----------	226, 078	16, 422	5, 756	243, 602
1937	7, 099	4, 248	(2)	----------	276, 010	10, 213	9, 618	307, 188
1938	2, 745	3, 677	(2)	21	166, 071	5, 265	1, 711	179, 490
1939	4, 836	6, 359	(2)	----------	223, 840	2, 611	4, 915	242, 561
1940	8, 462	8, 752	(2)	28	225, 856	----------	3, 515	246, 613
1941	8, 234	21, 447	(2)	62	389, 391	----------	62	419, 196
1942	8, 665	20, 278	(2)	35	366, 621	3, 610	33	419, 242
1943	28, 555	24, 009	(3)	3	385, 655	1, 144	889	440, 255
1944	7, 966	19, 196	(3)	----------	353, 247	2, 610	30	383, 049
1945	2, 545	13, 247	(3)	2	355, 768	2, 625	12	374, 199
1946	5, 463	6, 050	(3)	24	442, 073	2, 750	328	456, 688
1947	8, 992	20, 034	(3)	----------	559, 279	6, 524	10	594, 839
1948	10, 513	18, 859	[3] 692	3	602, 216	15, 514	84	647, 881
1949	13, 722	22, 720	[3] 497	249	470, 783	1, 221	174	509, 366
1950	9, 464	14, 907	[3] 1, 522	273	678, 696	426	170	705, 458
1951	7, 725	23, 583	[3] 712	311	726, 770	2, 237	535	761, 873
1952	10, 543	26, 902	[3] 607	274	668, 900	1, 761	482	709, 469
1953	9, 990	26, 430	[3] 619	1, 750	652, 117	325	1, 014	692, 245
1954	7, 219	27, 400	[3] 1, 280	1, 256	640, 282	292	877	678, 390
1955	8, 420	28, 699	189	3, 348	699, 087	----------	680	740, 423
1956	14, 640	33, 175	----------	3, 150	633, 746	6	4, 317	689, 034

[1] Designated "Other British," 1935–41.
[2] Assumed source; classified in import statistics under "Union of South Africa."
[3] Assumed source; classified in import statistics under "Southern British Africa." No transactions reported 1935–47.

TABLE 14.—*Imports of spinning grades of asbestos into the United States from Canada, 1945–56, in short tons*

[Based on Dominion Bureau of Statistics data]

Grades	1945	1946	1947	1948	1949	1950
Crude No. 1	184	221	168	274	203	390
Crude No. 2	419	291	278	307	206	260
Other crudes	176	8	49	94	437	1, 114
Spinning and textile	18, 063	18, 704	17, 836	20, 770	13, 738	24, 417
Total	18, 842	19, 224	18, 331	21, 445	14, 584	26, 181

Grades	1951	1952	1953	1954	1955	1956
Crude No. 1	126	144	168	82	65	50
Crude No. 2	226	332	207	181	164	217
Other crudes	384	79	467	844	644	6
Spinning and textile	22, 463	24, 112	19, 417	18, 319	21, 339	20, 638
Total	23, 199	24, 667	20, 259	19, 426	22, 212	20, 911

TABLE 15.—*Total shipments and imports into the United States of Canadian crudes and spinning fibers, 1949–56, in short tons*

	1949	1950	1951	1952	1953	1954	1955	1956
Total shipments	23, 296	34, 859	33, 884	36, 673	36, 751	35, 933	43, 805	34, 656
Shipments into United States	13, 831	25, 247	23, 199	24, 667	20, 259	19, 426	22, 212	20, 911
Percent of total imported into United States	59	72	70	67	55	62	51	60

The need for spinning-grade chrysotile asbestos with a lower iron content than that produced in Quebec was urgent during World War II and in the early postwar period. Such fibers were needed for electrical applications, including cable construction on naval vessels. For many years the principal source of low-iron fibers was Southern Rhodesia but, as indicated in table 16, imports of the spinning grades dropped from 5,891 tons in 1948 to only 343 tons

TABLE 16.—*Asbestos (chrysotile) imported for consumption in the United States from Southern Rhodesia,*[1] *by grades, 1943–56, in short tons*

[U. S. Department of Commerce]

Year	Crude No. 1 [2]	Crude No. 2 [2]	Spinning and textile	Total spinning grades	Other	Grand total
1943	1, 566	5, 618	----------	7, 184	[3] 21, 927	29, 111
1944	1, 490	4, 519	----------	6, 009	1, 957	7, 966
1945	459	1, 911	----------	2, 370	----------	2, 370
1946	762	1, 475	----------	2, 237	3, 225	5, 462
1947	1, 593	4, 226	----------	5, 819	3, 156	8, 975
1948	1, 174	4, 697	20	5, 891	3, 531	9, 422
1949	1, 270	2, 905	81	4, 256	[3] 9, 466	[3] 13, 722
1950	2, 124	1, 844	556	4, 524	4, 940	9, 464
1951	678	1, 239	25	1, 942	5, 783	7, 725
1952	462	1, 363	177	2, 002	8, 541	10, 543
1953	1, 039	814	730	2, 583	7, 407	9, 990
1954	181	275	156	612	6, 607	7, 219
1955	105	162	76	343	8, 077	8, 420
1956	61	71	339	471	14, 169	14, 640

[1] Effective July 1, 1954, reported by the Department of Commerce as Federation of Rhodesia and Nyasaland. Believed to be all from Southern Rhodesia.

[2] Believed to be equivalent to C & G No. 1 and C & G No. 2.

[3] Includes imports from Mozambique.

in 1955. The decline was due largely to increasing demands for the fiber in other countries, particularly in Great Britain. The shortage of imports created a serious situation for several years, but discovery in the early 1950's of a large low-iron asbestos deposit in British Columbia, Canada, relieved the stress.

Amosite, a variety of asbestos mined only in the Union of South Africa, also has strategic importance, particularly as a lightweight thermal insulator. Imports during the period 1943–56 are indicated in table 17.

African crocidolite (blue asbestos), although it has not been classed as strategic, has important uses, chiefly in the manufacture of asbestos-cement pipe, and it is in strong demand in the United States. Imports are recorded in table 17.

TABLE 17.—*Imports of amosite and crocidolite (blue asbestos) into the United States, 1943–56, in short tons*

[U. S. Department of Commerce]

Year	Amosite	Crocidolite
1943	20, 129	3, 880
1944	15, 660	3, 051
1945	9, 054	4, 515
1946	8, 414	1, 261
1947	10, 801	7, 851
1948	12, 551	4, 060
1949	14, 892	5, 259
1950	8, 105	5, 423
1951	15, 131	5, 473
1952	18, 323	6, 885
1953	15, 261	7, 781
1954	14, 634	10, 911
1955	11, 745	14, 592
1956	11, 735	19, 270

Bolivian crocidolite was regarded as essential for gas-mask filters during World War II and the early postwar period and was purchased for the national stockpile. Since effective Fiberglas filters have been developed, requirements for Bolivian crocidolite for such use have been virtually eliminated. There is little or no commercial demand for it. Imports have ranged from 68 to 828 tons a year since 1948 but with completion of the Government purchase program have virtually ceased.

EXPORTS

Although the United States produces only a fraction of its requirements of asbestos, it nevertheless exports substantial quantities. Table 18 shows the tonnage and value of exports from 1947 to 1956. Approximately 15 percent of the exports comprised material that had been imported and later exported without change. The remainder was asbestos of domestic origin or foreign material that had been milled, blended, or otherwise processed in the United States. The latter item was the largest. It consisted principally of Canadian fibers blended in various ways to suit the needs of Latin-American or European countries. South America has over 20 asbestos-products plants. Some of them have been supplied in part from small local asbestos mines and limited shipments received from Africa, but the plants depend primarily upon direct shipments from Quebec or upon imports of prepared fibers from United States suppliers. Continental European countries were the principal destinations because their domestic supplies were small or nonexistent and their customary sources were inadequate. Export trade declined greatly in 1953 and 1954, when world supply more nearly balanced demand.

TABLE 18.—*Exports of asbestos from the United States, 1947–56* [1]

[U. S. Department of Commerce]

Year	Short tons	Value
1947	2, 680	$436, 300
1948	9, 227	1, 804, 611
1949	19, 445	4, 152, 344
1950	20, 890	4, 084, 384
1951	16, 526	3, 662, 270
1952	10, 724	2, 670, 970
1953	3, 076	592, 222
1954	1, 894	291, 157
1955	2, 787	267, 776
1956	2, 950	374, 964

[1] Figures for years preceding 1947 are not comparable.

Some of the asbestos export trade during the early postwar era when asbestos was in short supply might be classed as gray-market transactions. Dealers or processors obtained fiber in various ways and sold it abroad, either as purchased or after processing, at the highest prices they could command. Canadian asbestos producers tried to confine their sales to legitimate consumers, but occasionally their asbestos fell into the hands of jobbers or traders who sold it to foreign consumers at prices far above regular market quotations. According to the figures given in table 18, the average price per ton from 1948 to 1952 was more than $200. As exports were predominantly of the shorter grades, this relatively high average reflects the prices that asbestos-hungry industries in foreign lands were willing to pay.

EXPORT CONTROL

Early in World War II the need for asbestos became so urgent that control measures were promulgated to restrict exports of fibers needed in the military program. In accord-

ance with Export Control Schedule No. 9, effective July 2, 1941, all export shipments of long-fiber crude chrysotile asbestos (fibers three-fourths inch or more in length) became subject to export license. Export Control Schedule No. 18, effective September 10, 1941, provided that short-fiber asbestos (fibers less than three-fourths inch in length) also required export license, except that exports could be made to certain specified countries without individual export permits under General License GLV if the value of the shipment did not exceed $25. A similar provision for long fiber became effective July 1, 1942. All of these controls were removed by Executive order on September 10, 1945.

Consideration was given in 1948 and 1949 to reestablishment of export controls, particularly on fibers that might conform with national stockpile specifications, but it was believed that such measures would afford little relief to the overall situation, and no action was taken at that time. However, with the participation of the United States in the Korean conflict, the situation became so acute that asbestos was again placed under export control. In October 1950 regulations were established whereby amosite grades B–1, B–3, and 3 DMI, Rhodesian chrysotile C & G 1, C & GP1, C & G 2, and C & GP2, and Arizona Crude Nos. 1 and 2, or equivalents of any of these grades, could be exported to no country except Canada without export license if the value of the shipment exceeded $100. In March 1951 the nonspinning milled fibers were placed under similar export control. In November 1951 the control measure was amended to read "crude asbestos and spinning fibers" and to include asbestos "waste and refuse." In other words, during the Korean conflict licenses were required for export of all grades of asbestos.

In July 1953 the class designated "waste and refuse" was removed from export control. In August 1953 nonspinning milled asbestos and in August 1954 crude and spinning fibers were also removed from the list. All export control ceased, therefore, in August 1954, and asbestos could again be exported to free-world destinations. Export license is still required, however, for shipments to the Soviet bloc, Communist China, Hong Kong, Macao, and Communist-controlled areas of Viet-Nam and Laos.

FOREIGN TRADE OF CANADA

As Canada is the principal source of supply of asbestos for the United States and a substantial source for many other countries, figures have been compiled in some detail indicating Canadian trade with foreign countries and the proportion of the more critical grades shipped to the leading consuming nations or areas. Table 19 presents the data thus assembled. Crudes and mill fibers (Groups 1 to 5), the most important grades in times of emergency, are shown separately in this table.

TABLE 19.—*Exports of asbestos from Canada, by country of destination, 1935–55, in short tons*

[Dominion Bureau of Statistics]

	1935	1936	1937	1938	1939	1940	1941
Production:							
Total	210, 467	301, 287	410, 026	289, 793	364, 472	345, 581	477, 846
Crudes and milled fibers [1]	104, 548	136, 728	204, 093	166, 008	197, 113	183, 966	226, 612
Exports							
Total	158, 143	218, 098	391, 041	288, 887	346, 018	336, 575	453, 909
Crudes and milled fibers	81, 494	109, 270	196, 511	165, 744	186, 238	181, 646	220, 255
Exports to United States:							
Total	113, 972	165, 139	274, 904	166, 867	225, 059	226, 031	388, 151
Crudes and milled fibers	43, 991	64, 354	98, 196	54, 323	77, 460	84, 601	162, 734
Exports to United Knigdom:							
Total	6, 572	8, 422	20, 450	24, 932	30, 169	54, 453	35, 627
Crudes and milled fibers	4, 437	4, 792	14, 093	19, 996	22, 610	42, 246	27, 751
Exports to other European countries:							
Total	17, 569	24, 186	57, 231	61, 530	46, 351	20, 108	1, 057
Crudes and milled fibers	13, 419	20, 077	47, 088	56, 543	42, 239	19, 208	1, 037
Exports to Latin America:							
Total	105	186	236	470	3, 629	1, 029	10, 528
Crudes and milled fibers	18	50	68	320	3, 428	927	10, 291
Exports to Australia:							
Total [2]	1, 281	2, 155	3, 057	6, 500	8, 248	7, 990	2, 139
Crudes and milled fibers [2]	1, 100	2, 152	3, 042	6, 478	8, 198	7, 970	2, 039
Exports to Japan:							
Total	18, 554	17, 887	34, 951	27, 437	30, 660	25, 199	14, 195
Crudes and milled fibers	18, 499	17, 782	33, 934	27, 089	30, 649	25, 169	14, 195
Canadian consumption [3]	52, 324	83, 189	18, 985	906	18, 454	9, 006	23, 937

See footnotes at end of table.

TABLE 19.—*Exports of asbestos from Canada, by country of destination, 1935–55, in short tons*—Con.

[Dominion Bureau of Statistics—Continued]

	1942	1943	1944	1945	1946	1947	1948
Production:							
Total	439, 460	467, 196	419, 265	466, 896	558, 181	661, 821	716, 769
Crudes and milled fibers [1]	202, 719	219, 905	191, 780	220, 748	228, 976	223, 154	242, 930
Exports:							
Total	427, 457	442, 999	395, 937	440, 557	520, 184	636, 896	690, 442
Crudes and milled fibers	201, 248	212, 827	183, 209	210, 628	215, 872	224, 646	237, 949
Exports to United States:							
Total	387, 772	385, 523	350, 926	353, 583	437, 534	557, 660	599, 749
Crudes and milled fibers	165, 621	160, 906	145, 852	135, 432	150, 099	161, 835	168, 855
Exports to United Kingdom:							
Total	25, 892	32, 836	23, 071	37, 567	27, 546	31, 817	38, 234
Crudes and milled fibers	22, 119	27, 541	16, 027	28, 799	23, 063	20, 418	24, 435
Exports to other European countries:							
Total	1, 737	2, 352	1, 880	22, 870	35, 534	23, 515	27, 400
Crudes and milled fibers	1, 679	2, 352	1, 880	20, 182	23, 466	19, 418	20, 901
Exports to Latin America:							
Total	8, 185	12, 593	9, 575	19, 155	10, 646	15, 585	15, 003
Crudes and milled fibers	8, 035	12, 470	9, 251	18, 904	10, 398	15, 112	14, 443
Exports to Australia:							
Total [2]	3, 853	9, 677	10, 427	7, 156	8, 367	7, 083	8, 954
Crudes and milled fibers [2]	3, 794	9, 558	10, 198	7, 087	8, 367	7, 083	8, 224
Exports to Japan:							
Total							
Crudes and milled fibers							
Canadian consumption [3]	12, 003	24, 197	23, 328	26, 339	37, 997	24, 925	26, 327

	1949	1950	1951	1952	1953	1954	1955
Production:							
Total	574, 906	875, 344	973, 198	929, 339	911, 226	924, 116	1, 061, 951
Crudes and milled fibers [1]	195, 235	306, 098	333, 749	352, 385	327, 121	327, 378	[4] 376, 298
Exports:							
Total	534, 990	829, 979	942, 314	902, 058	878, 530	887, 728	1, 001, 827
Crudes and milled fibers	182, 272	290, 643	325, 254	340, 510	317, 226	313, 485	366, 566
Exports to United States:							
Total	461, 453	667, 006	712, 065	678, 932	644, 159	634, 123	693, 569
Crudes and milled fibers	126, 797	181, 409	199, 632	193, 132	169, 351	151, 457	169, 357
Exports to United Kingdom							
Total	28, 848	52, 395	68, 830	57, 340	51, 922	58, 743	76, 478
Crudes and milled fibers	19, 058	29, 912	30, 807	36, 726	19, 609	25, 130	37, 810
Exports to other European countries:							
Total	26, 415	62, 912	94, 140	113, 200	199, 723	105, 244	133, 130
Crudes and milled fibers	19, 056	39, 117	45, 539	58, 461	62, 708	65, 417	81, 840
Exports to Latin America:							
Total	9, 806	24, 582	30, 409	31, 200	35, 332	37, 201	44, 740
Crudes and milled fibers	8, 958	20, 848	23, 451	23, 941	29, 350	30, 128	33, 216
Exports to Australia:							
Total [2]	6, 785	12, 411	13, 542	16, 166	18, 124	21, 906	23, 378
Crudes and milled fibers [2]	6, 725	10, 767	12, 065	13, 055	17, 504	21, 661	22, 668
Exports to Japan:							
Total	98	5, 306	15, 464	13, 865	20, 025	18, 564	19, 832
Crudes and milled fibers	98	3, 884	7, 686	7, 122	11, 872	12, 196	12, 830
Canadian consumption [3]	39, 916	45, 365	30, 884	27, 281	32, 696	36, 388	60, 124

[1] Groups 1 to 5, Canadian classification.
[2] Includes New Zealand.
[3] Production minus exports; imports are negligible.
[4] Estimate derived by adding to Quebec crudes and milled fibers all of British Columbia production and one-third of Ontario production.

The United States, the largest consumer, generally receives 70 to over 75 percent of the total Canadian production; 70 to 77 percent of the Canadian production of crudes and mill fibers were shipped to the United States in 1947 and 1948, but since that time shipments have declined to only 45 percent in 1955. The decreasing proportion shipped to the United States is due chiefly to the substantial increase in sales to continental Europe—from 9 percent

in 1948 to 22 percent in 1955. This increase reflects the rehabilitation of war-devastated asbestos-products plants in that area.

Shipments of crudes and mill fibers from Canada to countries other than the United States and the United Kingdom reached a high of 55 percent in 1938. During World War II, however, such shipments declined greatly, reaching a low of only 7 percent in 1942. Since the war the percentage has risen gradually.

Shipments to Latin America, Australia, and Japan have been increasing. Exports of crudes and milled fibers to the United Kingdom, except for a recession in 1953 and 1954, have remained remarkably constant at about 10 percent during recent years.

FOREIGN TRADE OF SOUTHERN RHODESIA

Rhodesia has a small asbestos-products-manufacturing industry, which is gradually expanding. Two plants were reported in operation in 1956. Accordingly, a large percentage of the asbestos produced is exported. Exports by country of destination are shown in table 20. Before World War II, 70 to 80 percent of the exports were consigned to the United Kingdom and other European countries. During the war continental Europe received very little, and the quantities shipped to the United States increased from a prewar 6 to 12 percent to a maximum of 58 percent in 1943 to supply war needs. Australia also received much larger quantities during the war than in the 1930's. Recently, 50 to 60 percent of the exports have been consigned to the United Kingdom. Twelve to 20 percent came to the United States from 1947 to 1953, but the proportion declined to 9 percent in 1954 and 8 percent in 1955. These figures relate to chrysotile of all grades but, as indicated in table 16, shipments of the spinning grades to the United States have declined to very small quantities. Shipments to continental Europe and Australia show substantial increases in 1954 and 1955.

TABLE 20.—*Exports of asbestos from Southern Rhodesia, by principal countries of destination, 1935–56, in short tons*

[Based on Annual Reports, Chief Government Mining Engineer and Chief Inspector of Mines, Southern Rhodesia]

Year	Production	Total exports	Exports to—					
			United States	United Kingdom	Continental Europe [1]	Latin America	Australia	India
1935 [2]	42, 598	45, 287	1, 418	13, 120	2, 000	97	1, 450	780
1936	56, 346	51, 227	4, 106	18, 627	23, 370	387	2, 166	1, 006
1937	57, 014	64, 453	8, 018	22, 904	25, 373	634	3, 410	1, 764
1938	58, 811	58, 610	3, 390	19, 861	25, 656	857	3, 302	3, 398
1939	58, 313	51, 013	5, 266	21, 141	15, 489	1, 023	3, 770	2, 027
1940	----------	57, 891	8, 295	25, 614	6, 199	1, 609	8, 168	6, 131
1941	44, 134	54, 224	12, 680	15, 829	744	1, 710	14, 794	8, 160
1942	55, 803	62, 332	12, 995	19, 130	300	2, 561	19, 034	7, 544
1943	58, 146	56, 382	32, 503	11, 553	600	1, 950	7, 300	1, 500
1944	58, 293	46, 755	6, 806	17, 637	980	3, 915	10, 112	6, 169
1945	56, 349	50, 251	2, 281	17, 499	12, 313	3, 700	8, 692	5, 116
1946	55, 872	61, 745	4, 476	26, 438	14, 508	3, 265	5, 327	6, 333
1947	54, 094	56, 325	10, 982	25, 705	6, 971	2, 463	6, 447	3, 500
1948	68, 897	67, 763	10, 142	35, 766	6, 577	3, 104	5, 465	5, 430
1949	79, 638	72, 808	13, 574	37, 354	7, 314	1, 310	4, 544	6, 450
1950	71, 527	73, 779	11, 316	39, 971	8, 427	3, 032	1, 810	7, 375
1951	77, 662	68, 304	9, 052	39, 521	7, 475	1, 372	2, 358	4, 815
1952	84, 834	83, 135	10, 180	51, 600	6, 286	767	1, 813	7, 518
1953	87, 739	71, 629	9, 862	43, 361	9, 796	702	637	2, 799
1954	79, 962	81, 172	7, 321	38, 643	16, 240	694	6, 587	6, 429
1955	105, 261	92, 477	7, 680	49, 806	19, 345	2, 128	3, 030	5, 821
1956	118, 973	107, 842	8, 212	55, 916	22, 060	2, 830	436	13, 271

[1] Excludes U. S. S. R. and satellite countries.
[2] Export destination data for 1935 incomplete; large quantities shipped to unspecified "optional ports."

FOREIGN TRADE OF THE UNION OF SOUTH AFRICA AND SWAZILAND

The Havelock mine in Swaziland has been a substantial producer of chrysotile asbestos since 1940. Although outside the boundaries of the Union of South Africa proper, it is close to the border, and the asbestos produced is shipped through Barberton in the Union. The preface to the official report, Annual Statement of Trade and Shipping of the Union of South Africa, states that export figures include shipments from Swaziland. Accordingly, in table 21 production of Swaziland has been added to that of the Union to furnish a true picture of the relation of exports to total output.

TABLE 21.—*Exports of asbestos from the Union of South Africa and Swaziland, by principal countries of destination, 1935–55, in short tons*

[Based on annual statements of Trade and Shipping, Union of South Africa, and Department of Mines, Union of South Africa]

Year	Production in Union	Production in Swaziland	Total production	Total exports [1]	Exports to—						
					United States	United Kingdom	Continental Europe [2]	Australia	India and Pakistan	Latin America	Japan
1935	22, 708		22, 708	23, 714	1, 114	12, 284	5, 201	2, 206	298	263	2, 302
1936	25, 236		25, 236	24, 709	1, 879	13, 611	3, 779	2, 446	364	74	2, 433
1937	28, 633		28, 633	27, 821	3, 010	14, 937	4, 541	1, 751	517	161	2, 774
1938	23, 176		23, 176	21, 978	3, 146	10, 879	3, 328	1, 875	983	39	1, 610
1939	22, 050	7, 973	30, 023	22, 636	7, 109	8, 826	4, 379	624		74	1, 610
1940	27, 392	20, 804	48, 196	43, 482	8, 787	29, 450	1, 004	1, 986			2, 141
1941	28, 280	21, 127	49, 407	43, 588	18, 008	19, 004		2, 090	3, 320	80	
1942	34, 559	25, 595	60, 154	55, 223	22, 518	25, 738	1, 500	4, 519		572	
1943	35, 656	18, 937	54, 593	50, 182	23, 250	20, 078	410	878	3, 765	292	
1944	34, 582	32, 659	67, 241	58, 278	18, 846	25, 932	5, 190	1, 902	5, 290	908	
1945	28, 216	23, 416	51, 632	40, 301	9, 674	23, 119	6, 712	184		503	
1946	20, 225	32, 138	52, 363	47, 894	9, 933	12, 089	15, 471	7, 906	2, 207	213	
1947	30, 142	27, 954	58, 096	64, 766	18, 190	27, 593	6, 090	4, 121	900	1, 107	
1948	45, 735	32, 431	78, 166	63, 982	18, 950	27, 611	7, 143	4, 030	2, 153	1, 955	
1949	70, 917	33, 966	104, 883	92, 113	20, 637	37, 158	17, 266	6, 479	2, 240	4, 417	470
1950	87, 414	32, 667	120, 081	101, 578	16, 115	37, 324	21, 821	12, 537	3, 155	7, 265	811
1951	107, 368	34, 964	142, 332	126, 500	24, 810	40, 020	28, 412	13, 283	6, 184	6, 632	1, 658
1952	133, 839	34, 769	168, 608	137, 142	28, 596	39, 472	40, 887	16, 628	3, 893	2, 485	597
1953	94, 817	30, 103	124, 920	101, 330	24, 272	27, 226	29, 302	10, 111	1, 630	2, 692	547
1954	109, 151	30, 142	139, 293	127, 426	29, 501	34, 360	33, 516	15, 311	2, 163	1, 939	2, 513
1955	119, 699	32, 613	152, 312								

[1] Includes exports of Swaziland asbestos.
[2] Excludes U. S. S. R. and satellite countries.

Table 21 shows exports by country of destination from 1935 to 1955. As the asbestos-product-manufacturing facilities of the Union are not extensive, 85 to 90 percent of total production is exported. Shipments to the United States have been fairly constant, averaging about 23 percent of the total quantity exported during recent years. As indicated in table 21, exports to other countries are erratic. For example, shipments to Continental European countries dropped from 32 percent in 1946 to only 9 percent in 1947. Over the period covered by this table, the United States received about 24 percent; the United Kingdom, 39 percent; other European countries, 18 percent; Australia, 8 percent; and India and Latin America, each about 3 percent of total exports.

Table 22 indicates that the export trade of the Union in chrysotile is unstable. Exports to the United Kingdom have declined greatly, while those to other European countries have more than doubled during recent years and in 1954 and 1955 comprised about two-thirds of the total. Shipments to Latin America are very small, but those to Australia have increased from zero in 1948 to 1950 to 18 percent of the total exports in 1955. Exports to the United States are negligible.

The Union of South Africa is the only producer of amosite in the world. Amosite is the most important strategic fiber produced in the Union. Table 23, which shows exports by country of destination, indicates that the export trade is relatively constant from year to

year; 25 to 40 percent of the export supply reaches United States markets. Thirty-five to forty percent goes to the United Kingdom and other European countries, and the balance is shipped chiefly to Australia. Canada, being the largest producer of asbestos in the world, is not a large importer, but as no amosite is produced within its borders it imports tonnages to supply specialized needs that cannot be met with chrysotile.

TABLE 22.—*Exports of chrysotile from the Union of South Africa, by principal countries of destination, 1945–56, in short tons*

[Union of South Africa, Department of Mines]

Year	Production	Total exports	Exports to—				
			United States	United Kingdom	Continental Europe [1]	Latin America	Australia
1945	1, 765	860	----------	----------	----------	860	----------
1946	1, 666	437	123	1	140	175	----------
1947	2, 253	845	----------	----------	73	668	104
1948	4, 441	1, 279	----------	40	257	622	----------
1949	7, 609	5, 142	----------	1, 139	2, 012	1, 035	----------
1950	14, 334	9, 153	----------	2, 025	2, 818	4, 143	----------
1951	19, 509	12, 048	2	3, 253	3, 613	3, 747	51
1952	24, 970	20, 313	1	2, 010	15, 582	359	----------
1953	18, 840	13, 821	----------	1, 576	9, 270	239	1, 811
1954	19, 373	15, 768	34	1, 076	10, 600	276	2, 440
1955	20, 535	18, 227	24	746	12, 142	1, 339	3, 191
1956	24, 336	17, 775	34	2, 626	10, 221	1, 044	2, 071

[1] Excludes U. S. S. R. and satellite countries.

The Union of South Africa is the principal producer of crocidolite, although substantial quantities similar in quality to the African variety have been produced in recent years in Australia. Table 24 shows exports by country of destination from 1945 to 1955. The United States and the United Kingdom each receive 18 to 30 percent of total exports. Thirty to forty percent is generally shipped to other European countries, while minor quantities go to Canada, Australia, and Latin America. Exports reached an all-time high of nearly 50,000 tons in 1955.

TABLE 23.—*Exports of amosite from the Union of South Africa, by principal countries of destination, 1945–56, in short tons*

[Union of South Africa, Department of Mines]

Year	Production	Total exports	Exports to—				
			United States	United Kingdom	Continental Europe [1]	Australia	Canada
1945	16, 737	12, 851	8, 598	3, 678	356	179	----------
1946	9, 838	12, 540	6, 322	2, 928	2, 333	882	75
1947	18, 780	19, 659	11, 002	4, 986	1, 833	1, 278	109
1948	30, 372	27, 635	12, 182	7, 052	4, 547	2, 566	225
1949	41, 974	39, 269	13, 194	12, 541	7, 836	4, 613	495
1950	42, 393	37, 175	8, 342	12, 097	7, 093	7, 799	592
1951	54, 053	43, 246	14, 333	12, 254	5, 725	8, 318	400
1952	63, 280	49, 324	19, 012	10, 793	8, 420	10, 149	918
1953	38, 258	32, 776	13, 608	7, 935	3, 182	5, 237	1, 039
1954	45, 922	41, 125	13, 861	12, 398	2, 766	9, 538	621
1955	50, 137	45, 853	12, 130	13, 650	4, 841	11, 775	250
1956	50, 097	46, 894	11, 188	16, 711	3, 159	9, 675	1, 070

[1] Excludes U. S. S. R. and satellite countries.

TABLE 24.—*Exports of crocidolite from the Union of South Africa, by principal countries of destination, 1945–56, in short tons*

[Union of South Africa, Department of Mines]

Year	Production	Total exports	Exports to—					
			United States	United Kingdom	Continental Europe [1]	Canada	Australia	Latin America
1945	9, 671	8, 276	3, 100	4, 165	859	----------	----------	25
1946	8, 691	8, 504	3, 296	1, 834	3, 324	----------	----------	50
1947	9, 079	12, 733	5, 845	2, 410	3, 806	----------	----------	620
1948	10, 909	9, 636	3, 492	2, 734	2, 515	----------	94	526
1949	21, 180	19, 017	4, 377	3, 440	6, 105	665	1, 629	2, 090
1950	30, 598	24, 159	4, 881	5, 313	9, 093	605	1, 051	2, 332
1951	33, 659	34, 334	6, 162	6, 189	13, 010	957	2, 230	2, 999
1952	44, 735	36, 896	8, 220	10, 175	13, 780	1, 260	738	1, 634
1953	37, 707	25, 194	6, 925	4, 629	10, 387	18	----------	1, 045
1954	43, 746	37, 429	12, 133	7, 924	10, 882	1, 299	295	858
1955	48, 842	49, 976	14, 799	9, 504	16, 653	2, 100	108	1, 060
1956	62, 087	58, 198	19, 456	4, 229	23, 465	3, 001	210	1, 844

[1] Excludes U. S. S. R. and satellite countries.

CHAPTER 11. INDUSTRY STRUCTURE

GENERAL STRUCTURE

Most of the asbestos mined in the world is produced by companies of the vertical type; that is, they mine and mill the raw asbestos and fabricate finished asbestos products. The leading producer of this type is the Johns-Manville Corp. of New York, N. Y., the largest producer in the world. This company operates asbestos mines in Quebec and Ontario, Canada, and in Southern Rhodesia and is also a manufacturer of a full range of asbestos products. Other Quebec firms that mine the asbestos and are affiliated with fabricating companies are Bell Asbestos Mines, a subsidiary of Turner & Newall, Ltd., of Manchester, England; the Quebec Asbestos Corp., Ltd., owned by Philip Carey Manufacturing Co. of Cincinnati, Ohio; Nicolet Asbestos Mines, a subsidiary of Nicolet Industries, Inc., of New York, N. Y.; and Flintkote Mines, Ltd., owned by the Flintkote Co., also of New York City. National Gypsum Co. of Buffalo, N. Y., another manufacturer of asbestos products, has acquired an asbestos deposit in Quebec, Canada, and is taking active measures to establish mining and milling facilities. The largest producer in the United States, Vermont Asbestos Mines, is owned by the Ruberoid Co., of New York, N. Y., a manufacturer of asbestos products.

African asbestos is produced predominantly by vertical-type companies. The Shabani, Gath's & King Mines of Southern Rhodesia, and the Havelock mine of Swaziland are operated by Rhodesian General Asbestos Corp., Ltd., a subsidiary of Turner & Newall, Ltd., of Manchester, England, the largest manufacturer of asbestos products in Great Britain. The principal amosite and crocidolite mines of the Union of South Africa are controlled by Egnep, Ltd., Amosa, Ltd., and Cape Blue Mines, Ltd., subsidiaries of Cape Asbestos Co., of London, England, manufacturer of a wide range of asbestos products. Cyprus Asbestos Mines, Ltd., a producer of asbestos in Cyprus, is owned by Tunnel Portland Cement Co. of Thurrock, England.

The largest independent producers are Asbestos Corp., Ltd., and Johnson's Co. of Thetford Mines, Quebec, Canada. Other independents are Cassiar Asbestos Corp., Ltd., of Toronto, Canada, operating in British Columbia, Canada, and Australian Blue Asbestos, Ltd., of Western Australia. There are many other independent producers, but their output is a relatively small part of the total.

MARKETING PROBLEMS

Asbestos is used in so many diverse products that its markets are numerous and widespread and its marketing complex. With increasing diversity in use and great expansion in long-established uses, the consumption of asbestos has increased steadily, and its distribution has become more involved.

Some fiber is handled by agents or jobbers, but most of it is shipped direct from mine to consumer. Fiber length and quality are usually guaranteed. The larger manufacturers of asbestos products have their own testing machines and can check a producer's fiber classification. As most producers have their own fabricating plants, they are so familiar with manufacturing conditions that they can prepare a satisfactory asbestos fiber for each particular use. The larger independent companies are likewise prepared to meet the exacting requirements of consumers.

Asbestos is generally sold in 100-pound (occasionally in 125-pound) bags on a short-ton basis, bags included. Canadian quotations are f. o. b. mines. No market quotations are published for African fibers. Prices quoted to individual consumers are usually f. o. b. port of embarkation, such as Beira or Lourenço Marques. The weight of a given volume varies with fiber length; the longer fibers are bulkier than the shorts. The volume of a short ton ranges from 60 to 90 cubic feet. When pressure packing is employed, the volume is reduced to about 40 cubic feet. A minimum carload of fiber is 20 tons and of refuse and shorts, 30 tons. Settlements usually are made on the basis of 2-percent discount within 10 days or 30 days net.

Market requirements are based principally on fiber length, but strength, flexibility, color, chemical composition, and cleanliness may have an important bearing on use. The principal market outlets are indicated in the following brief summary of uses.

The longer and more valuable crudes and mill fibers are used in manufacturing woven

brake linings, electrical insulation products, textile fabrics, packings, and gaskets. The next lower grades are used in making asbestos-cement products, such as pipe for underground use, flue pipe, roofing shingles, lumber, and corrugated sheathing. Shorter fibers are used for paper and millboard manufacture and the lowest grades for heat-insulating cements, molded articles, and fillers in such products as asphalt tile. There are multitudes of other uses.

Most of the world supply of raw asbestos is in strong hands, and distribution is chiefly to asbestos-products manufacturers, most of whom are also strong, well-organized concerns.

NECESSITY FOR A BALANCED MARKET

In any asbestos deposit the length of the fiber varies considerably from point to point. Thus, when the total fiber recovered is classified into grades according to length, quite a number of grades may result. Canadian asbestos, for example, falls into seven major grades, ranging from the longest (Crude No. 1) to the very short fibers classified as "refuse and shorts." Most of the major groups are divided into several subgroups. The proportions falling in the several grades are fairly constant for any one deposit; and, as the miner has to take the rock as it comes, he has little control over the proportions of the various grades in his mill product. The demand for certain grades may be stronger than for others; during periods when the supply of most grades exceeds the demand, producers are obliged to stock up on the less salable types or sell them at a sacrifice. Success in an asbestos-mining enterprise under such conditions depends to some extent upon developing a balanced market that will absorb all grades, roughly in the proportion in which they are produced. During the period 1945–50, however, the demand for all grades exceeded supply, and marketing problems were simplified. When, under emergency conditions, abnormal demands for some grades develop, specifications should be modified as much as possible to ease the pressure on the critical grades. For certain uses grades are interchangeable to some extent, and the maximum use of the most plentiful grade is to be encouraged. Where grades are interchangeable, a price differential favoring the more abundant type will tend to keep demand in step with supply.

SALE AND DISTRIBUTION PRACTICES

Virtually all of the important asbestos deposits of the world, except those in the U. S. S. R., are within the British Commonwealth. Such deposits are those in Canada, Southern Rhodesia, Union of South Africa, Swaziland, Australia, and Cyprus. British Commonwealth needs naturally receive first attention, but large quantities of asbestos are shipped to outside countries. During World War II the Combined Raw Materials Board worked out plans for equitable distribution of Canadian and African asbestos between the United States and Great Britain, and the allocations were satisfactory. Since World War II the United States has been receiving a somewhat smaller proportion of the spinning grades than during the war; however, at all times it receives a large proportion of the shorter grades of Canadian fiber.

Imports of the strategic grades of low-iron chrysotile from Southern Rhodesia into the United States dropped alarmingly during the war and postwar years because of increasing British requirements. In 1954 and 1955 they declined to a mere fraction of prewar receipts but, fortunately, the discovery and development of similar fiber from British Columbia, Canada, has relieved the situation.

The major output of asbestos, both in Canada and Africa, is in the hands of strong, well-financed organizations. Canadian producers have an industry organization—the Quebec Miners' Association.

The distribution of Canadian asbestos is strongly influenced by individual producers. Most of the output is from captive mines whose products are used principally in the manufacturing plants of the mine owners, but surplus asbestos and the output of independent producers enter normal distribution channels. The handling of customers' orders has been arbitrary at times, but rejections of orders or allocations on a reduced basis were due in large measure to the shortage of supply that characterized the World War II and early postwar period. One authority in the asbestos-production field claimed in 1950 that world production of Group 4 asbestos (shingle stock) or its equivalent was less than two-thirds of that needed to supply plants in the world then using these grades, even when operating at 85 percent capacity. During this stringency of supply the establishment of new asbestos-products industries was difficult because new customers were at a disadvantage. Producers generally gave preference to old customers, and when supplies were short the newcomers received nothing.

The distribution of asbestos to continental Europe has fluctuated notably. Many asbestos-products plants were active before World War

II, but fiber resources were limited in European countries east of the Soviet Union. Their principal supplies were obtained from Canada and Southern Rhodesia, although substantial quantities were received from the Union of South Africa. During the war years 1940 to 1944 these industries were virtually paralyzed, as very little asbestos was received from any source. Postwar rehabilitation was rapid and, as it took place at a time of worldwide asbestos shortage, great difficulty was experienced in obtaining adequate asbestos supplies. Canada allocated available fibers on the basis of the prewar consumption of each plant. Obviously, new enterprises were at a decided disadvantage. When the supply situation improved, importations of asbestos increased greatly, exceeding 100,000 tons annually since 1950. Canada continues to be the leading supplier. The Union of South Africa has surpassed Rhodesia as the second important source.

The Latin American countries had very small asbestos-products-manufacturing facilities before World War II but have attained much greater importance during recent years. They require 30,000 to more than 45,000 tons of asbestos a year, a small part of which is derived from local mines. A large proportion of the requirements of raw asbestos is obtained from Canada. The Union of South Africa is becoming an increasingly important source, and smaller quantities are furnished by Rhodesian suppliers.

The Australian asbestos-products industry is gradually expanding. Fiber imports have ranged from 25,000 to more than 30,000 tons a year, chiefly from Canada and the Union of South Africa.

CHAPTER 12 PRICES

PRICE HISTORY OF CANADIAN AND UNITED STATES ASBESTOS

Prices of Canadian asbestos have fluctuated greatly since the close of World War I. In 1920 they skyrocketed to unprecedented heights, Crude No. 1 selling for more than $3,000 a ton. In 1921 the price dropped to less than half that amount, and by 1925 the highest grades were selling at only about one-eighth of the price received in 1920. Figure 7 shows the general trend of prices of Canadian milled fibers and shorts from 1929 to 1955. Milled fibers include Groups 3 to 5 of the Canadian classification—that is, spinning or textile, shingle, and paper fibers. Shorts are the fibers below Group 5.

Table 25 shows average prices of the better grades of Quebec asbestos from 1926 to 1956, f. o. b. mines. Except for the depression years in the early 1930's, the trend has been generally upward. Prices were 2½ to 3 times as high in 1956 as in 1926.

Asbestos from British Columbia, Canada, was first quoted in market reports in January 1954. Spinning fibers (3K) were priced at $460 and shingle grade (4K) at $185 per ton, f. o. b. Vancouver. In January 1956 the quotations included AAA, $750, and AC, $300 per ton. In April 1956 the quotation for shingle fiber (4K) was raised from $185 to $205 per ton.

TABLE 25.—*Price history of asbestos sold in Canada, in dollars per short ton, 1926–56* [1]

Year	Crude No. 1	Crude No. 2	Spinning fibers	Shingle fibers	Millboard and paper fibers
1926	$504. 16	$289. 58	$185. 00	$65. 00	$45. 00
1927	525. 00	312. 50	193. 75	70. 83	39. 17
1928	575. 00	375. 00	225. 00	80. 00	35. 00
1929	575. 00	375. 00	225. 00	80. 00	35. 00
1930	570. 83	362. 50	216. 67	78. 33	34. 17
1931	466. 67	241. 67	135. 00	65. 00	30. 00
1932	450. 00	200. 00	110. 00	60. 00	30. 00
1933	450. 00	200. 00	110. 00	60. 00	30. 00
1934	450. 00	200. 00	120. 00	60. 00	32. 50
1935	500. 00	200. 00	120. 00	60. 00	32. 50
1936	545. 83	200. 00	120. 00	60. 00	32. 50
1937	725. 00	250. 00	155. 00	66. 75	42. 50
1938	725. 00	250. 00	155. 00	67. 75	42. 50
1939	725. 00	250. 00	155. 00	67. 75	42. 50
1940	725. 00	250. 00	155. 00	71. 25	44. 75
1941	725. 00	250. 00	155. 00	71. 25	44. 75
1942	700. 00	275. 00	178. 75	72. 50	46. 75
1943	700. 00	275. 00	178. 75	72. 50	46. 75
1944	700. 00	275. 00	178. 75	72. 50	46. 75
1945	700. 00	275. 00	192. 00	76. 25	48. 50
1946	800. 00	385. 00	220. 50	88. 75	55. 75
1947	800. 00	423. 75	262. 50	104. 75	65. 75
1948	928. 00	447. 50	291. 25	106. 25	73. 75
1949	1, 005. 00	475. 00	328. 50	118. 25	83. 25
1950	1, 005. 00	475. 00	337. 50	130. 00	91. 00
1951	1, 300. 00	692. 50	362. 50	143. 00	107. 00
1952	1, 300. 00	750. 00	412. 50	175. 00	120. 00
1953	1, 300. 00	750. 00	412. 50	175. 00	120. 00
1954	1, 300. 00	750. 00	412. 50	175. 00	120. 00
1955	1, 300. 00	750. 00	412. 50	175. 00	120. 00
1956	1, 562. 50	925. 00	462. 50	197. 50	125. 00

[1] Figures for 1926–36 from Dominion Bureau of Statistics, yearly averages; for 1937–50 figures furnished by Canadian producers to Asbestos; averages of December range for each year.

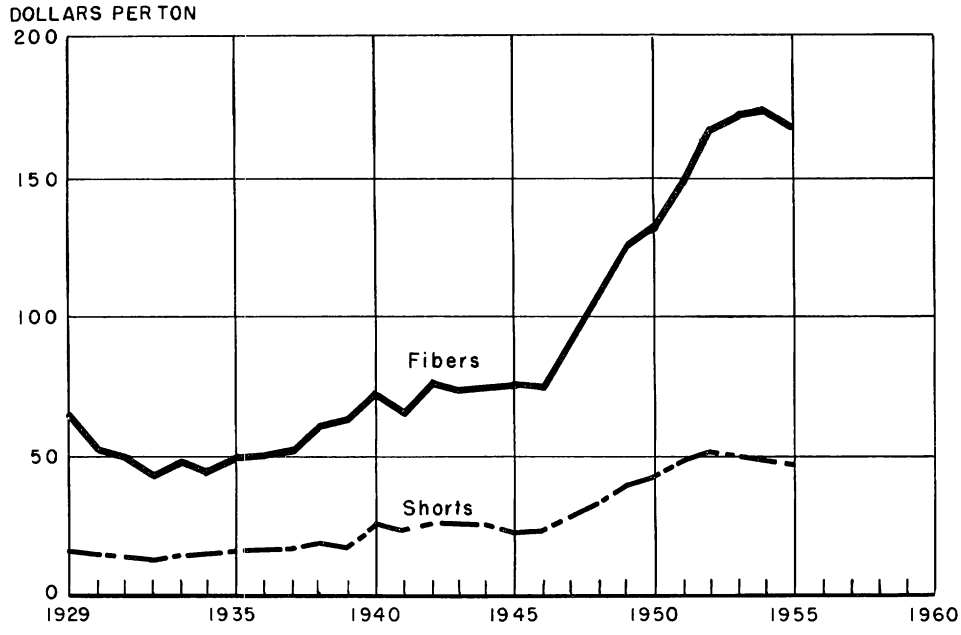

FIGURE 7.—Average Yearly Price of Canadian Asbestos Per Ton, 1929–55.

TABLE 26.—*Prices of Vermont asbestos, in dollars per short ton, 1931–56* [1]

Year	Spinning or filtering [2]	Shingle fiber	Paper fiber	Waste, stucco, or plaster [3]
1931		$50. 71	$35. 00	$20. 00
1932		42. 92	32. 92	20. 00
1933		42. 92	32. 71	20. 25
1934		45. 00	35. 00	23. 00
1935		46. 25	35. 00	23. 00
1936		47. 50	35. 00	23. 00
1937		57. 00	40. 00	25. 00
1938		57. 00	40. 00	25. 00
1939		57. 00	40. 00	25. 00
1940		57. 00	40. 00	25. 00
1941		58. 50	44. 00	30. 00
1942		64. 00	48. 50	33. 00
1943		64. 00	49. 00	33. 00
1944		64. 00	49. 00	33. 00
1945		64. 00	49. 00	33. 00
1946		79. 00	55. 75	39. 00
1947		97. 50	69. 00	48. 50
1948		102. 00	76. 75	56. 00
1949		117. 75	87. 75	59. 00
1950		135. 55	96. 50	64. 90
1951	$290. 75	148. 50	98. 25	71. 40
1952	334. 50	164. 50	121. 00	78. 00
1953	334. 50	164. 50	121. 00	78. 00
1954	334. 50	164. 50	120. 50	77. 00
1955	334. 50	164. 50	120. 50	77. 00
1956	368. 00	181. 00	129. 50	82. 00

[1] Quotations from Metal and Mineral Markets, 1931–40; since 1940 figures from Asbestos; average of December range for each year.
[2] Quoted only since June 1951.
[3] Classed as "cement stock" before 1941.

Table 26 shows prices of the better grades of Vermont asbestos from 1931 to 1956, f. o. b. Hyde Park or Morrisville, Vt. The upward movement was more rapid for the Vermont than for the Canadian fibers, the 1956 prices being 3½ to 4 times as high as those of 1931.

Arizona prices have been quoted in the open market only since early 1952; hence, they have a short price history. Soft Arizona asbestos is of excellent quality but is costly to mine, and the prices are so high that market resistance is strong. Prices, f. o. b. Globe, Ariz., are given in table 27.

TABLE 27.—*Prices of Arizona asbestos, in dollars per short ton, 1952–56* [1]

Year	Crude No. 1	Crude No. 2	Crude No. 3	Filter fiber
1952	$1, 350. 00	$950. 00	$412. 50	$450. 00
1953	1, 350. 00	950. 00	412. 50	437. 50
1954	[2] 1, 650. 00	[2] 1, 025. 00	[2] 475. 00	350. 00
	[3] 1, 350. 00	[3] 900. 00	[3] 400. 00	
1955	[2] 1, 625. 00	[2] 975. 00	[2] 425. 00	350. 00
	[3] 1, 350. 00	[3] 900. 00	[3] 400. 00	
1956	[2] 1, 625. 00	[2] 975. 00	[2] 425. 00	350. 00
	[3] 1, 350. 00	[3] 900. 00	[3] 400. 00	

[1] Quotations from Asbestos; average of December range for each year. First quotations, May 1952.
[2] Soft.
[3] Semisoft.

PRICES OF AFRICAN ASBESTOS

Prices of African asbestos fibers are not quoted in the open market; sales are generally made by direct negotiation with consumers. Approximate prices of the better grades of Rhodesian asbestos may be determined from

figures of quantities and declared values of imports. Table 28 shows such figures for Rhodesian C & G Nos. 1 and 2 for a 10-year period.

TABLE 28.—*Approximate prices* [1] *of Rhodesian asbestos, in dollars per short ton, 1946–56*

[Based on import data]

Year	Crude No. 1 [2]	Crude No. 2 [3]	Year	Crude No. 1 [2]	Crude No. 2 [3]
1946	$303.00	$238.00	1952	$729.00	$523.00
1947	339.00	218.00	1953	617.00	564.00
1948	382.00	187.00	1954	654.00	591.00
1949	433.00	295.00	1955	668.00	556.00
1950	421.00	395.00	1956	791.00	735.00
1951	503.00	421.00			

[1] Value at African port of shipment.
[2] Believed to be equivalent to C & G No. 1.
[3] Believed to be equivalent to C & G No. 2.

Import data for amosite and crocidolite show quantities and values of total imports but, as no detail by grades is given, prices by grades cannot be obtained from this source. Prices were quoted in E&MJ Metal and Mineral Markets from 1938 to 1941, but most of the grades then quoted are not recognized in the more recent classification.

The purchase price for amosite for the national stockpile in 1956 was $212 per ton for D3 and $168 per ton for DX and D11. These figures included ocean freight and $9 a ton for bags.

A figure quoted by one large consumer of crocidolite in 1956 was $200 to $220 per ton, f. o. b. shipping point, for the medium-length grades used in the manufacture of asbestos-cement pipe.

CHAPTER 13 USES AND REQUIREMENTS OF USE

GENERAL FEATURES

Asbestos has a great variety of uses. On the basis of use, it falls into two principal classes—spinning and nonspinning fiber. Spinning fiber comprises the longer grades of chrysotile and crocidolite; nonspinning fiber includes the shorter grades of these varieties and both the long and short grades of amosite, anthophyllite, and tremolite. For some of the uses the requirements are exacting. For others fibers of varying quality and character may be used. Grades are interchangeable to some extent, depending upon price and availability. For the purpose of this report emphasis is placed upon the spinning grades because they are of greatest strategic importance.

SPINNING FIBERS

TEXTILE USES

The long fibers (such as Canadian Groups 1, 2, and 3; Arizona Nos. 1 and 2 soft types; Rhodesian C & G 1, C & G 2, and to some extent, C & G 3 and VRA 2; Swaziland HVL1 and HVL2; the longer African and Australian blue fibers; and Russian C–1, C–2, and I–2) are adaptable for making textile products (such as cloth, yarn, tape, and rovings). The asbestos is spun and woven in much the same way as cotton, silk, wool, or rayon. The woven products are in turn manufactured into fire-resistant clothing, gloves for handling hot metals, mechanical packings and gaskets, brake linings, lagging cloth used in large quantities by the Navy, and for many other products.

An outstanding characteristic of asbestos fabrics is their fireproof quality. Also, they have superior heat-insulating properties but lower tensile strength than products made from other fibers. The low tensile strength is not due to lack of strength of the individual fibers, which generally are as strong or stronger than silk; it is due to their shortness (¼ to ¾ inch) and also to their lack of coherence. Because of the shortness and smoothness of the fibers, it is difficult to make a 100-percent asbestos cloth; only small quantities, applied to specialized uses, as in electrolytic cells, are now manufactured.

To give adequate strength to asbestos fabrics, cotton, rayon, or other organic fibers are blended with the asbestos in varying proportions. As the organic fiber content is increased, the strength increases, but the resistance to heat decreases. Accordingly, the proportion of organic fiber is adjusted to suit the conditions of end use. The higher the asbestos content, the more difficult the manufacturing processes, but these difficulties may be overcome to some extent by making a heavier cloth. Table 29 presents the standard classification of asbestos fabrics and gives the heat resistance of each grade (*2*).[1]

TABLE 29.—*Asbestos content and heat resistance of asbestos fabrics*

Grade	Asbestos content, percent	Maximum temperature for end use, °F.
Commercial	75 to but not including 80.	350–400
Underwriters'	80 to but not including 85.	400–450
A	85 to but not including 90.	450–550
AA	90 to but not including 95.	550–600
AAA	95 to but not including 99.	600–750
AAAA	99 to and including 100	750–900

Fabrics containing both asbestos and Fiberglas are also made. A cloth made in accordance with Federal Specification SS–C–466a consists of a 2-ply yarn composed of one 10-cut asbestos yarn and one continuous filament of glass.

Much research was devoted to asbestos textile manufacture in the late 1930's, and many improvements were made, particularly in the development of lighter and thinner textiles. Textiles weighing as little as 9 ounces per square yard can now be made. Firemen's suits formerly weighing 25 pounds or more can now be made weighing less than half that amount.

Many tests have been made to determine the tensile-strength characteristics of asbestos textiles at high temperatures. The mineral chrysotile when heated to about 1,500° F. inverts

[1] Italicized numbers in parentheses refer to items in the bibliography at the end of this chapter.

to a nonhydrous variety of magnesium silicate, which exhibits the olivine structure, and the original fibrous habit is ostensibly destroyed. However, it has been found that when high-quality asbestos textiles are subjected to a sensible tensile stress at temperatures ranging from 1,500° to 2,500° F. they may exhibit remarkable load-bearing properties without failure. Much information on the qualities and uses of asbestos in textiles has been published (*3*).

NONTEXTILE USES OF LONG FIBERS

Spinning-grade fibers are used also for certain nonspinning uses, such as compressed sheet packings and gaskets. Another important nontextile use is in the manufacture of low-iron spinning-grade fibers into strong asbestos paper known as Pyrotex. When used in tape form for wrapping electric wires, it is said to make a covering superior to that obtained by wrapping the wire with asbestos roving. Because of their superior electrical resistance, Rhodesian C & G Nos. 1 and 2, Arizona Nos. 1 and 2 (soft), and Cassiar 3K and AAA are used for electric-cable coverings and for primary electrical insulation on magnet wire. Long fiber in the form of rovings is used as cable filler (material used to fill in spaces in groups of insulated cables on shipboard). Long fibers are also used in making compressed sheet packings of high strength for the high steam pressures now in general use. A small tonnage of the longer Vermont fibers is used for filters in electrochemical cells.

FRICTION MATERIALS

A very important use of asbestos fabrics is for the manufacture of friction materials. Such materials are brought into contact with moving members (brakedrums, flywheels, or other rotating equipment) in such a manner as to retard the free motion of the rotating part. The effect of the friction is to convert the kinetic energy of the moving member into heat. The best braking materials are those that convert the kinetic energy into heat the most rapidly and then dissipate the heat as quickly as possible. The friction material must also be heat-resistant and nonflammable. Asbestos is regarded as indispensable in most types of friction materials.

Brake linings are of three principal types. In early days virtually all brakebands were of woven asbestos fabrics, but at the close of World War I the molded type was invented and is now used extensively. Molded linings are of several types, but all consist primarily of asbestos fibers bonded with an organic matrix. Metallic reinforcing, such as brass, zinc, or lead, is commonly added, and the shaped products are thoroughly cured. The asbestos required is chrysotile ranging in length from fibers just under spinning grades to those as short as 7F in the Canadian classification. A preponderance of the shorter fibers is used because of the price advantage.

A second type of friction materials is the rubberized fabric lining consisting of multilayer woven structures held together with wire-inserted asbestos yarn. The asbestos is of spinning grade.

The third type is the woven brake lining made in roll form in a variety of widths and thicknesses. It permits a wide range of service with a relatively small inventory. Its general utility popularizes it, particularly in the industrial field. As such linings are woven fabrics, chrysotile of spinning grades is required.

The evolution of friction materials from the all-woven to a wide use of molded types has had a profound effect on the asbestos industry in that it has permitted a wide substitution of shorter fibers for the spinning grades. This is a fortunate circumstance because spinning fibers constitute a relatively small proportion of the asbestos recovered.

Friction materials are of primary strategic importance because they are essential to all types of mobile military equipment, as well as many kinds of industrial and oil-well machinery.

MISCELLANEOUS NONTEXTILE USES

Fibers that are somewhat shorter, such as Canadian Group 4 (to some extent, Groups 5 and 6) and Grade MS of Cape Blue, are used widely for asbestos-cement products. These consist of about 80 percent portland cement and 20 percent asbestos fiber. Roofing shingles, flat and corrugated siding, and asbestos-cement water, gas, oil, or sewer pipe are also well-known products.

Canadian Groups 4 and 5 and African amosite are used extensively in making 85-percent magnesia block and pipe insulation. These products consist of about 85 percent basic magnesium carbonate and about 15 percent asbestos.

Canadian Group 5 is suitable for asbestos paper and millboard manufacture. Such products are made on standard papermaking machines. An important use of asbestos paper is for making the so-called air-cell pipe covering.

The shortest fibers are used for boiler and roofing cements and molded plastics, as fillers in asphalt floor tile, and for various other products. It has been estimated that as much as 14,000 tons of asbestos fibers, ranging from Group 4 to floats, are used annually in the plastics industry (*5*).

INTERCHANGEABILITY OF GRADES

As pointed out elsewhere in this report, the asbestos miner has no control over the percentage of the various grades in his rock. He must mine the rock as he finds it and extract from it all salable grades present, the proportions of which are fixed in nature. It is inevitable that some grades are more in demand than others, and the most desirable grades may be those that are in short supply. Thus, shortages may develop for the preferred grades, and at times stocks of the less marketable fibers may accumulate.

To meet this condition, a great deal of research has been devoted to substitution of the more abundant grades for those that are less plentiful but more in demand. For example, much work has been done in trying to adapt Canadian Group 6 fibers for use in asbestos-cement products for which Groups 4 or 5 are preferred. It was found that a thorough fiberization permitting intimate contact between cement and fiber made it possible to use the Group 6 short fibers successfully. Similar problems are being investigated constantly.

USES OF AMOSITE

The principal use of amosite is as felted insulation in blanket form for high-temperature services up to 900° F. A loosely compacted form is applied as a covering for marine turbines, jet engines, and similar applications. Amosite is especially well adapted for use as an insulator, because it does not pack under vibration, and if it becomes wet it dries without detriment to the product. Amosite insulation mattresses weigh only 9½ pounds per cubic foot; if made of chrysotile, they would weigh 50 percent more and therefore would not conform with Navy specifications. For felted insulation the long-fiber grades such as D–3 are preferred, although DX and D 11 are also used.

Another important use of amosite is as a constituent of 85-percent magnesia and similar types of insulation. For such application the shorter grades such as W3 and K3 (chiefly the grades just below spinning length) are generally employed for blending with Canadian chrysotile. The product consists essentially of 15 percent asbestos and 85 percent basic magnesium carbonate. The asbestos content used by some manufacturers is 40 to 60 percent amosite and the remainder Canadian chrysotile of Groups 4 or 5.

One manufacturer finds it advantageous to use higher percentages of amphibole fibers. At this plant the asbestos content consists of 8 percent short blue fiber (crocidolite), 8 percent Canadian 4K chrysotile, 56 percent W3 amosite, and 28 percent K3 amosite. Hence, 84 percent of the asbestos used is amosite and only 8 percent chrysotile. The preference for the amosite and blue fiber is based largely on the fact that they are harsher and perform better in the molding process than the soft, silky Canadian fibers. Another reason is the lower cost of the amosite compared with Canadian fibers of equivalent length. Some years ago Canadian 3T was used, but it became too expensive.

A product consisting almost entirely of amosite with a binder is used for certain special applications where the temperature range is 550° to 750° F. Another product containing not more than 50 percent amosite and the remainder diatomite and other fillers is said to be serviceable where the temperatures reach 1,200° F.

Most of the manufacturers of 85-percent magnesia and at least two other companies make calcium-silicate insulation. One method of manufacture is to calcine diatomite with lime in an autoclave. To this product is added about 18 percent asbestos and 11 percent magnesia. The asbestos used by one company is entirely amosite, ⅔ of which is W3 and ⅓ K3. Calcium-silicate insulation is said to resist temperatures of 1,050° to 1,200° F. Its price range is comparable with that of 85-percent magnesia, which it replaces to some extent.

The shorter grades of amosite constitute 10 to 15 percent of another insulation product—diatomaceous silica—which is employed at about the same temperature range as calcium silicate.

An important special use for long-fiber amosite is for insulating underground pipes. Its quality of moisture resistance prevents or reduces corrosion and electrolytic reaction detrimental to the pipes.

The medium-length and shorter grades of amosite are also used extensively as the fiber constituents of a light weight, fireproof, marine partition board. If chrysotile were substituted for amosite, the product would be considerably heavier per unit volume. Marine board is used extensively by the Coast Guard and Merchant Marine but not by the Navy, which employs steel bulkhead construction.

USES OF CROCIDOLITE

Crocidolite (blue asbestos) is characterized by high tensile strength, acid resistance, and harshness in wet mix. The longer fibers are used for spinning and weaving. It is reported that during Warld War II crocidolite yarn was manufactured on a small scale in the United States and was woven into fabrics for making chemically resistant packings, but according to current information no spinning or weaving of

463673°—59——5

blue fiber is done in the United States at present. These processes are conducted chiefly if not exclusively in the United Kingdom. J. W. Roberts, Ltd., at Armley, Leeds, a subsidiary of Turner & Newall, specializes in woven products of blue fiber, particularly mattresses for locomotive-boiler lagging. Blue-asbestos fabrics for acid-resistant packings or for other uses in the United States are now imported. Canadian fiber cannot be substituted for blue asbestos in such packings.

The principal use of African and Australian crocidolite is as a fiber additive to cement in making asbestos-cement pipe. In this process the asbestos and other ingredients are agitated in water. The solids are drawn from the slurry on a fabric belt and deposited on a rotating mandril. A great advantage in using crocidolite is its property of free and rapid filtration, which reduces greatly the drying time and therefore speeds up the manufacturing process. The quality of filterability of asbestos fibers has been described (*1*). Crocidolite also gives high strength to the pipe. In current practice, a blend of crocidolite and Group 4 chrysotile is used. If chrysotile alone were used, the rate of manufacture would be greatly retarded and plant capacity reduced accordingly.

Free filterability is a property of the harsh fibers as contrasted to the slow filter action of fibers that are soft, silky, and slimy. Several years of research have disclosed that the quality of harshness can be superinduced by a flash-heating process applied to soft and silky fibers (*4*). Such processed chrysotile may, in time, take the place of imported crocidolite in the manufacture of asbestos-cement pipe. Blue fiber is used to some extent as a constituent of 85-percent magnesia insulation.

Long blue fibers are exceptionally well adapted for gas filters. Bolivian blue is preferred for this use. This is the only type of blue fiber that was regarded as strategic during World War II and the early postwar period. Very little if any Bolivian blue is used in the ordinary crocidolite applications.

DISTRIBUTION OF ASBESTOS ACCORDING TO USE

Much has been written on the multitudinous uses of asbestos, but little information is available on the quantities or proportions that are applied to the several uses. The classification by use, such as spinning fibers, cement stock, paper stock, and magnesia and compressed sheet fibers, would seem to indicate distribution by use, but mixed grades are used so extensively that such a classification affords no criterion of the actual quantities applied to each use. Data on the grades, qualities, and quantities of fiber used, for example, in asbestos-cement pipe, 85-percent magnesia, or brakeband linings are not easily available.

For the purpose of this report, the distribution according to use of the strategic grades is of paramount importance. Fortunately, a record of allocations by end use of strategic asbestos during World War II was made by the War Production Board, and these records furnish a basis for tables 30 and 31.

Total allocations indicated in tables 30 and 31 may be summarized as follows:

	Short tons
Canadian chrysotile spinning fibers, textile uses	15, 800
Canadian chrysotile spinning fibers, nontextile uses	3, 000
Total Canadian spinning fibers	18, 800
Rhodesian chrysotile C & G Nos. 1 and 2	5, 800
Amosite	22, 100
Total strategic grades	46, 700

In table 32 the allocations according to end use are compared with actual end use during 1944, also compiled by the WPB.

TABLE 30.—*Allocation of strategic grades of asbestos in 1944, by end use,*[1] *textiles uses*

Product	Textiles from Canadian fiber, short tons	Textiles from Rhodesian C & G Nos. 1 and 2, short tons
Mechanical packings and gaskets	4, 300	----------
Asbestos safety clothing	820	----------
Woven brake linings and clutch facings	6, 700	----------
Navy lagging cloth	3, 000	----------
Navy cable filler and conductor insulation [2]	4, 000	4, 000
Aircraft	675	----------
Navy and aircraft hose	135	----------
Laminated plastics	----------	630
Electrical equipment, new, and maintenance	----------	1, 500
Maintenance and repair, other than electrical	1, 000	----------
Asbestos yarn in flexible metal tubing	220	----------
Miscellaneous textile uses	1, 600	----------
Total textiles	22, 450	6, 130
Asbestos content of textiles [3]	19, 000	5, 800
Deduct C & G No. 3 substituted for Canadian [4]	3, 200	----------
Net allocation of Canadian	15, 800	----------

[1] Compiled from records of WPB.
[2] The filler was probably Canadian fiber; the conductor insulation C & G Nos. 1 and 2; hence, one-half of total is arbitrarily assigned to each.
[3] Assuming that 85 percent of textiles consists of asbestos fibers.
[4] WPB Conservation Order M-79, as amended October 1943, required that 1 ton of Rhodesian C & G No. 3 be used with every 5 tons of Canadian 3R used in textile manufacture.

TABLE 31.—*Allocation of strategic grades of asbestos in 1944, by end use, nontextile uses* [1]

Product	Canadian spinning grades, short tons	African amosite, short tons
Compressed sheet packing	[2] 3,000 (3R and 3T)	
Molded amosite insulation		5,500
85-percent magnesia and other high-temperature insulation		4,800
Navy felt insulation (lightweight blankets)		8,700
Marine insulating board		2,400
Sprayed insulation [3]		700
Total	3,000	22,100

[1] Compiled from records of WPB.
[2] Omitting 650 tons 3Z.
[3] Sprayed insulation also required 500 tons of Rhodesian C & G No. 3.

TABLE 32.—*Correlation of allocation and actual use of strategic grades of asbestos during 1944*

Kind of asbestos	Allocations, short tons	Actual consumption, short tons
Canadian Groups 1, 2, and 3	18,800	[1] 18,122
Rhodesian C & G Nos. 1 and 2	5,800	6,646
Amosite	22,100	15,609

[1] Canadian Groups 1, 2, and 3, except 3Z.

This table indicates a fair correlation, except for amosite, in which instance actual use fell considerably below the allocations. However, the proportional distribution by use is probably fairly accurate.

On the basis of WPB figures as given in tables 30 and 31, the strategic grades of asbestos were distributed by use in 1944 approximately as indicated in table 33.

These proportions are to be regarded as approximations only. They might vary considerably from year to year, depending upon circumstances, but at least they present a use pattern that existed under the war emergency. Under present conditions the allocation by use for Canadian spinning fibers would probably follow aproximately the same pattern as that given in the preceding table, but the Rhodesian proportions might change considerably because the asbestos from British Columbia, Canada, may be substituted for the Rhodesian. Sprayed insulation is a product that might be eliminated from the list of uses requiring amosite. Very little of this type of insulation is now used by the Navy, and when used by either the Navy or Maritime Commission Fiberglas may be employed in place of asbestos.

TABLE 33.—*Allocation of asbestos, by end use, in 1944*

Types of fibers	Percent
Canadian spinning fibers:	
Woven brake linings and clutch facings	30
Mechanical packings and gaskets	19
Navy cable filler	18
Navy lagging cloth	13
Maintenance and repair other than electrical	4
Asbestos safety clothing	4
Aircraft	3
Asbestos yarn in flexible metal tubing	1
Miscellaneous textile uses	8
	100
Rhodesian C and G Nos. 1 and 2:	
Navy cable insulation	65
Electrical equipment, new, and maintenance	25
Laminated plastics	10
	100
African amosite:	
Navy felt insulation (lightweight blankets)	39
Molded amosite insulation	25
85-percent magnesia and other high-temperature insulation	22
Marine insulating board	11
Sprayed insulation	3
	100

DIRECTORY OF ASBESTOS PRODUCTS MANUFACTURERS

There are over 100 manufacturers of asbestos products in the United States. Only the larger manufacturers of products that may be regarded as of greatest strategic importance are listed here.

Asbestos textile products

	Plant location
American Asbestos Textile Corp.	Norristown, Pa.
Asbestos Textile Co., Inc	North Brookfield, Mass.
Asten Hill Manufacturing Co	Philadelphia, Pa.
Carolina Asbestos Co	Davidson, N. C.
Garlock Packing Co	Palmyra, N. Y.
Johns-Manville Sales Corp	Manville, N. J.
Keasbey & Mattison Co	Meredith, N. H.
Raybestos-Manhattan, Inc	Manheim, Pa.
	North Charleston, S. C.

Asbestos textile products—Continued

	Plant location
Russell Manufacturing Co	Middletown, Conn.
Southern Asbestos Co	Charlotte, N. C.
Tallman-McCluskey Fabrics Co.	Kirkwood, Mo.
Union Asbestos & Rubber Co	Marshville, N. C.
U. S. Rubber Co	Hogansville, Ga.

Asbestos packings and gaskets

American Asbestos Textile Corp.	Norristown, Pa.
Atlas Asbestos Co	North Wales, Pa.
Colt's Patent Fire Arms Co	Hartford, Conn.
Crane Packing Co	Chicago, Ill.
Detroit Gasket & Manufacturing Co.	Detroit, Mich.
Garlock Packing Co	Palmyra, N. Y.
Goodyear Tire & Rubber Co	Akron, Ohio
Green Tweed & Co	North Wales, Pa.
Johns-Manville Products Corp.	Manville, N. J. Waukegan, Ill.
Keasbey & Mattison Co	Ambler, Pa.
Philip Carey Manufacturing Co.	Cincinnati, Ohio
Raybestos-Manhattan, Inc	Manheim, Pa. Stratford, Conn. North Charleston, S. C.
Rubber & Asbestos Corp	Bloomfield, N. J.
Union Asbestos & Rubber Co	Marshville, N. C.

85-percent magnesia insulation

Ehret Magnesia Co	Valley Forge, Pa.
Fiberboard Paper Products Corp.	Emeryville, Calif.
Johns-Manville Products Corp.	Waukegan, Ill.
Keasbey & Mattison Co	Ambler, Pa.
Mundet Cork Corp	North Bergen, N. J.
Philip Carey Manufacturing Co.	Plymouth Meeting, Pa.

Molded brake linings

American Brake Shoe Co	Detroit, Mich. Winchester, Va.
Asbestos Manufacturing Co	Huntington, Ind.
Asbestos Textile Co	Chicago, Ill.
Gatke Corp	Do.

Molded brake linings—Continued

	Plant location
General Motors Corp	Dayton, Ohio
Johns-Manville Products Corp.	Waukegan, Ill.
Lasko Brake Products Corp	Oakland, Calif.
L. J. Miley Co. of Indiana	North Manchester, Ind.
Palmer Asbestos & Rubber Co	Chicago, Ill.
Raybestos-Manhattan, Inc	Manheim, Pa. Passaic, N. J. Stratford, Conn.
Russell Manufacturing Co	Middletown, Conn.
Thermoid Co	Trenton, N. J.

FABRICATION OF ASBESTOS PRODUCTS

Table 34 shows the principal asbestos products manufactured and their value by groups. Although most of these materials are consumed in the United States, the export trade (table 35) is significant.

TABLE 34.—*Value of shipments of asbestos products in the United States, 1954–55*

[U. S. Department of Commerce, Bureau of the Census]

Product	1954	1955
Asbestos textiles	$28, 535, 000	$32, 863, 000
Asbestos friction materials	73, 852, 000	96, 969, 000
Asphalt floor tile	90, 672, 000	99, 130, 000
Asbestos-cement shingles and clapboard	53, 263, 000	57, 112, 000
Asbestos-cement flat and corrugated sheets and wallboard	21, 766, 000	22, 805, 000
Other asbestos-cement products	53, 904, 000	65, 729, 000
Not specified by kind	1, 101, 000	1, 101, 000
Total	323, 093, 000	375, 709, 000

TABLE 35.—*Value of asbestos products exported from the United States, 1951–56*

[U. S. Department of Commerce, Bureau of the Census]

Product	1951	1952	1953	1954	1955	1956
Brake linings and blocks	$7, 359, 936	$5, 537, 071	$4, 268, 736	$4, 620, 416	$4, 995, 315	$5, 380, 551
Clutch facings and linings	935, 913	996, 080	900, 725	879, 450	927, 597	910, 820
Construction materials	2, 526, 784	2, 822, 802	2, 457, 973	2, 521, 652	3, 055, 227	3, 749, 659
Pipe covering and cement	453, 367	655, 254	592, 054	635, 224	806, 976	737, 666
Textiles, yarn, and packing	2, 391, 982	2, 428, 123	2, 013, 852	2, 434, 904	2, 605, 656	2, 785, 596
Other	652, 407	588, 409	382, 492	383, 436	430, 146	607, 017
Total	14, 320, 389	13, 027, 739	10, 615, 832	11, 475, 082	12, 820, 917	14, 171, 309

The fire resistance of asbestos, combined with its fibrous character, adapts it admirably for the manufacture of flexible, heat-insulating products, packing, and gaskets for use in places where articles containing fibers of animal or vegetable origin would be less enduring and would create fire hazards. The addition of asbestos to various fireproof building materials

lends strength and flexibility; furthermore, manufacturers of many miscellaneous products find that asbestos, when used as an ingredient, imparts superior qualities.

The manufacture of asbestos products involves many diversified and complex processes. Only a brief summary of the principal operations is presented herein because this report deals primarily with raw materials.

FABRICS

The processes involved in manufacturing asbestos fabrics, in general, follow those employed in spinning and weaving cotton, wool, silk, or rayon. The asbestos fibers are generally shorter than those of organic origin, but they differ from them mainly in the nature of the fiber surface. Wool fibers are covered with scaly bands known as imbrications, and cotton fibers are rough, twisted, and irregular; but asbestos fibers have no nodules, twists, or irregularities on the surface that permit one fiber to cling to another. This smooth, slippery condition creates such difficulties in spinning that the manufacture of a 100-percent asbestos yarn is slow and costly. For this reason, some other fiber, such as cotton or rayon, is added to act as a vehicle to carry the asbestos through the spinning process. The proportion of organic fiber added varies with the character of the asbestos and the requirements of the finished product.

The preliminary treatment of asbestos fibers before they are made into fabrics has been described under Milling Methods. The prepared asbestos fibers, with the addition of the necessary quantity of cotton or rayon, are mixed thoroughly with revolving beaters. Some manufacturers, however, introduce the organic material at a later stage.

Carding is the next step in the manufacturing process. Leather-covered carding rolls are fitted with sharp steel bristles. They comb the fibers into parallel position and remove short fibers, bits of rock, and dust. After passing a succession of carding rolls, the fiber emerges as a loose blanket, which may be turned 90° and passed through another carding machine. The blanket is then separated into rovings, which are gathered in a roll on a Jack spool and spun into yarn as in ordinary textile mills.

Yarns are made in various sizes; a "5-cut" yarn measures about 500 yards to the pound and a "30-cut" yarn about 3,000 yards. Yarn is twisted exceptionally hard for thread used in sewing theater curtains, asbestos clothing, or other asbestos fabrics. The spindles of single-ply yarn are transferred to twisting machines and twisted into 2- or 3-ply yarn, which is wound on spools. Asbestos cord and rope are made by twisting several strands together.

When yarn is to be used for making brake-bands or packings, it usually is reinforced with fine copper, brass, or lead wire. Thus, for brakebands 3 strands of single-ply yarn and 2 strands of brass wire of gage Nos. 0.006, 0.007, or 0.008 may be twisted together. For packings a single lead wire or 1 to 3 strands of brass wire are twisted with 2 or 3 strands of asbestos yarn. Products prepared in this way are known as "metallic yarns."

Weaving into fabrics follows well-known processes employed in cotton or woolen textile mills. Asbestos cloth is used for lagging on shipboard, for theater curtains, fireproof clothing, and many other textile products. Single-ply asbestos yarn is braided into tape. Metallic yarn containing about 16 percent cotton is woven into strips for brakeband linings. Standard widths range from 1 inch to 6 inches and standard thicknesses from $\frac{1}{8}$ to $\frac{3}{8}$ inch. They are processed with rubber and other ingredients.

Asbestos packings and gaskets are made in various ways. Asbestos yarn may be twisted or braided into valve-stem packings, the braided forms may be compressed into rings, and asbestos cloth may be cut into gaskets or other desired forms. They may be coated or impregnated with rubber compounds, oil, or flake graphite. Metallic yarn is used in some packings. Further detail on the use of asbestos in fabrics has been published (*3*).

SHINGLES AND LUMBER

Asbestos building materials, such as roofing shingles and siding, consist of portland cement, about 15 percent of shingle-grade asbestos, and coloring matter as desired. When manufactured by the so-called dry process, the raw materials are mixed dry in a cylindrical mixer provided with paddles. The mixture is spread evenly on an 18-inch conveyor belt and sprayed with water at 180° F. Rollers compress it to the required thickness, and a rotary cutter separates it into individual shingles or slabs. Shingles or slabs, separated by steel pallets, are piled in stacks and squeezed in hydraulic presses at a pressure of 20,000 pounds per square inch; they are then cured and trimmed. Shingles are punched for nailing.

Such products are also made by a wet method known as the laminated or "Hatschek" process, first used in Austria and named after the inventor. Cement, shingle-grade asbestos, and coloring matter are mixed with a large quantity of water, agitated thoroughly with a beater, and pumped to the Hatschek machine, which builds up sheets in successive laminations to the desired thickness. Portland cement thus mixed with a large quantity of water does not lose its property of setting at a later stage when

most of the water is removed. Steam curing hastens the setting. For shingle manufacture thin sheets are made. Lumber consists of thicker and larger sheets. Corrugated sheets are made by crimping flat sheets.

PAPER AND MILLBOARD

Asbestos of paper-stock grade is mixed with water to make a thin slurry, which is agitated thoroughly in 5-foot drums covered with slats. Starch, flour or size, and sodium silicate derived partly from the liquid squeezed out of the paper at a later stage are added to the slurry. The material is conveyed to a paper machine similar to that used in manufacturing paper from rags or wood pulp. Particles of stone or other impurities are removed with sand-catching equipment. The sheets of paper pass between rollers to remove most of the water, are dried on hot cylinders, and are wound in rolls. If a two-ply paper is desired, one side of a sheet is coated lightly with sodium silicate, and the two sheets are run together over several hot rolls. Crimped paper is made by passing the sheets over corrugated rolls. In the manufacture of air-cell pipe covering, the tips of the corrugations are coated with sodium silicate, and a flat sheet is added. When the process is repeated a 2-ply, 3-ply, or thicker air-cell covering may be made.

Millboard is generally classed with paper because it is manufactured by the same process. It is simply a thick paper; it bears the same relation to asbestos paper that cardboard bears to wrapping paper. The board usually is built up on rectangular screens rather than on drums.

The manufacture of millboard gaskets is an exacting process. The high speeds, temperatures, and pressures attained by modern automobiles and other machinery demand precise qualities in the millboard used. It must have uniform density and high strength. Variations in thickness of the sheet must not exceed 0.002 inch.

ASBESTOS-CEMENT PIPE

The most widely used method of making asbestos-cement pipe is a modification of the laminated process used for making shingles and lumber. Portland cement and 15 or 20 percent of asbestos and other ingredients are agitated in water. The solids are drawn from the slurry on a fabric belt and deposited in successive layers on a rotating mandril, the diameter of which will be the inside diameter of the finished pipe. When the desired thickness is reached, the pipe is removed from the mandril, trimmed, dried, and cured under steam pressure.

The time required for manufacture is governed largely by the drying period. The use of asbestos having free and rapid filterability will greatly speed up the process. For this reason, South African and Australian crocidolite are preferred types of asbestos, as they possess superior rapid-filtering qualities. Asbestos-cement pipes are used extensively because they resist corrosion, compression, traction, or shock. An admixture of sulfur and asbestos is used for making chemically resistant pipes, or linings for steel pipes. The sulfur is highly resistant to chemical action, and the asbestos supplies the desired strength.

ASBESTOS-MAGNESIA INSULATION

Magnesium carbonate in a light fluffy form combined with asbestos makes an effective heat insulator for steam pipes. The magnesium carbonate used with the asbestos is chiefly of seawater origin from the gulf coast. Magnesia is also derived from dolomite, which is a double carbonate of calcium and magnesium. By a complex chemical process the magnesia is separated in the form of a light, fine-grained, basic magnesium carbonate. This product is also derived from bitterns (the residual brines at saltworks). A California plant uses a hydrous-magnesia chemical-plant sludge.

About 15 percent by weight of asbestos is added to the magnesium carbonate and the mixture agitated thoroughly in water. The solids are collected on a filter press and cast in the form of pipe and block insulation. Such products are designated "85-percent magnesia."

The asbestos used is commonly a mixture of Canadian chrysotile and amosite. The proportions may be 40 to 60 percent amosite and the remainder chrysotile of Canadian Group 4 or 5. When fibers of fair length are used, the proportion of fiber possibly may be reduced to as low as 11 percent. If shorter fibers are used, the percentage must be increased, possibly to more than 15 percent. The shorter the fibers, the greater the breakage loss in the finished product. Long fibers of amosite cost less than Canadian fibers of similar length.

HIGH-TEMPERATURE INSULATION

Special products consisting almost entirely of amosite will resist temperatures of 550° to 900° F. Higher temperature insulating products, such as calcium silicate and diatomaceous silica, are said to withstand temperatures of 1,050° to 1,200° F. They contain small quantities of asbestos (usually amosite), possibly up to 15 percent, that are added to serve as binders.

Fibrous products are now made that will resist temperatures above 2,000° F., but they contain no asbestos.

COMPOUNDED PACKINGS

Packings are used to prevent the escape of steam or compressed air around the moving parts of machinery. Compounded packings are made of asbestos mixed with fillers and binders. Fillers commonly used are clay, barite, magnesia, iron oxide, graphite, and cellulose. The binding materials are gums, resins, lac, or rubber dissolved in a volatile solvent. High-grade packings contain about 2 parts of asbestos to 1 part of filler. The mixture is molded into sheets of any desired thickness and may be reinforced with copper or lead foil.

ASBESTOS CEMENT

A type of boiler insulation consists chiefly of short-fiber asbestos; a binder such as plastic clay is used. The ingredients are mixed with water to form a paste, which is applied with a trowel. The fibers employed for such cements are the shortest and lowest priced grades.

MOLDED ARTICLES

Increasing quantities of short-fiber asbestos are used in manufacturing laminated plastics, electrical fittings, and household appliances. Mixtures of asbestos, oil, gilsonite, resins, cement, and other ingredients are ground and compressed in molds. Some of them are baked in ovens and then polished and lacquered. Gilsonite imparts a brown color; if gray is desired, the gilsonite is omitted. Short-fiber asbestos mixed with synthetic resins, vegetable oils, or other ingredients is compressed in molds to make so-called asphalt floor tile. Such tiles may contain 40 percent or more of short-fiber asbestos; the industry has grown to such proportions that it has created a market for large quantities of the shorter fibers that formerly were discarded as waste.

NONCORROSIVE FILTERS

High-grade tremolite and anthophyllite varieties of amphibole asbestos are more resistant to chemical action than chrysotile. Suitable fibers of these varieties are washed, thoroughly fiberized, and acid-treated to remove soluble impurities. The prepared fibers are used in Gooch crucibles or for other filtering processes employing strong acids or alkalies.

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CHAPTER 14. SUBSTITUTES FOR ASBESTOS

INCENTIVES FOR SUBSTITUTE RESEARCH

Shortage is a strong incentive for seeking substitutes. The general worldwide shortage of asbestos that existed during World War II and the early postwar period led to wide research and experimentation on materials that might take its place. Germany's virtual isolation from sources of asbestos prompted testing in that country of such possible substitutes as glass wool, steel wool, iron wire, synthetic rubber, organic plastics, cellulose, and treated paper. Work on substitutes also was conducted with considerably intensity in the United States and several other countries.

Expanded production and a reduction in military requirements for asbestos by 1954 had brought supply and demand into approximate balance, and the progressive relief from shortages that characterized the years 1952 to 1954 led to a relaxation in efforts to find substitute products. Accordingly, there are few recent developments in this field. However, the major dependence of the United States upon foreign asbestos supplies, even though they are largely controlled by a traditionally friendly nearby nation, is a situation that demands constant awareness of the possibilities for substitution under emergency conditions. The merits of possible alternate products are therefore considered here.

SODA-LIME-SILICA GLASS FIBERS AND MINERAL WOOL

Glass and related fibers are manufactured in two basic forms—a short-fiber woollike material and a continuous filament. Rock wool, glass wool, and slag wool are used primarily as lightweight thermal insulation, such as house fill. Such applications, in general, are not substitutes for asbestos. Glass filaments made by more refined processes involving the use of platinum dies are of high quality and uniform size. Some of them are less than one-half micron in diameter and are adaptable to highly specialized uses, such as weaving into fabrics. Such filaments are used as substitutes for asbestos in some applications.

Glass fibers will not burn, but they will soften and coalesce when the temperature reaches a certain point, which varies according to the composition of the glass. The heat and moisture resistance of the glass filaments is limited by the organic film applied to the individual fibers during manufacture to improve processing and reduce breakage during subsequent plying and weaving operations. Without such a coating, the fibers are relatively brittle and self-abrasive. For high-temperature applications most of the organic film is removed by heating for a short time at about 300° C. (572° F.). The fibers are then recoated with a material suitable for the operating temperature. When glass filaments are used without such coatings, their properties are impaired to some extent, but they will withstand temperatures up to 1,200° F., which is an advantage in certain applications.

Normally, glass resists weathering very well. Windowpanes generally show no weathering effects, even after many decades of use. However, the surface area per unit volume of very fine glass fibers is so great that exposure to water vapor results in relatively rapid deterioration. Fiberglas is therefore less resistant than asbestos to the effects of steam or moisture. Attempts have been made to use glass fibers in place of asbestos in asbestos-cement products, but such tests have given unsatisfactory results, chiefly because of a chemical reaction between the glass and cement, which decomposes the fibers and destroys their effective strength.

Glass fibers are efficient thermal insulators in various types of equipment, such as stoves and refrigerators, where conditions are not corrosive. The high tensile strength, the greater thermal stability compared with organic fibers, and the electrical resistance of glass fibers make them suitable for electrical insulation, such as sleeving for wire and tapes for the construction of some types of motors. Fiberglas is used in conjunction with, or as an optional alternate material for, asbestos in Navy shipboard cables. It is claimed, however, that the use of asbestos results in greater resiliency in finished cables than can be obtained with Fiberglas. Glass fibers are permitted in specifications for cable filler (material that fills in the spaces in a group of insulated cables), but they have not yet been developed in a form that gives entirely satisfactory cable performance. Because of its high electrical and heat resistance, very thin glass-

fiber paper may find advantageous use in condensers for electronic equipment; for example, its use may make possible a reduction in the size of the condensers.

A glass-asbestos cloth was designed during World War II to extend the supply of asbestos textile fibers. It has continued in use as a covering on thermal insulation applied to piping on naval vessels. It is woven with a plied yarn having one strand each of glass and asbestos yarn. Glass fabrics or combined glass-asbestos fabrics have some advantage over asbestos textile products because of lighter weight per square yard and greater strength, but they are generally inferior to asbestos fabrics in resistance to flexure, abrasion, and chemical action. Fabrics consisting of interwoven glass and asbestos yarns are now made in many weights and colors for use as theater curtains and for fireproof draperies in schools, hospitals, libraries, hotels, and ships.

Coarse glass fibers compressed into bats are efficient lightweight air filters that are used extensively for cleaning large volumes of air. Asbestos is not widely used in this field.

The use of Fiberglas as a substitute for asbestos in friction equipment has, in general, given unsatisfactory results, chiefly because of the abrasive effects of glass on brakedrums. Also, the glass fabrics lack the high resiliency of those made of very finely divided asbestos filaments.

During World War II and the Korean conflict a large part of the production of Fiberglas was applied to military uses. Many manufacturers of electric insulating materials, such as manufacturers of asbestos cloth and tapes, laminates, varnished tubing, magnet-wire covering, and mica-insulating products, are listed as users of Fiberglas. Fiberglas was widely used during World War II for heat, sound, and electric insulation on aircraft. Over 90 percent of the output during World War II was used for military or essential civilian use.

Since it appears that Fiberglas can be substituted for asbestos in certain fields of application, its future availability is of first importance. A question has been raised as to the adequacy of Fiberglas production facilities. The manufacture of Fiberglas in ultrafine filaments was originally limited to a single plant operated by the Owens-Corning Fiberglas Corp. Such a situation tends to impose a serious limitation on the supply of an essential product in an emergency. With limited manufacturing facilities, the substitute product might be as difficult to obtain as the asbestos it is supposed to replace.

However, that situation no longer exists. The original company has enlarged its operations greatly; it manufactures Fiberglas in seven widely separated factories. Furthermore, several other companies now manufacture the product under license. It is believed that facilities will be adequate to meet any reasonable demands that may develop in the near future.

A question has also been raised as to limitations on Fiberglas manufacture imposed by the need of platinum. At one stage in the process of Fiberglas manufacture the molten glass is drawn through perforations in a platinum-bottomed cell or bushing; apparently, no other substance can be substituted for the platinum so used. Because platinum is produced in limited quantities—a free-world production of about 800,000 troy ounces a year—and has wide scientific and industrial use, its availability for wider application in this industry deserves careful consideration. Platinum is a critical material during war periods. Three important circumstances tend to relieve to some extent the threat of a possible shortage:

1. There is very little loss of platinum during the process of Fiberglas manufacture. The holes through which the fibers are drawn will gradually enlarge, and the platinum bushing will accordingly have to be rebuilt, using the same platinum. Care is taken to recover any dust or fragments of platinum. The first installation is the important consideration, but subsequent replacement of losses is very small.
2. Research is being conducted constantly to find ways of reducing the quantity of platinum required in each bushing. Presumably, some saving is possible and will be accomplished.
3. Research is also being devoted to possible substitution of some less costly and more abundant substance for platinum. Limited progress has been made, and there is at least some promise of success.

Another raw material essential to Fiberglas manufacture that may be in short supply in times of emergency is cryolite, sodium-aluminum fluoride (Na_3AlF_6), which is mined only in Greenland. The supply, however, is augmented by artificial cryolite manufactured from fluorspar. If supplies of both these materials are limited, sodium silicofluoride may be substituted. It has been produced as a byproduct from phosphate rock.

HIGH-SILICA GLASS FIBERS

Glass fibers approximating vitreous silica in composition are superior to soda-lime-silica glass fibers in resistance to deterioration from the action of water vapor and to high temperatures, but their manufacture is a difficult problem. Fused silica is extremely viscous at its melting point (1,728° C.), and its manufacture into thin filaments is very difficult. To over-

come this high viscosity, fluxes are added, the fibers are made, and the fluxes are then removed. Several methods are used, but they are similar in principle. First, filaments are formed from an easily workable composition, such as an alkali silicate. Second, the alkali or flux in the filament is removed by leaching or ionic substitution. The resulting fibers are relatively porous and high in silica. They will withstand with little deterioration temperatures exceeding 1,000° C. The minimum diameter of high-silica fibers on which data were available in 1952 was about 2 microns, and the average was much greater. On the other hand, natural asbestos fibers are only a fraction of a micron in diameter. Correspondingly, the silica fibers are much less flexible than natural chrysotile. Because of their high moisture resistance and ability to withstand high temperatures, the vitreous silica filaments undoubtedly can be substituted for asbestos in some applications, but it is doubtful if they can replace asbestos where flexibility and elasticity are prime considerations. Furthermore, the cost of manufacture is very high. High-silica-glass fibers are now made in much finer sizes than in 1952.

Dr. Rudolf Leutz claims to be the inventor of a process for making synthetic asbestos in Germany. His product, however, could not be called synthetic because its base was sodium silicate, and an analysis of the final product indicated that it consisted of over 97 percent SiO_2. It was, in fact, a silica-glass fiber. Three companies were licensed to manufacture this product in 1943, but because of the military reverses suffered by Germany no progress was made (*4*).[1]

OTHER SILICEOUS FIBERS

At least three companies are now making aluminum silicate fibers. They employ blowing processes, which do not require the use of platinum spinnerettes. Fusion may be accomplished with an electric arc. These fibers may be employed where exposed to temperatures of 2,000° F. or higher. They are costly to make and have special uses beyond the temperature ranges where asbestos products are employed.

Fibers of pure quartz are now made in micron sizes. They are also costly and are applied only at high temperatures.

ORGANIC SUBSTITUTES

German scientists attempted to manufacture yarn from short-fiber asbestos mixed with long organic fibers, such as cotton, cellulose, or synthetics, but the product obtained was very weak (*2*). Cardboard with an organic plastic was used in Germany as a substitute for asbestos packing in flanges of steam and water pipes. This packing was satisfactory at pressures up to 5 atmospheres and temperatures up to 160° C. It is stated that substitutes for asbestos in high-pressure packings have not been successful and that all substitutes developed and used up to 1944 were inferior to asbestos (*1*).

A diaphragm of Perlon (synthetic fiber) paper coated with barite paste was tried by I. G. Farbenindustrie as a substitute for asbestos cloth as a diaphragm in a Stemens-Billiter cell in the manufacture of NaOH by electrolysis of NaCl solution. It failed within 30 minutes. However, a polyvinyl chloride diaphragm gave results equal to those obtained with asbestos cloth (*3*).

Although reports are somewhat conflicting, polyvinyl fibers appear to be inferior to asbestos in asbestos-cement products. Silicone products alone or in combination with glass fibers have been used successfully as wire covering in certain applications.

SUBSTITUTES FOR AMOSITE

As indicated elsewhere, an important use for amosite is in the manufacture of light, fluffy insulation for use on marine turbines and jet-planes. The fluffiness appears to be a function of fiber diameter, the finer fibers showing the higher degree of thermal efficiency per unit weight. Accordingly, it has been found that Fiberglas having fiber diameters of less than 1 micron has a thermal efficiency comparable with that of amosite, but Fiberglas of this quality costs 5 or 6 times as much as amosite. Calcium silicate and diatomaceous-silica insulation products are used as substitutes for amosite in some applications.

Chrysotile can be substituted for amosite in 85-percent magnesia products, with some increase in weight per cubic foot and with a somewhat lower thermal efficiency. A substantial substitution of chrysotile for amosite would, in some instances, increase the weight per unit volume beyond the limitations of military specifications.

SUBSTITUTES FOR CROCIDOLITE

Crocidolite was used widely for a time in making gas-mask filters. However, the Naval Research Laboratory found that glass fibers make superior gas filters. In gas-mask tests in a smoke-filled room, it was found that only 1 particle in 100,000 passed through the Fiberglas filter, and at the same time the mask caused no noticeable increase in normal breathing resistance. The filter paper can be made in any

[1] Italicized numbers in parentheses refer to items in the bibliography at the end of this chapter.

ordinary paper mill (*5*). Because of the success attained with Fiberglas air filters, the use of Bolivian crocidolite is no longer regarded as essential in this application.

Because of its high resistance to chemical action, crocidolite has found wide use in making acidproof packings. One of the newer plastics is now replacing crocidolite to an increasing extent in this application, because it is stable up to 480° F., is resistant to acids and alkalies, and has low absorption.

The chief use of crocidolite in the United States is in the manufacture of asbestos-cement pipe. Its principal assets are its free filterability and high strength. No satisfactory substitutes are now available. Substitution of chrysotile for crocidolite in this application would, it is claimed, retard the drying time of the fabricated pipes so greatly that plant capacity might be reduced as much as 50 percent. However, some of the harsh Canadian chrysotile fibers, such as those produced at the Munro mine, Ontario, can be substituted for blue asbestos to some extent.

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CHAPTER 15. BENEFICIATION OF ASBESTOS

THE LOW-IRON PROBLEM

During World War II and the following Korean conflict there was an acute shortage of low-iron asbestos suitable for Navy cable construction. A quantity representing one-third of the total shipboard cable requirement of fiber was necessary to provide fireproof electric insulation. According to Navy specifications, the total iron content of such asbestos could not exceed 3.5 percent and the magnetic iron content, 2 percent. Canadian fiber does not satisfy the specification for such use. Except for a small supply from Arizona, the entire requirement was obtainable only from Southern Rhodesia, and supplies from that source were becoming smaller year by year. Under such circumstances it became imperative that research be conducted on methods of purifying Canadian asbestos to make it suitable for Navy use. This work was done mainly by industry, although Government made some contribution.

The other two-thirds of shipboard-cable-asbestos needs called for long-fiber chrysotile with total iron not exceeding 6 percent and magnetic iron 4 percent. The supply of this material was critical, but it did not present as serious a problem as the electrical grade.

Recently, a large deposit of low-iron asbestos was found in British Columbia, Canada, and supplies of the so-called nonferrous asbestos adequate for Navy use are now obtainable from that source. Hence, the urgency for development of deironing processes no longer exists. However, a record of the processes developed is of value, particularly as those established by industry are still in use.

TREATMENT OF HIGH-IRON ASBESTOS

The Johns-Manville Corp. conducted a great deal of research on this problem and obtained results justifying the erection of a special plant at Tilton, N. H., for manufacturing an asbestos-base, inorganic, electric-insulating paper or tape named "Quinterra" paper. Tilton was chosen because it has a dust-free atmosphere, is within easy reach of the Canadian asbestos mines, and is favorably located for marketing. Another reason was an abundant water supply. Water is a prime necessity, as 7,500 pounds is required in the manufacture of each pound of Quinterra paper. Canadian asbestos is beaten and agitated in water to separate the magnetite from the fiber. The purified asbestos, blended with clay, is fabricated by a special papermaking process. The paper has a closed structure; that is, it has neither holes nor interstices such as those in woven products. The severe mechanical treatment required to free the magnetite tends to break the asbestos fibers into shorter lengths. As short fiber is used as raw material, the paper is relatively weak. To give additional strength when needed, the paper can be laminated with a Fiberglas fabric or grid.

Raybestos-Manhattan, Inc., has developed a wet-process method of treating fibers, even those of spinning length. To free the magnetite from the fibers, a dispersing agent is used to separate the fibers. Many agents were tried, and one was finally found that would disperse or separate the fibers from each other with minimum mechanical force. In other words, a chemical process of fiber separation is substituted for the mechanical beating or crushing method. Thus, the magnetite is set free so that it can be removed magnetically with very little damage to the fibers. The purified fibers are made into paper of the desired thickness, which can be reinforced with Fiberglas or other materials for added strength. The product is known by the trade name "Novabestos." In connection with the Novabestos process, a patented process for dispersing chrysotile asbestos by means of a monovalent anion in combination with a polyvalent cation (*5*)[1] should be mentioned.

Both Quinterra and Novabestos are now manufactured commercially and are used extensively in cable construction and for other nonferrous uses. According to the Bureau of Ships, they are satisfactory products for Navy use.

The recent importation of large quantities of low-iron chrysotile from British Columbia, Canada, apparently has had little effect on the scope of the operations described. The deironing is simply one step in a complex process developed through years of research.

During the early 1950's the Bureau of Mines conducted tests on removal of magnetite from

[1] Italicized numbers in parentheses refer to items in the bibliography at the end of this chapter.

asbestos by crushing and magnetic separation. It was found, however, that much of the magnetite is so intimately associated with Canadian asbestos that separation in a dry state was unsatisfactory.

The Naval Research Laboratory has demonstrated the ability of a papermaker's Vortrap to remove magnetite from a wet slurry of asbestos. Essentially the separation is effected by the swirling action that arises when rapidly flowing water is introduced into a pipe in a tangential manner. The concomitant centrifugal action tends to throw the heavy magnetite against the walls, while the asbestos fibers, freed from magnetite, remain suspended and ultimately pass up and out of the instrument to a decker or other fiber-recovery apparatus. Fibers of spinning length have been cleaned with fair success in a laboratory-size Vortrap (1¾-inch). As the magnetite grains tend to be intimately attached to the fibers, some asbestos is carried away with the heavy fraction; on the other hand, some fibers to which fine grains of magnetite are attached, are light enough to be carried upward with the iron-free asbestos.

In accordance with plans formulated by the Naval Research Laboratory and the Bureau of Mines, larger scale Vortrap tests with Canadian asbestos were made in 1952, but the results were inconclusive.

From 1953 to 1955 the Bureau of Mines conducted similar experimental work with its own equipment, which disclosed that the Vortrap is both a purifier and a classifier of asbestos fiber. Tests made with this equipment indicate that the magnetic-iron content of ordinary Quebec asbestos can readily be reduced to satisfy the requirement of 2 percent or less stipulated in the National Stockpile Specification P–3–R, dated June 10, 1953. At the same time it separates much of the short fibers present. As the deironing problem was no longer urgent, this work was suspended.

Some investigators believe that the actual quantity of total iron and magnetic iron in asbestos or its products is a faulty criterion of its electrical resistance because much depends upon the condition of the iron present. For example, a large fragment of magnetite would be more detrimental than the same quantity in the form of numerous small fragments because the large mass might constitute an uninterrupted path for the electric current, whereas the small particles separated from each other by comparatively resistant materials would provide a less ready pathway along which the electric current could travel. Accordingly, removal of the larger fragments would improve the electrical resistance of the product more than removal of the same quantity of iron in the form of small fragments only.

Furthermore, the specifications recognize that magnetic iron is more detrimental than the nonmagnetic forms. If the iron-bearing asbestos were carried between the terminals of an electric arc, the short circuit created when a relatively large piece of magnetite reaches the space between the terminals would not only break up the fragment into small particles but would oxidize the magnetite to ferric forms, which are less harmful. Methods of modifying the form and particle size of the iron minerals in asbestos have not yet been fully explored. Possibly, the best results can be obtained by combining processes of removing iron with methods of modifying the form and grain size of the iron particles that remain.

The Jeffrey Manufacturing Co. developed a method about 1925 whereby woven asbestos tapes were passed between electrodes, with the result that the larger particles of magnetite were volatilized or converted to nonmagnetic compounds of iron. The resulting perforations in the tape were sealed by a following treatment with resins. When nonferrous tapes of satisfactory dielectric resistance became generally available, this method of treatment was rarely used.

In this connection it is pertinent to point out the desirability of a more complete investigation of types of asbestos that may be high in iron but in which the iron is present in silicate forms that are relatively resistant to the passage of electricity. Crocidolite, for example, is high in iron, but little free iron oxide is present. The possibility of using crocidolite for fabrics suitable for wire covering has not been fully explored.

The Bureau of Mines has undertaken a study of all accessory minerals associated with asbestos and their effects upon its utilization. Methods of removing undesirable impurities of all kinds are being studied. Studies are also in progress on the composition of asbestos and on its physical and chemical properties in relation to use.

ELONGATION OF SHORT FIBERS

There is a growing need for a larger supply of long spinning fibers of both the low-iron and the high-iron types. As pointed out elsewhere in this report (p. 34), spinning fibers produced in Canada constitute only about 4 percent of total production. If some method could be devised for converting short fibers into long ones, the supply could be enlarged. To make short fibers out of long ones is easy (all mill operators wish that it were not so simple), but to elongate short fibers is more difficult. Fortunately, the research scientist is not terrified by apparently

insurmountable barriers, and some research has already been done in this field.

Driscoll and Bruce (*1*) claim that an improved product can be made by mixing a slightly soluble metal compound, such as lime, with the short asbestos fibers. A soluble silicate is then used to impregnate the asbestos mass and cause precipitation of a bonding agent such as calcium silicate.

Lüdke (*2*) claims that short fibers can be converted into long fibers. The fibers are oriented by some means, as electrostatically, into parallel position and are then exposed to water and fluorine vapors at elevated temperatures.

Callinan (*3*) has devised a method of improving the structural and mechanical properties of asbestos. He claims that the reaction between asbestos and silicon tetrachloride results in a product that has a higher silicon content and greater tensile strength. He postulates that the silicon tetrachloride reacts with the terminal hydroxyl groups of chrysotile and causes a condensation, which leads to a substantial increase in chain length.

Brandenberger and others (*4*) found that when serpentine synthesis was conducted in the presence of natural serpentine fibers (chrysotile) no enlargement in the grain size of the natural fibers took place.

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[2] Titles enclosed in brackets are translations from the language in which the item was published.

CHAPTER 16. ASBESTOS SYNTHESIS

As United States mines furnish only a small fraction of domestic requirements of asbestos, the synthesis of long-fibered, strong, and flexible asbestos is highly desirable as it would tend to overcome the present major dependence of the United States upon foreign countries in times of emergency. Mineral synthesis is a well-established art. Synthetic sapphires and rubies have been used as jewel bearings for many years. Recently, remarkable success has been attained in making synthetic quartz crystal, some progress has been realized in synthesizing mica, and even the diamond is now made as a furnace product. Some progress has been made in synthesizing amphibole asbestos, but chrysotile synthesis appears to be much more difficult.

SYNTHESIS OF CHRYSOTILE

Although there is little evidence of current research on chrysotile synthesis, considerable work has been done in the past. In 1929 Wells (*2*) [1] synthesized what he termed "a hydrous magnesium silicate very similar to serpentine" by the interaction of sodium silicate solution with $MgCO_3$ at 375° to 475° C. under pressures of 200 to 230 atmospheres. Under similar conditions, Ipatiev and Muromtseff (*1*) claim to have prepared chrysotile from a silica gel and magnesium salt solutions.

Using MgO and an alkali-free silicic acid, Jander and Wuhrer (*3*) synthesized serpentine at temperatures below the critical point of water. No mention was made of fibers.

Noll (*11*) reduced the number of nuclei formed during the synthesis by introducing the reactants with great care into nickel or silver tubes in the form of solutions in two layers or strata. One layer was composed of water glass and caustic soda and the other of a magnesium salt such as $MgCl_2$. A gel that formed quickly at the interface served as a diffusion membrane, which retarded the mixing of the solutions. The tube and its contents were heated rapidly to 300° C. under a pressure of 100 atmospheres. By this means groups or pockets of chrysotile fibers were formed. The maximum fiber length of the filaments was 0.2 mm., which is longer than the fiber length of the product obtained without the diffusion process.

[1] Italicized numbers in parentheses refer to items in the bibliography at the end of this chapter.

Studies of the MgO–SiO_2–H_2O system by Bowen and Tuttle (*7*) have shown that chrysotile can be synthesized at temperatures below 500° C. and at pressures of 2,000 to 4,000 p. s. i. The fibers thus formed were very small.

The properties determined on samples of synthetic chrysotile are found to be similar to those reported for the naturally occurring mineral. For example, both exhibit similar dehydration curves, X-ray patterns, and refractive indices (*9*).

Bates and coworkers (*8*) have reported that chrysotile fibers are actually hollow tubes. Electron micrographs indicated that synthetic chrysotile may have the same tubular structure (*10*). However, as a result of more recent research, one author takes exception to the "hollow tube" theory on the ground that the density is too nearly theoretical to allow space for the voids in hollow tubes (*15*).

The New Jersey Ceramic Research Station, Rutgers University, has made a study of the hydrothermal synthesis of chrysotile. A primary objective was to determine the factors that will promote growth of the fibrous habit. Best results were obtained with gels. The effects of variations in pressure, temperature, duration of run, and composition were investigated. The chrysotile filaments produced were of submicroscopic size, and no progress was made in increasing their length.

Tests made at the Johns-Manville Research Center in 1948 indicated that magnesia and silica reacted under high pressure in the presence of mineralizers in a stainless-steel bomb to form a product which, under magnification, appears to have a fibrous crystalline structure similar to that of chrysotile asbestos.

SYNTHESIS OF AMPHIBOLES

Research on the synthesis of asbestos was conducted in Germany many years ago. As early as 1935 Dr. Werner Lüdke claimed to have made synthetic amphibole asbestos (*5*). Lüdke's process was a type of pneumatolytic synthesis; that is, it involved the reaction resulting from the passage of heated vapor over compounded mixtures. Bloomfield (*6*), who reviewed thoroughly all attempts to synthesize asbestos in Germany, was present at a meeting in 1935 at which representatives of the asbestos-products industry expressed the opinion that

Dr. Lüdke's synthetic fiber in the state of development at that time was an unsatisfactory replacement for natural asbestos. However, as the country was faced with an acute shortage of asbestos, the Anhaltische Studiengesellschaft supported Dr. Lüdke, and a pilot plant was built at Bernburg in 1940, where attempts were made to develop the process commercially. The synthetic fibers produced, however, were inferior in quality and were never improved. An attempt was made to manufacture high-pressure gaskets, but the synthetic material was not only chemically unstable but it would not withstand the mechanical handling necessitated by quantity production. The requirements demanded for these gaskets could not be satisfied by the experimental samples made of synthetic asbestos. Asbestos paper and millboard made of the synthetic fibers did not compare favorably with those made of natural asbestos.

Sitz (*4*) has described Lüdke-process asbestos which, at one stage of development, came from the furnace in the form of a large plate about 300 mm. thick. He states that it was broken up, shredded, and used in high-pressure packings, brakebands, insulation, airplane coverings, and paints. Sitz's report indicates that no improvement had been made over the previously stated results obtained by using Doctor Lüdke's material.

Lüdke's most successful experiments were reinvestigated at the Electrotechnical Laboratory of the Federal Bureau of Mines, Norris, Tenn., to determine more precisely the effect of variations in conditions during synthesis on the quality of the product. This research resulted in the synthesis of an alkali-containing amphibole at a temperature as low as 400° C. and a pressure of 1 atmosphere.

A critical review of previous syntheses of the amphiboles, both by reactions in the solid state and by crystallization from melts, are given by Comeforo and Kohn (*12*). In the synthesis of amphiboles a promising technique is to replace the hydroxyl normally present in natural amphiboles by fluorine, just as in the more familiar phlogopite-mica synthesis. By this means synthetic amphibole can be produced by crystallizing a melt of the amphibole composition in a closed container to retard volatilization of the fluorides.

A study of well-formed, single crystals of synthetic fluortremolite showed that the indices of refraction of the synthetic product were slightly lower and the extinction angle slightly higher than those of the natural mineral. To show how closely the crystal structure of the synthetic compares with that of natural tremolite, the unit-cell dimensions are compared in table 36.

TABLE 36.—*Cell dimensions of natural and artificial tremolite*

	Natural tremolite (Warren)[1]	Artificial tremolite (Comeforo and Kohn) (*12*)
a_o angstrom units	9. 78	9. 781
b_o do	17. 8	18. 007
c_o do	5. 26	5. 267
β	73°58′	75°29′

[1] Warren, B. E., [The Structure of Tremolite $H_2Ca_2Mg_5(SiO_3)_8$]. Ztschr. Krist., vol. 72, 1930, p. 44.

As all synthetic fibers made up to the time of this investigation were weak and brittle, steps were taken to improve the physical quality of the fibers and to determine the most satisfactory compositions that will produce fibers relatively free from impurities. To this end an extensive study of the isomorphism of synthetic fluoramphiboles was made at the Electrotechnical Laboratory of the Bureau of Mines. This work resulted in the synthesis of amphiboles in a wide range of chemical compositions unknown in nature.

A later report (*13*) of the Bureau of Mines shows that the synthetic amphiboles fluor-richterite and fluor-edenite differ very little from the natural minerals except in the replacement of hydroxyl by fluorine and by a higher degree of purity. As the synthesized products were made of pure constituents, they did not contain the accessory components commonly occurring in the natural minerals. The control of composition is an important factor in asbestos synthesis. The properties of synthetic amphiboles are, in general, almost identical with those of their naturally occurring analogs. The replacement of hydroxyl by fluorine results in no appreciable change in X-ray or optical properties. Further studies have been made of the synthesis of fluoramphiboles from melts (*16*).

Controlled thermal gradients can be used to induce alinement of the crystals, first, by cooling the melt from the bottom and, second, by varying the shape of the container so that cooling will begin at one small area. Figure 8 shows the definite vertical orientation of amphibole fibers obtained by synthesis. (Scale on photograph in millimeters.)

The Bureau of Mines has synthesized amphibole asbestos fibers in very fine filaments. Many were so small that they were well below the resolving power of a petrographic microscope. These fibers were synthesized by pneumatolytic or solid-state reactions. Although too weak for the ordinary uses of chrysotile,

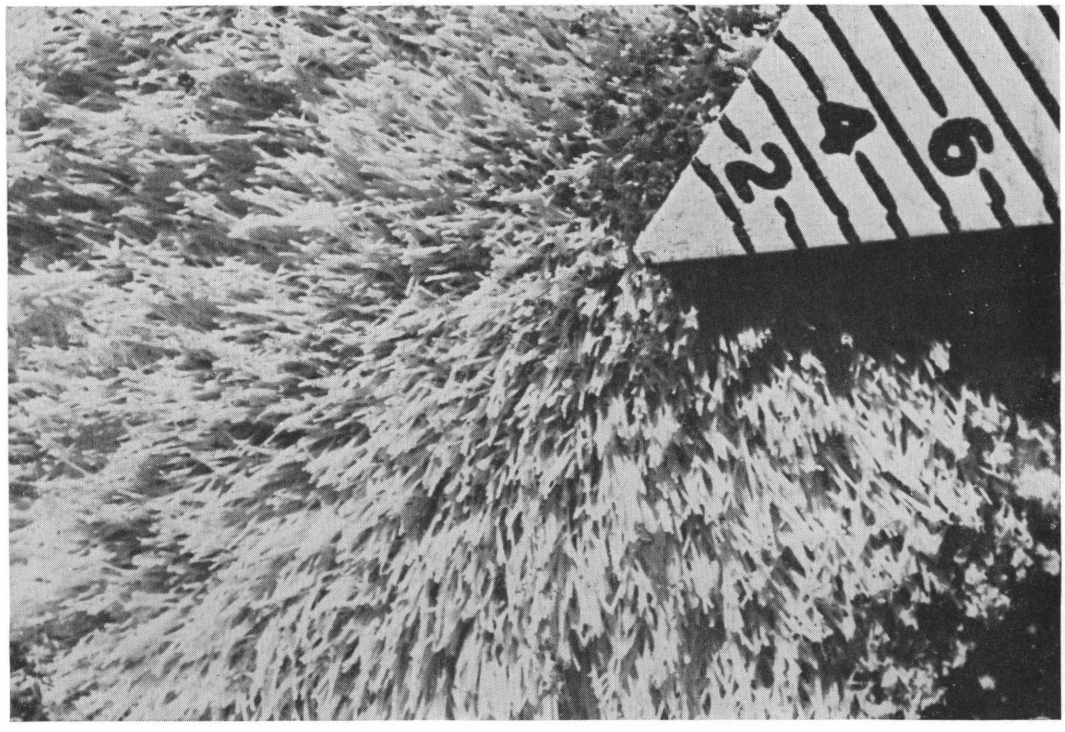

FIGURE 8.—Synthetic Amphibole Asbestos Made in Electrotechnical Laboratory, Norris, Tenn.

they may prove useful in applications where high fiber strength is not essential—for example, as a constituent of impact-resistant ceramic dielectrics.

Amphiboles are more easily synthesized than chrysotile but, unfortunately, the ordinary amphiboles have limited use. A highly desirable research objective is the synthesis of amphibole fibers approaching amosite or crocidolite in strength and flexibility.

SYNTHESIS OF ASBESTIFORM PRODUCTS

In addition to research on synthesis of chrysotile and amphiboles—the two naturally occurring fibrous minerals of commercial interest—experimentation is in progress on the synthesis of other inorganic, crystalline, fibrous materials. The Bureau of Mines has produced a potassium-lead silicate ($K_2Pb_4Si_8O_{21}$) in a fluffy fibrous form closely resembling natural asbestos in appearance. The fibers are weak and brittle and therefore not adapted for spinning and weaving. However, they have properties such as purity of composition, good electrical insulating qualities, and high resistance to thermal shock and impact that adapt them well for use in ceramic bodies. They are easily fabricated at relatively low temperatures (600° to 780° C.). Another possible use is as a filler in plastics. The method of synthesis and the physical and chemical properties of the fibers have been described (*14*). The potassium-lead silicate is isomorphous with lead-aluminum silicate, which also crystallizes in a fibrous habit. Although there is no immediate promise of the substitution of such fibers for asbestos, their synthesis may contribute to the general theoretical study of inorganic crystalline fibers.

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CHAPTER 17. GOVERNMENT STOCKPILE PROGRAM

In every national emergency certain essential types of asbestos have been in such short supply that they have attained high priority among strategic materials. Because of the serious situations that have arisen through the inadequacy of supplies, asbestos has found a place in the stockpiling program, a brief history of which is presented herein.

A realization that the maintenance of national stockpiles of strategic and critical materials is an essential element of national security led to extensive studies of strategic-material problems, particularly during the late 1930's and for some years thereafter. During 1938 and early 1939 the Army and Navy Munitions Board, with the assistance of the Departments of State and Interior and other agencies, developed recommendations on stockpiling, which led to the enactment of Public Law 117, 76th Congress, on June 7, 1939; this authorized expenditure of $100 million for stockpiling of strategic and critical materials during the period 1939 to 1943, inclusive. Under this act the Secretaries of War, the Navy, and the Interior, acting jointly through the Army and Navy Munitions Board, were authorized to determine what materials were strategic and critical and the quantities and qualities of such materials that should be stockpiled. Under the authorization of Public Law 117, appropriations totaling $70 million were made by the Congress.

Public Law 117 was designed to provide a basis for stockpiling in peacetime, but when war broke out in Europe and when the United States later became involved in the conflict conditions changed greatly. Further legislation was enacted to meet the current needs, and stockpile policies were developed to meet wartime conditions.

Public Law 117 was amended by Public Law 520, 79th Congress, on July 23, 1946, known as the "Strategic and Critical Materials Stockpiling Act." Among its major objectives, it provided for the acquisition and stockpiling of strategic minerals that are deficient or insufficiently developed in the United States and, through the Bureau of Mines and the Geological Survey, the conduct of scientific, technologic, and economic investigations of domestic minerals essential to the common defense or industrial needs of the United States.

As a result of studies conducted in the early 1940's by the various agencies involved, the Army and Navy Munitions Board issued on November 20, 1944, a list of strategic and critical materials. The asbestos varieties Rhodesian chrysotile and South African amosite appeared in group A of the list. Group A included "materials for which stockpiling is deemed the only satisfactory means of insuring an adequate supply for a future emergency." Hence the stockpiling program for these minerals began as of that date. Authorization to stockpile Bolivian crocidolite was granted December 22, 1949. No other types or varieties of asbestos have been added to the stockpile list. After stockpile specifications were established the word "Rhodesian" was omitted when reference was made to chrysotile. About 1944 the Army and Navy Munitions Board established stockpile committees on which various services and agencies were represented. These groups working in cooperation with the Bureau of Mines and the Geological Survey made studies of available supplies, future requirements, and prospective shortages of the strategic minerals and made recommendations as to stockpiling programs. Stockpile objectives for the strategic grades of asbestos were changed from time to time in accordance with changing circumstances. These objectives as well as stockpile acquisitions are classified data that cannot be discussed herein. The stockpile objective was reached and Government purchase ceased for Bolivian crocidolite in 1955 and for chrysotile early in 1956. The amosite objectives have not yet been reached.

To encourage expansion in production of low-iron chrysotile in Arizona and at the same time to accumulate a supplementary stockpile, a domestic purchase program was established by Defense Minerals Production Administration in December 1952. It authorized purchase and warehousing of Crude No. 1, No. 2, and No. 3 grades. It provided that the program would run until October 1, 1957, or until a total of 1,500 tons (Crude No. 1 and No. 2 combined) had been purchased, whichever occurred first. The latter alternative was reached early in 1956.

Although the material constitutes a supplementary stockpile, it is not usable in its present form. To make it conform with national stockpile specifications will require milling and grad-

ing, with a consequent substantial reduction in the tonnage of recoverable acceptable fiber.

By congressional action (Public Law 733, 84th Cong., dated July 19, 1956) a new program was established whereby the Department of the Interior was authorized to purchase domestic nonferrous chrysotile asbestos meeting the same specifications and under the same regulations as those in effect during the former purchase program. The prices to be paid are those that were in effect January 1, 1956. Purchases are not to exceed 2,000 tons of No. 1 and No. 2 combined and not to exceed 2,000 tons of No. 3, excepting that the No. 3 may be purchased only when offered with No. 1 or No. 2, or both, in a ratio not in excess of 1 ton of No. 3 to 1 ton of No. 1 or No. 2, or both. The Department of the Interior delegated the authority to make these purchases to General Services Administration July 31, 1956.

As stockpile objectives for low-iron chrysotile have been reached and the situation is no longer critical with respect to this commodity, the new purchase program was not established primarily to meet national-security needs. Its main purpose is to assist Arizona producers in establishing their operations on a commercial basis that will permit continued activity without governmental assistance. Some purchases were made with funds remaining from the previous program, but such funds were inadequate for completion of the new program which was suspended in April 1957. In June 1957 the Congress appropriated $2½ million for purchase of domestic low-iron chrysotile during fiscal year 1958.

CHAPTER 18. WAR CONTROLS AND EXPERIENCES

WORLD WAR II CONTROLS AND EXPERIENCES

A brief chronological history of asbestos procurement during World War II follows. This history was compiled by the War Production Board in 1945. Copies of the various restrictive orders follow this history. A section on restrictions during the Korean conflict has been added.

Chronological outline of a history of asbestos procurement during World War II

1940 (early): Dr. Oliver Bowles, Bureau of Mines, recommended to the National Defense Commission action to insure production and importation of adequate supplies of Canadian and African asbestos.

June 27, 1940: Meeting of asbestos importers and manufacturers held with Government officials to discuss means of ascertaining stocks in the United States and measures to insure adequate supply.

October 15, 1940: National Defense Commission, Mining and Mineral Products Division, outlined a plan for asbestos procurement; recommended Government purchase for stockpile:

	Short tons
Chrysotile, Rhodesian	8,500
Amosite	8,000
Crocidolite	3,500
Total	20,000

October 25, 1940: National Defense Commission official recommended the following purchases:

	Short tons
Chrysotile, Rhodesian	3,000
Amosite	9,000
Crocidolite	8,000
Total	20,000

August 20, 1941: National Defense Commission official recommended to Deputy Administrator, Federal Loan Agency, the following purchases:

	Short tons
Chrysotile, Rhodesian:	
C & G 1	900
C & G 2	3,600
Amosite:	
B1	1,000
B3 or D3	15,000
Crocidolite:	
A	100
C	100
MS	10,000
Total	30,700

December 1941: Critical need for asbestos was recognized: It was decided at a meeting of Office of Production Management and asbestos-industry officials to conserve available stocks. A draft conservation order was given preliminary discussion. Demands for asbestos-cement corrugated sheets and asbestos textiles exceeded supply (sheets used for aircraft hangars and ordnance works).

January 20, 1942: Office of Production Management Conservation Order M–79 was issued to effect conservation of the asbestos supply and restrict the usage of African fibers.

February 28, 1942: Order M–79 was revised to tighten restrictions.

1942 (early): War Production Board Order M–123 was issued to restrict the sale of asbestos textiles and packings containing asbestos textiles.

April 1942: A ship carrying 3,300 tons of African fiber was lost by sinking. Conservation Order M–79 was amended to tighten restrictions.

July 4, 1942: Order M–123 was amended to include woven friction materials.

July 1942: Cork and Asbestos Section, WPB, had received questionnaire replies from manufacturing plants showing estimated raw-fiber requirements; it recommended to Stockpiling and Shipping Branch, WPB, the following Government purchases:

	Short tons
Chrysotile, Rhodesian:	
C & G 1	2,600
C & G 2	10,000
Amosite:	
B1	2,000
B3 or D3	17,000
Crocidolite:	
A	100
C	100
MS	12,500
Total	44,300

July 1942: Cork and Asbestos Section "made diligent efforts to obtain requirements from the Armed Forces for asbestos products. These requirements were finally obtained (date not stated) but were presented in a form that was not useful, nor was much faith placed in these figures."

December 1942: Order M–123 was amended to add a list of prohibited uses and restrictions on permitted types of asbestos textiles; it was decided in consultation with Canadian producers and with the cooperation of the Canadian Controller of Metals to develop an allocation method for the distribution of asbestos fibers of Groups 1, 2, and 3. The plan provided for suggestions to the Canadian controller on the distribution of shipments to United States manufacturers.

Contracts were signed for the purchase of asbestos by the Government after a number of conferences between representatives of the Board of Economic Warfare and of the British Mission of Supply. These contracts called for delivery of the following types of African asbestos during 1943:

	Short tons
Chrysotile:	
C & G 1	1,861
C & G 2	6,459
C & G 3	18,746
C & G 4	6,404
Amosite:	
B1	1,200
B3 or D3	6,000
3DM–1	3,600
M–1	10,020
Crocidolite:	
MS	2,800
S	400
Total	57,490

February 20, 1943: Some Order M–123 restrictions were combined with Conservation Order M–283, which placed asbestos textiles under complete allocation procedure; allocations were based on quarterly decisions, established by the Requirements Committee (WPB).

Chief, Asbestos Section, WPB, protested to Chief, Minerals and Metals Division, Board of Economic Warfare, objecting to phases of the purchase contract (for African asbestos), particularly to the large amount of C & G 4 and the small amount of crocidolite purchased. This letter was acknowledged March 5, 1943, "but up until August 7 that year no changes were made in the stockpiling and purchase recommendation. There were unquestionably errors in judgment made by all concerned in this transaction."

March 17, 1943: Order M–283 changed to remove lamp and burner wicks from restricted list.

April 1943: Order L–41–d was issued. This exempted asbestos-cement siding and roofing from the provisions of Order L–41. (Under Order L–41, the use of asbestos-cement siding and roofing shingles was limited. Since about 95 percent of Canadian asbestos was then so used the mines had no outlet and could not continue production of the needed long fiber.)

July 1943: Combined Raw Materials Board (United States, British, and Canadian) assumed responsibility for distribution of the supply of Canadian and African asbestos among the three countries. "Had they entered the picture earlier it would have been very beneficial, for, by and large, a fair distribution of asbestos was made after the completion of the Board of Economic Warfare's 1943 contracts, which had been signed at London in December 1942."

October 1, 1943: Conservation Order M–79 was amended to include restrictions on the use of Canadian long-fiber asbestos and require the use of 1 ton of Rhodesian C & G 3 for each 5 tons of Canadian 3R, also further to restrict the use of Rhodesian chrysotile fibers.

October 11, 1943: Conservation Order M–283 was amended to include remaining restrictions on the uses of asbestos in Order M–123, which was then revoked.

January 31, 1944: Conservation Order M–79 was amended to change restrictions on the uses of Rhodesian fibers and changing allocations of Canadian 3R from a monthly to a quarterly basis.

April 1944: The Navy called for a larger increase in requirements for Navy lagging cloth and asbestos textiles for Navy cable construction. After discussion with the industry, it was decided to expand facilities. Orders were placed for additional machinery. Research was started on the production of a combination glass and asbestos cloth for Navy lagging. By August this cloth had been developed and approved, and the resultant increase in production largely solved the Navy lagging-cloth problem.

November 1944: Navy radically reduced requirements for cable.

December 8, 1944: Order M–79 was amended to remove restrictions on the use of African asbestos.

January 4, 1945: Order M–283 was amended to permit certain uses of asbestos textiles (due to lower Navy requirements) and to permit the filing of applications for Navy cable construction on a quarterly basis and thus enable manufacturers better to schedule their production.

March 20, 1945: Order M–79 was changed to allow the use of 1 ton of Rhodesian C & G 1 or C & G 2 (as well as C & G 3) per 5 tons of Canadian spinning fiber, Grade 3R.

August 11, 1945: Order M–283 was amended to permit production of civilian passenger-car and truck friction materials.

August 20, 1945: Order M–79 was revoked.

August 31, 1945: Order M–283 was revoked (all controls on the asbestos industry were ended).

OFFICE OF PRODUCTION MANAGEMENT CONSERVATION ORDER M–79 CURTAILING THE USE OF CERTAIN TYPES OF ASBESTOS

WHEREAS national defense requirements have created shortage of certain types of asbestos for the combined needs of defense, private account, and export; and the supply now is and will be insufficient for defense and essential civilian requirements unless their use in certain products manufactured for civilian use is curtailed; and it is necessary in the public interest, to promote the defense of the United States, to conserve the supply and direct the distribution thereof:

Now, therefore, it is hereby ordered,

That:

1064.1 (a) Restrictions on the Use of Certain Types of Asbestos.

(1) Unless otherwise specifically authorized by the Director of Priorities, after February 1, 1942, no person shall fabricate, spin, or process in any other way asbestos fibre imported from South Africa except where such fabrication, spinning, or processing is necessary to fill Defense Orders as defined in Priorities Regulation No. 1, as amended from time to time.

(2) In addition to the above limitation, unless otherwise specifically authorized by the Director of Priorities, after February 1, 1942, no person shall fabricate, spin, or process in any other way:

(i) Chrysotile asbestos fibre (Rhodesian) Grade C and G–1 and 2 except where such fabricating, spinning, or processing is necessary to fill Defense Orders for:

(*a*) Core rovings to meet Navy specifications Number 17–1–29 (INT); (Insulation, electrical, asbestos fibre, treated and untreated, dated October 1, 1941, or as same may be amended.)

(*b*) Tapes and cloth which are required by specification to be of a nonferrous nature;

(*c*) Nonferrous lapps.

(ii) Amosite asbestos fibre (Grade B–1 or amosite asbestos having a fibre length equivalent to that of Grade B–1) except where such fabricating, spinning, or processing is necessary to fill Defense Orders for Amosite woven felt blankets and mattresses for turbine insulation for use on naval and maritime ships.

(iii) Amosite asbestos fibre (Grade B–3, D–3, or amosite asbestos having a fibre length equivalent to that of Grade B–3 or D–3) except where such fabricating, spinning, or processing is necessary to fill Defense Orders for:

(*a*) Woven felt blankets and mattresses and fittings for turbine insulation for use on naval and maritime ships;

(*b*) Fire proof board;

(*c*) Sprayed amosite;

(*d*) Eighty-five percent magnesia pipe covering and blocks;

(*e*) Molded amosite pipe covering and blocks;

(*f*) Flexible amosite pipe insulation;

(*g*) Dry pack insulation.

(3) In addition to the above limitations unless otherwise specifically authorized by the Director of Priorities, after February 1, 1942, no person shall install eighty-five percent magnesia or other high temperature pipe covering except in installations where temperatures of 200° Farhenheit or over occur.

(b) Reports.

(1) Any person who manufactures or processes asbestos fibre shall, on or before the 10th day of February, 1942, and on or before the 10th day of each calendar month thereafter, file with the Office of Production

Management, Ref: M–79, all of the information required by Forms PD–251 and PD–252, whichever is applicable.

(2) In addition, any person who manufactures or processes asbestos fibre shall, when requested, file with the Office of Production Management, Ref: M–79, all the information required by Form PD–253.

(c) Prohibitions Against Sales or Deliveries. No person shall hereafter sell or deliver asbestos fibre to any person if he knows, or has reason to believe, such material is to be used in violation of the terms of this Order.

(d) Limitation of Inventories. No manufacturer shall receive delivery of asbestos fibre or products thereof, in the form of raw materials, semi-processed materials, finished parts of sub-assemblies, nor shall he put into process any raw material in quantities which in either case shall result in an inventory of such raw-semi-processed or finished material in excess of a minimum practicable working inventory, taking into consideration the limitations placed upon the production of asbestos fibre products by this Order.

(e) Miscellaneous Provisions:

(*1*) *Applicability of Priorities Regulation No. 1.* This Order and all transactions affected thereby are subject to the provisions of Priorities Regulation No. 1 (Part 944), as amended from time to time, except to the extent that any provision hereof may be inconsistent therewith, in which case the provisions of this Order shall govern.

(*2*) *Appeal.* Any person affected by this Order who considers that compliance therewith would work an exceptional and unreasonable hardship upon him or that it would result in a degree of unemployment which would be unreasonably disproportionate compared with the amount of asbestos fibre conserved, or that compliance with this Order would disrupt or impair a program of conversion from non-defense work to defense work, may appeal to the Office of Production Management, Ref: M–79, setting forth the pertinent facts and the reason he considers he is entitled to relief. The Director of Priorities may thereupon take such action as he deems appropriate.

(*3*) *Applicability of Order.* The prohibitions and restrictions contained in this Order shall apply to the use of material in all articles hereafter manufactured irrespective of whether such articles are manufactured pursuant to a contract made prior or subsequent to the effective date hereof, or pursuant to a contract supported by a preference rating. Insofar as any other Order of the Director of Priorities may have the effect of limiting or curtailing to a greater extent than herein provided the use of asbestos fibre in the production of any article, the limitations of such other Order shall be observed.

(*4*) *Correspondence and Communication.* All reports required to be filed hereunder, and all communications concerning this Order, shall, unless otherwise directed, be addressed to:

Office of Production Management
Washington, D. C., Ref: M–79

(*5*) *Violations.* Any person who willfully violates any provision of this Order, or who by any act or omission falsifies records to be kept or information to be furnished pursuant to this Order, may be prohibited from receiving further deliveries of any material subject to allocation, and such further action may be taken as is deemed appropriate, including a recommendation for prosecution under Section 35 A of the Criminal Code (18 U. S. C. 80).

(*6*) *Effective Date.* This Order shall take effect immediately and shall continue in effect until revoked.

(P. D. Reg. 1, Amended, Dec. 23, 1941, 6 F. R. 6680; O. P. M. Reg. 3 Amended, Sept. 2, 1941, 6 F. R. 4865; E. O. 8629, Jan. 7, 1941, 6 F. R. 191; E. O. 8875, Aug. 28, 1941, 6 F. R. 4483; sec. 2 (a), Public No. 671, 76th Congress, Third Session, as amended by Public No. 89, 77th Congress, First Session).

Date, this 20th day of January 1942.

J. S. Knowlson
Acting Director of Priorities

WAR PRODUCTION BOARD CONSERVATION ORDER M–79 CURTAILING THE USE OF CERTAIN TYPES OF ASBESTOS, AMENDMENT 1

(a) Paragraph (a) (3) of Section 1064.1 (Conservation Order No. M–79) is hereby amended to read as follows:

"In addition to the above limitations, unless otherwise specifically authorized by the Director of Industry Operations, after February 1, 1942, no person shall install eighty-five per cent magnesia or other high temperature pipe covering except (1) in installations where temperatures of 200° F. or over occur, or (2) in installations on ships."

(b) This amendment shall take effect immediately.

Issued this 28th day of February, 1942.

J. S. Knowlson,
Director of Industry Operations

WAR PRODUCTION BOARD CONSERVATION ORDER M–123—ASBESTOS TEXTILES

The fulfillment of requirements for the defense of the United States has created a shortage in the supply of Asbestos Textiles for defense, for private account, and for export; and the following Order is deemed necessary and appropriate in the public interest and to promote the national defense:

Section 1172.1 Conservation Order M–123.

(a) Unless otherwise specifically authorized by the Director of Industry Operations, after April 4, 1942, no manufacturer of Asbestos Textiles shall deliver Asbestos Textiles except

(1) for use in the manufacture of industrial packings or

(2) on orders bearing a preference rating of A–10 or higher.

(b) Applicability of Priorities Regulation No. 1. This Order and all transactions affected hereby are subject to the provisions of Priorities Regulation No. 1 (Part 944), as amended from time to time, except to the extent that any provision hereof may be inconsistent therewith in which case the provisions of this Order shall govern.

(c) Appeals. Any person affected by this Order who considers that compliance herewith would work an exceptional and unreasonable hardship upon him may appeal to the War Production Board, setting forth the pertinent facts and the reasons such person considers that he is entitled to relief. The Director of Industry Operations may thereupon take such action as he deems appropriate.

(d) Communications. All communications concerning this Order shall, unless otherwise directed, be addressed to:

War Production Board
Washington, D. C., Ref: M–123

(e) Violations. Any person who willfully violates any provision of this Order, or who by any act or omission falsifies records to be kept or information to be furnished pursuant to this Order may be prohibited from receiving further deliveries of any material subject to allocation, and such further action may be taken as is deemed appropriate, including a recommendation for

prosecution under Section 35 (A) of the Criminal Code (18 U. S. C. 80).

(f) **Effective Date.** This Order shall take effect immediately.

Issued this 30th day of March, 1942.

J. S. KNOWLSON
Director of Industry Operations

WAR PRODUCTION BOARD CONSERVATION ORDER M-79 AS AMENDED JUNE 18, 1942—ASBESTOS

Section 1064.1 (Conservation Order No. M-79) is hereby amended to read as follows:

1064.1 Conservation Order M-79—(a) Restrictions on the Use of Certain Types of Asbestos. (1) Unless otherwise specifically authorized by the Director of Industry Operations, no person shall fabricate, spin, or process in any way asbestos fibre imported from South Africa except where such fabrication, spinning, or processing is necessary to fill Defense Orders as defined in Priorities Regulation No. 1, as amended from time to time.

(2) In addition to the above limitation, unless otherwise specifically authorized by the Director of Industry Operations, no person shall fabricate, spin, or process in any way:

(i) Rhodesian chrysotile asbestos fibre of Grade C and G-1 or Grade C and G-2, or Rhodesian chrysotile asbestos having a fibre length equivalent to that of Rhodesian Grade C, G-1 and G-2, except where such fabrication, spinning, or processing is necessary to fill Defense Orders for:

(*a*) Products covered in Navy specification Number 17-I-29 (Insulation, Electrical, Asbestos Fibre, Treated and Untreated, dated January 2, 1942, or as same may be amended).

(*b*) Lapps, yarns, tapes, and cloth which are required by Army, Navy, or Maritime Commission specifications or underwriter's or governmental safety regulations in effect on May 1, 1942, to be of a non-ferrous nature;

(ii) Amosite asbestos fibre of Grade B-1, or amosite asbestos having a fibre length equivalent to that of Grade B-1, except where such fabricating, spinning, or processing is necessary to fill Defense Orders for amosite woven felt blankets and mattresses and fittings for use as insulation on ships.

(iii) Amosite asbestos fibre of Grade B-3 or D-3, or amosite asbestos having a fibre length equivalent to that of Grade B-3 or D-3, except where such fabricating, spinning, or processing is necessary to fill Defense Orders for:

(*a*) Amosite woven felt blankets and mattresses and fittings for use as insulation on ships.

(*b*) Fireproof insulating board for installation on ships.

(*c*) Molded amosite pipe covering and blocks for use as insulation on ships, provided, however, that the amount of D-3 or B-3 or equivalent length amosite fibre used in such pipe covering or blocks shall not exceed 15 per cent by weight of finished product.

(*d*) Flexible amosite pipe insulations for installation on ships.

(b) Restrictions on the Use of Certain Types of Asbestos Pipe Coverings. In addition to the above limitations, no person shall install 85 per cent magnesia pipe covering or other high temperature molded asbestos pipe covering except (1) in installations where temperatures of 212° Fahrenheit or over occur, (2) in installations underground or in ships, or (3) as specifically authorized by the Director of Industry Operations.

(c) Use of Waste Asbestos Materials. Waste or scrap materials produced in the fabrication, spinning, or processing of asbestos fibre imported from South Africa, which cannot be reprocessed and used in fabricating, spinning, or processing operations permitted under the foregoing limitations of this Order, may be sold or disposed of without further restriction.

(d) Reports.

(1) Any person who manufactures or processes any type of asbestos fibre shall on or before the 10th day of each calendar month file with the War Production Board, Ref: M-79, all of the information required by Forms PD-251 and PD-252, whichever is applicable.

(2) Any person who manufactures or processes any type of asbestos fibre shall, when requested, also file with the War Production Board, Ref: M-79, all the information required by Form PD-253.

(e) Prohibitions Against Sales or Deliveries. No person shall hereafter sell or deliver South African asbestos fibre or products made therefrom, to any person if he knows, or has reason to believe, such material or products are to be used in violation of the terms of this Order.

(f) Limitation of Inventories. No person shall receive delivery of Rhodesian or amosite asbestos fibre products in the form of semi-processed materials, finished parts or sub-assemblies, nor shall he put into process said fibre as raw material, in quantities which in either case shall result in an inventory of such semi-processed or finished material in excess of a minimum practicable working inventory, taking into consideration the limitations placed upon the production of asbestos fibre products by this Order.

(g) Miscellaneous Provisions.

(*1*) *Applicability of Priorities Regulation No. 1.* This Order and all transactions affected thereby are subject to the provisions of Priorities Regulation No. 1 (Part 944) as amended from time to time, except to the extent that any provision hereof may be inconsistent therewith, in which case the provisions of this Order shall govern.

(*2*) *Appeal.* Any person affected by this Order who considers that compliance therewith would work an exceptional and unreasonable hardship upon him or that it would result in a degree of unemployment which would be unreasonably disproportionate compared with the amount of asbestos fibre conserved, or that compliance with this Order would disrupt or impair a program of conversion from non-defense work to defense work, may appeal to the War Production Board, Ref: M-79, by letter or other written communication, in duplicate, setting forth the pertinent facts and the reason he considers he is entitled to relief. The Director of Industry Operations may thereupon take such action as he deems appropriate.

(*3*) *Applicability of Order.* The prohibitions and restrictions contained in this Order shall apply to the use of material in all articles hereafter manufactured irrespective of whether such articles are manufactured pursuant to a contract made prior or subsequent to the effective date hereof, or pursuant to a contract supported by a preference rating. Insofar as any other Order of the Director of Industry Operations may have the effect of limiting or curtailing to a greater extent than herein provided the use of asbestos fibre in the production of any article, the limitations of such other Order shall be observed.

(*4*) *Correspondence and Communications.* All reports required to be filed hereunder, and all communications concerning this Order, shall, unless otherwise directed, be addressed to: War Production Board, Washington, D. C., Ref: M-79.

(*5*) *Violations.* Any person who willfully violates any provision of this Order, or who, in connection with this Order, willfully conceals a material fact or furnishes false information to any department or agency of the United States is guilty of a crime, and upon conviction may be punished by fine or imprisonment.

In addition, any such person may be prohibited from making or obtaining further deliveries of, or from processing or using, material under priority control and may be deprived of priorities assistance.

Issued this 18th day of June, 1942.

J. S. KNOWLSON
Director of Industry Operations

WAR PRODUCTION BOARD CONSERVATION ORDER M–123 AS AMENDED JULY 4, 1942—ASBESTOS TEXTILES

Section 1172.1 (Conservation Order M–123) is hereby amended to read as follows:

§ 1172.1 Conservation Order M–123. (a) Unless otherwise specifically authorized by the Director of Industry Operations, no manufacturer of asbestos textiles shall use asbestos textiles or deliver asbestos textiles for use except:

(1) In the manufacture of industrial packings or woven friction material; or

(2) On orders bearing a preference rating of A–10 or higher.

(b) Applicability of Priorities Regulation No. 1. This order and all transactions affected thereby are subject to the provisions of Priorities Regulation No. 1 (Part 944), as amended from time to time, except to the extent that any provisions hereof may be inconsistent therewith, in which case the provisions of this order shall govern.

(c) Appeal. Any person affected by this order who considers that compliance therewith would work an exceptional and unreasonable hardship upon him, or that it would result in a degree of unemployment which would be unreasonably disproportionate compared with the amount of asbestos textiles conserved, or that compliance with this order would disrupt or impair a program of conversion from non-defense to defense work, may appeal to the War Production Board by letter or other written communication, in triplicate, setting forth the pertinent facts and the reason he considers he is entitled to relief. The Director of Industry Operations may thereupon take such action as he deems appropriate.

(d) Communications to War Production Board. All reports required to be filed hereunder, and all communications concerning this order, shall, unless otherwise directed, be addressed to: War Production Board, Cork-Asbestos Branch, Washington, D. C., Ref.: M–123.

(e) Violations. Any person who willfully violates any provision of this order, or who, in connection with this order willfully conceals a material fact or furnishes false information to any department or agency of the United States is guilty of a crime, and upon conviction may be punished by fine or imprisonment. In addition, any such person may be prohibited from making or obtaining further deliveries of, or from processing or using, material under priority control and may be deprived of priorities assistance.

(P.D. Reg. 1, as amended, 6 F.R. 6680; W.P.B. Reg. 1, 7 F.R. 561; E.O. 9024, 7 F.R. 329; E.O. 9040, 7 F.R. 527; E.O. 9125, 7 F. R. 2719; sec. 2 (a), Pub. Law 671, 76th Cong., as amended by Pub. Laws 89 and 507, 77th Cong.)

Issued this 4th day of July 1942.

J. S. KNOWLSON
Director of Industry Operations.

WAR PRODUCTION BOARD CONSERVATION ORDER M–79 AS OF SEPTEMBER 30, 1942

WHEREAS national defense requirements have created a shortage of certain types of asbestos for the combined needs of defense, private account, and export; and the supply now is and will be insufficient for defense and essential civilian requirements unless their use in certain products manufactured for civilian use is curtailed; and it is necessary in the public interest, to promote the defense of the United States, to conserve the supply and direct the distribution thereof:

Now, therefore, it is hereby ordered,

That:

§ 1064.1 Conservation Order M–79—(a) Restrictions on the Use of Certain Types of Asbestos. (1) Unless otherwise specifically authorized by the Director General for Operations, no person shall fabricate, spin, or process in any way asbestos fibre imported from South Africa except where such fabrication, spinning, or processing is necessary to fill defense orders as defined in Priorities Regulation No. 1, as amended from time to time.

(2) In addition to the above limitation, unless otherwise specifically authorized by the Director General for Operations, no person shall fabricate, spin, or process in any way:

(i) Rhodesian chrysotile asbestos fibre of Grade C and G–1 or Grade C and G–2, or Rhodesian chrysotile asbestos having a fibre length equivalent to that of Rhodesian Grade C, G–1 and G–2, except where such fabrication, spinning, or processing is necessary to fill defense orders for:

(*a*) Products covered in Navy specification Number 17–I–29 (Insulation, Electrical, Asbestos Fibre, Treated and Untreated, dated January 2, 1942, or as same may be amended).

(*b*) Lapps, yarns, tapes, and cloth which are required by Army, Navy, or Maritime Commission specifications or underwriter's or governmental safety regulations in effect on May 1, 1942, to be of a non-ferrous nature;

(ii) Amosite asbestos fibre of Grade B–1, or amosite asbestos having a fibre length equivalent to that of Grade B–1, except where such fabricating, spinning, or processing is necessary to fill defense orders for amosite woven felt blankets and mattresses and fittings for use as insulation on ships.

(iii) Amosite asbestos fibre of Grade B–3 or D–3, or amosite asbestos having a fibre length equivalent to that of Grade B–3 or D–3, except where such fabricating, spinning, or processing is necessary to fill defense orders for:

(*a*) Amosite woven felt blankets and mattresses and fittings for use as insulation on ships.

(*b*) Fireproof insulating board for installation on ships.

(*c*) Molded amosite pipe covering and blocks for use as insulation on ships: *Provided, however*, That the amount of D–3 or B–3 or equivalent length amosite fibre used in such pipe covering or blocks shall not exceed 15 per cent by weight of finished product.

(*d*) Flexible amosite pipe insulations for installation on ships.

(b) Restrictions on the Use of Certain Types of Asbestos Pipe Coverings. In addition to the above limitations, no person shall install 85 per cent magnesia pipe covering or other high temperature molded asbestos pipe covering except (1) in installations where temperatures of 212° Fahrenheit or over occur, (2) in installations underground or in ships, or (3) as specifically authorized by the Director General for Operations.

(c) Use of Waste Asbestos Materials. Waste or scrap materials produced in the fabrication, spinning, or processing of asbestos fibre imported from South Africa, which cannot be reprocessed and used in fabricating, spinning, or processing operations permitted under the foregoing limitations of this order, may be sold or disposed of without further restriction.

(d) Reports. (1) Any person who manufactures or processes any type of asbestos fibre shall on or before

the 10th day of each calendar month file with the War Production Board, Ref.: M–79, all of the information required by Forms PD–251 and PD–252, whichever is applicable.

(2) Any person who manufactures or processes any type of asbestos fibre shall, when requested, also file with the War Production Board, Ref.: M–79, all the information required by Form PD–253.

(e) **Prohibitions Against Sales or Deliveries.** No person shall after June 18, 1942, sell or deliver South African asbestos fibre or products made therefrom, to any person if he knows, or has reason to believe, such material or products are to be used in violation of the terms of this order.

(f) **Limitation of Inventories.** No person shall receive delivery of Rhodesian or amosite asbestos fibre products in the form of semi-processed materials, finished parts or sub-assemblies, nor shall he put into process said fibre as raw material, in quantities which in either case shall result in an inventory of such semi-processed or finished material in excess of a minimum practicable working inventory, taking into consideration the limitations placed upon the production of asbestos fibre products by this order.

(g) **Miscellaneous Provisions**—(*1*) *Applicability of Priorities Regulation 1.* This order and all transactions affected thereby are subject to the provisions of Priorities Regulation 1 (Part 944) as amended from time to time, except to the extent that any provision hereof may be inconsistent therewith, in which case the provisions of this order shall govern.

(*2*) *Appeal.* Any person affected by this order who considers that compliance therewith would work an exceptional and unreasonable hardship upon him or that it would result in a degree of unemployment which would be unreasonably disproportionate compared with the amount of asbestos fibre conserved, or that compliance with this order would disrupt or impair a program of conversion from non-defense work to defense work, may appeal to the War Production Board, Ref.: M–79, by letter or other written communication, in duplicate, setting forth the pertinent facts and the reason he considers he is entitled to relief. The Director General for Operations may thereupon take such action as he deems appropriate.

(*3*) *Applicability of Order.* The prohibitions and restrictions contained in this order shall apply to the use of material in all articles manufactured after June 18, 1942, irrespective of whether such articles are manufactured pursuant to a contract made prior or subsequent to June 18, 1942, or pursuant to a contract supported by a preference rating. Insofar as any other order of the Director General for Operations may have the effect of limiting or curtailing to a greater extent than herein provided the use of asbestos fibre in the production of any article, the limitations of such other order shall be observed.

(*4*) *Correspondence and Communications.* All reports required to be filed hereunder, and all communications concerning this order, shall, unless otherwise directed, be addressed to: War Production Board, Washington, D. C., Ref.: M–79.

(*5*) *Violations.* Any person who willfully violates any provision of this order, or who, in connection with this order, willfully conceals a material fact or furnishes false information to any department or agency of the United States is guilty of a crime, and upon conviction may be punished by fine or imprisonment. In addition, any such person may be prohibited from making or obtaining further deliveries of, or from processing or using, material under priority control and may be deprived of priorities assistance.

(P. D. Reg. 1, as amended, 6 F. R. 6680; W. P. B. Reg. 1, 7 F. R. 561; E. O. 9024, 7 F. R. 329; E. O. 9040, 7 F. R. 527; E. O. 9125, 7 F. R. 2719; sec. 2 (a), Pub. Law 671, 76th Cong., as amended by Pub. Laws 89 and 507, 77th Cong.)

Issued June 18, 1942.

WAR PRODUCTION BOARD CONSERVATION ORDER M–123 AS AMENDED DECEMBER 14, 1942—ASBESTOS TEXTILES

Section 1172.1 (Conservation Order M–123) is hereby amended to read as follows:

§ 1172.1 Conservation Order M–123—(a) Definitions. For the purposes of this order:

(1) "Asbestos textile" means any material produced from the mineral asbestos by a carding operation. The term also includes such material at any stage of process subsequent to the carding operation, except where it has become a finished item, or part thereof, or has been physically incorporated in a finished item, or part thereof. The term does not include scrap.

(2) "Supplier" means any person who produces any asbestos textiles in any form, either for use by himself as a manufacturer or for sale to other manufacturers. The term also includes any person who offers any asbestos textile for sale to manufacturers.

(3) "Manufacturer" means any person who uses any asbestos textile to manufacture or fabricate a finished item.

(4) "Put into process" means the first change by the manufacturer in the form of material from that form in which it is received by him.

(5) "Process" means change in any way the size, form, shape, or characteristics of the material. It also means assemble.

(6) "Assemble" means combine or add parts, whether of asbestos textile or any other material, with or to other products or parts manufactured or fabricated in whole or in part of asbestos textile, where the final product will not be a finished item ready for immediate sale or use without the combination or addition of such products or parts. The term shall not be deemed to include the putting together of a finished item after delivery to a sales outlet or consumer in knockdown form pursuant to an established custom. The term shall also not be deemed to include adding finished parts to an otherwise finished item where the placing of one or more finished parts, or the size or type of one or more finished parts, is determined by the use to which the ultimate consumer is to put the item.

(7) "Finished item" means oil burner wicking or any item on List A or List B.

(8) "Inventory" of a person includes the inventory of affiliates and subsidiaries of such person, and the inventory of others where such inventory is under the control of, or under common control with, or available for the use of, such person.

(9) "Implements of war" means combat and products, complete for tactical operations (including, but not limited to, aircraft, ammunition, armament, weapons, ships, tanks, and military vehicles), and any parts, assemblies, and materials to be incorporated in any of the foregoing items being produced for the Army or the Navy of the United States, the Maritime Commission, the War Shipping Administration, or for any foreign government pursuant to the act approved March 11, 1941, entitled "An Act to Promote the Defense of the United States" (Lend-Lease Act), where the use of any asbestos textile to the extent employed is required by the latest issue of government specifications (including performance specifications, unless otherwise directed by the Director General for Operations) applicable to the contract, subcontract, or purchase order. The term does not include facilities or equipment used to manufacture the foregoing items.

(10) "Scrap" means any asbestos textile, the further process of which as an asbestos textile is not practicable.

(b) **Restrictions on Delivery of Asbestos Textiles.** On and after December 14, 1942, no supplier shall deliver any asbestos textile to any manufacturer when he knows, or has reason to know, that such manufacturer will receive or use such asbestos textile in violation of the terms of this order.

(c) **Restrictions on Manufacture of List A Products**—(*1*) *Putting into Process.* On and after December 14, 1942, no manufacturer shall put into process any asbestos textile to make any item on List A or part thereof.

(*2*) *Processing.* On and after December 14, 1942, a manufacturer may continue the processing of any asbestos textile already in process on such date to make any item on List A or part thereof, provided the processing thereof will be completed on or before February 1, 1943. On and after February 1, 1943, no manufacturer shall process in any way any asbestos textile to make any item on List A or part thereof.

(d) **Restrictions on Manufacture of List B Products.** On and after the governing date specified in List B, no manufacturer in the manufacture of any item on List B shall put into process any asbestos textile of a grade containing a greater percentage of asbestos than underwriter's grade as defined in paragraph (5) (a) of A. S. T. M. Designation: D299–37.

(e) **Restrictions on Manufacture of Oil Burner Wicking.** In the period between December 14, 1942, and January 1, 1943, and in any calendar month thereafter, no manufacturer shall put into process any asbestos textile in the manufacture of oil burner wicking in excess of 1/24 of the aggregate amount by weight of such asbestos textile put into process by such manufacturer in the manufacture of oil burner wicking in the calendar year 1941.

(f) **Restrictions on Delivery of Finished Items.** No person shall deliver or accept delivery of any finished item which he knows, or has reason to know, was manufactured in violation of the terms of this order.

(g) **General Exception.** Except as provided in paragraph (f), none of the provisions of this order shall be deemed to limit or restrict the sale, delivery, or use of any finished item, or the further processing of any such item, provided such further processing is necessary for purposes of installation, application, servicing, or repair of such item.

(h) **Limitations of Inventories**—(*1*) *Suppliers' Inventories.* No supplier shall produce asbestos textiles which shall result in an inventory of such material in excess of a minimum practicable working inventory, taking into consideration the limitations placed upon the use of asbestos textiles by this order.

(*2*) *Manufacturers' Inventories.* No manufacturer shall receive delivery of any asbestos textile in the form of raw materials, semi-processed materials, finished parts or sub-assemblies, nor shall he put into process any raw material in quantities which in either case shall result in an inventory of raw, semi-processed, or finished material in excess of a minimum practicable working inventory, taking into consideration the limitations placed upon the use of asbestos textiles by this order.

(i) **Reports.** Each supplier, each manufacturer, and every other person affected by this order shall file such reports as may be requested from time to time by the Director General for Operations.

(j) **Miscellaneous Provisions**—(*1*) *Appeal.* Any appeal from the provisions of this order shall be made by filing a letter in triplicate, referring to the particular provision appealed from and stating fully the grounds of the appeal.

(*2*) *Applicability of Order.* The prohibitions and restrictions contained in this order shall apply to the use of material in all items manufactured after December 14, 1942, irrespective of whether such items are manufactured pursuant to a contract made prior or subsequent to such date. Insofar as any other order of the Director General for Operations may have the effect of limiting or curtailing to a greater extent than herein provided the use of asbestos textile in the production of any item, the limitations of such other order shall be observed.

(*3*) *Applicability of Priorities Regulations.* This order and all transactions affected thereby are subject to all applicable provisions of the priorities regulations of the War Production Board, as amended from time to time.

(*4*) *Communications to War Production Board.* All reports required to be filed hereunder, and all communications concerning this order, shall, unless otherwise directed, be addressed to: War Production Board, Cork-Asbestos Division, Washington, D. C., Ref.: M–123.

(*5*) *Violations.* Any person who willfully violates any provision of this order, or who, in connection with this order, willfully conceals a material fact or furnishes false information to any department or agency of the United States is guilty of a crime, and upon conviction may be punished by fine or imprisonment. In addition, any such person may be prohibited from making or obtaining further deliveries of, or from processing or using, material under priority control and may be deprived of priorities assistance.

(P.D. Reg. 1, as amended, 6 F.R. 6680; W.P.B. Reg. 1, 7 F.R. 561; E.O. 9024, 7 F.R. 329; E.O. 9040, 7 F.R. 527; E.O. 9125, 7 F. R. 2719; sec. 2 (a), Pub. Law 671, 76th Cong., as amended by Pub. Laws 89 and 507, 77th Cong.)

Issued this 14th day of December 1942.

ERNEST KANZLER,
Director General for Operations.

RESTRICTED USES OF ASBESTOS TEXTILES UNDER CONSERVATION ORDER M–123 AS AMENDED DECEMBER 14, 1942

LIST A

1. Theater curtains and scenery.
2. Vibration eliminators (except for implements of war).
3. Gun covers.
4. Radiator hose (except for implements of war).
5. Ammunition containers.
6. Fire stops in automotive vehicles, buses, or trucks.
7. Conveyor belts (except for glass industry).
8. Heaters and heater accessories (except for implements of war).
9. Filter sacks for liquids.
10. Parachute flare shields.
11. Clutch facing for automotive vehicles (except for implements of war), in accordance with numbers assigned by the Brake Lining Manufacturers Association in B. L. M. A. Catalog as shown in the 1939 edition, the 1940 supplement to the 1939 edition, and the 1941 edition, to-wit:

416	732	902A	946
506	736A	905	953A
516	736B	905A	953C
614	738	905D	953D
620	821B	905E	953E
621	827	905F	954
621A	859	909	955
628	862A	909A	955A
629	862B	909B	955B
636	880	929B	956
637	891	929D	956A
638	896A	930–1	966
718	898	940	967
719B	900	941A	967A

968	990A	1047	1059B
968B	991	1047A	1068
969	991A	1051	1072
975	991B	1052	1142B
979	993	1053	1142C
980	993A	1056	1154A
982	994	1057	1169
985	995	1057A	1169A
985A	999	1057B	1170
987	1005A	1057C	1173
988	1007A	1058	1181
988A	1008A	1059	
990	1033	1059A	

12. Brake lining in widths less than 2″ or in thickness less than ¼″ (except for implements of war and except for B. L. M. A. Nos. 336 and 341A).

LIST B

	Governing date
1. Laminated plastics	February 14, 1943.
2. Mechanical packing or gasket material, which means any asbestos textile material which has been graphited, friction treated, or otherwise treated with an adhesive or impregnating substance, for use as, or for use in the manufacture of, mechanical packings or gaskets (except that produced from blue asbestos fiber, and except for implements of war)	December 14, 1942.

WAR PRODUCTION BOARD CONSERVATION ORDER M–283—ASBESTOS TEXTILES

The fulfillment of requirements for the defense of the United States has created a shortage in the supply of asbestos textiles for defense, for private account, and for export; and the following order is deemed necessary and appropriate in the public interest and to promote the national defense:

§ 1172.3 Conservation Order M–283—(a) Definitions. For the purposes of this order:

(1) "Asbestos textiles" means any material initially produced from the mineral asbestos by means of a carding operation and includes all such material in the following forms subsequent to the carding operation:

Carded fiber.
Plain roving (underwriter's and commercial).
Plain roving (above underwriter's grade).
Reinforced roving.
Cable filler.
Lapps.
Wick made from roving.
Wick made on wicking card.
Yarn—single.
Yarn—plied.
Yarn—metallic.
Cloth—1¼ pounds per square yard and lighter, all weaves.
Cloth—heavier than 1¼ pounds per square yard, non-metallic, plain weave.
Cloth—heavier than 1¼ pounds per square yard, metallic, plain weave.
Cloth—all weights, metallic and non-metallic other than plain weave.
Tape—.010 to .025″ thick.
Tape—1/32″ thick and up.
Cord—Plain or treated.
Tubing—woven or braided.

(2) "Supplier" means any person who produces asbestos textiles from the mineral asbestos by means of a carding operation.

(3) "Consumer" means any person who purchases or accepts delivery of asbestos textiles from a supplier for resale, or for use in the manufacture of other forms of asbestos textiles or of articles made in whole or in part of asbestos textiles, or for any other use. A supplier, who uses asbestos textiles which he has produced in the manufacture of any product which is not itself an asbestos textile as defined in paragraph (a) (1), shall be deemed also to be a consumer.

(b) Restrictions on Use and Delivery of Asbestos Textiles. (1) On and after April 1, 1943, no supplier shall deliver asbestos textiles, and no person shall accept delivery of asbestos textiles from a supplier, except upon specific authorization by the Director General for Operations upon application pursuant to paragraph (d) or except as provided in paragraph (c).

(2) Each person specifically authorized to accept delivery of asbestos textiles shall use such asbestos textiles for the purpose for which the authorization was requested, except as otherwise directed by the Director General for Operations.

(3) The Director General for Operations at his discretion may at any time issue special directions to any person, with respect to the use, process to final product, delivery, acceptance of delivery, or placing of orders, of asbestos textiles by such person, notwithstanding the provision of paragraph (c) hereof, or special directions to any supplier with respect to the kinds of asbestos textiles which he may or must manufacture, and the grades and types of asbestos fiber which he may or must use in the production of asbestos textiles.

(4) Such authorizations and directions will be made to ensure the satisfaction of requirements, direct and indirect, for the defense of the United States and for essential civilian supply; and may also be made in consideration of any possible dislocation of labor, of the problems of transportation, including cross-hauling, and of the necessity of keeping a plant in operation so that it may be able to fulfill war orders and essential requirements; and may be issued, and, unless otherwise specified by the Director General for Operations, shall be complied with, without regard to preference ratings.

(c) Small Order Exemption. (1) Any person may accept delivery of 100 pounds or less of asbestos textiles in the aggregate during any one calendar month without specific authorization, provided that such person has not been specifically authorized to accept delivery of any quantity of asbestos textiles during such month; and

(2) Any supplier may deliver asbestos textiles without specific authorization to any person who shall certify to him in writing that he is entitled, pursuant to paragraph (c) (1), to accept delivery, provided that:

(i) No supplier shall deliver in the aggregate in any calendar month, pursuant to this paragraph (c), an amount in excess of 5 per cent by weight of his actual shipments of asbestos textiles for the preceding month;

(ii) No supplier shall make deliveries during any calendar month, pursuant to this paragraph (c), if such deliveries will prevent completion of any deliveries which have been specifically authorized for such month;

(iii) Such certification shall be signed by an authorized official, either manually or as provided in Priorities Regulation No. 7, and shall be in substantially the following form:

The undersigned hereby certifies pursuant to War Production Board Order M–283 that the requested delivery of asbestos textiles plus other deliveries of asbestos textiles heretofore accepted during the month for which delivery is requested does not exceed 100 pounds in the aggregate; and that the undersigned has not been specifically authorized by the War Production Board to accept delivery of any quantity of asbestos textiles during the month for which delivery is requested.

Dated _____

By _____
Authorized Official

(iv) No supplier shall make deliveries, even against such certification, if he knows or has reason to believe that the certification is false; but in the absence of such

knowledge or reason to believe, he may rely on such certification.

(3) For the purpose of this paragraph (c), the 100 pounds exemption for each person shall be deemed to extend only to an individual, partnership, association, business trust, corporation, governmental corporation or agency, or other business organization as a unit, and shall not be deemed to extend to each division, plant, store, or purchasing agency of such unit.

(d) Applications and Reports—(*1*) *Consumers.* Each consumer seeking authorization to accept delivery of asbestos textiles during any calendar month shall file application on Form PD–779. Six copies shall be prepared, of which three (with table II left blank) shall be forwarded, not later than the 1st day of the month preceding the month for which authorization for delivery is requested, to the supplier with whom the order or orders described in such application are placed, and two (with table II filled out) shall be sent, not later than the 10th day of the month preceding the month for which authorization for delivery is requested, to the War Production Board. A separate set of forms shall be prepared for each plant location of the applicant and for each supplier from whom the delivery of asbestos textiles is sought.

(*2*) *Suppliers.* Suppliers shall seek authorization to deliver asbestos textiles only to consumers who have filed with them Form PD–779 in triplicate. Each supplier seeking authorization to make such deliveries to any consumer during any calendar month shall fill out all three copies of Form PD–779 received from such consumer, indicating thereon his proposed deliveries during such month to such consumer, and shall file two of such copies with the War Production Board on or before the 15th day of the month preceding the month for which delivery is requested by the consumer.

(*3*) *Other Reports.* All persons affected by this order shall file such other reports as may be requested from time to time by the Director General for Operations.

(e) Special Provisions. (1) Each supplier who consumes all or part of his production of asbestos textiles in the manufacture of any product which is not itself an asbestos textile, as defined in paragraph (a) (1), shall treat the production and consumption parts of his operations as separate divisions, and delivery to himself for consumption shall be deemed delivery, requiring authorization within the meaning of paragraph (b) (1). Each such supplier in his separate capacity as a consumer and as a supplier shall file all the applications and reports required by paragraphs (d) (1) and (d) (2). A supplier who consumes all or any part of his production of asbestos textiles in the manufacture of products which are not asbestos textiles as defined in subparagraph (a) (1) must request allocation only for that type of asbestos textile that immediately precedes the manufacturing process which changes its form beyond that shown in the list of asbestos textiles in paragraph (a) (1).

(2) Each supplier shall notify the War Production Board of the cancellation by a consumer of any authorized delivery or of his own inability to make authorized delivery within 5 days after he has notice of such fact.

(f) Miscellaneous Provisions—(*1*) *Applicability of Priorities Regulations.* This order and all transactions affected thereby are subject to all applicable provisions of the priorities regulations of the War Production Board, as amended from time to time.

(*2*) *Communications to War Production Board.* All reports required to be filed hereunder, and all communications concerning this order, shall, unless otherwise directed, be addressed to: War Production Board, Cork-Asbestos and Fibrous Glass Division, Washington, D. C., Ref.: M–283.

(*3*) *Violations.* Any person who willfully violates any provision of this order, or who, in connection with this order, willfully conceals a material fact or furnishes false information to any department or agency of the United States is guilty of a crime, and upon conviction may be punished by fine or imprisonment. In addition, any such person may be prohibited from making or obtaining further deliveries of, or from processing or using, material under priority control and may be deprived of priorities assistance.

Issued this 9th day of February 1943.

CURTIS E. CALDER,
Director General for Operations.

WAR PRODUCTION BOARD CONSERVATION ORDER M–283 AS AMENDED MARCH 17, 1943—ASBESTOS TEXTILES

The fulfillment of requirements for the defense of the United States has created a shortage in the supply of asbestos textiles for defense, for private account, and for export; and the following order is deemed necessary and appropriate in the public interest and to promote the national defense:

§ 1172.3 Conservation Order M–283—(a) Definitions. For the purposes of this order:

(1) "Asbestos textiles" means any material initially produced from the mineral asbestos by means of a carding operation and includes all such material in the following forms subsequent to the carding operation:

NOTE: Items pertaining to wicks were deleted March 17, 1943.

Carded fiber.
Plain roving (underwriter's and commercial).
Plain roving (above underwriter's grade).
Reinforced roving.
Cable filler.
Lapps.
Yarn—single.
Yarn—plied.
Yarn—metallic.
Cloth—1¼ pounds per square yard and lighter, all weaves.
Cloth—heavier than 1¼ pounds per square yard, non-metallic, plain weave.
Cloth—heavier than 1¼ pounds per square yard, metallic, plain weave.
Cloth—all weights, metallic and non-metallic other than plain weave.
Tape—.010 to .025" thick.
Tape—1/32" thick and up.
Cord—plain or treated.
Tubing—woven or braided.

(2) "Supplier" means any person who produces asbestos textiles from the mineral asbestos by means of a carding operation.

(3) "Consumer" means any person who purchases or accepts delivery of asbestos textiles from a supplier for resale, or for use in the manufacture of other forms of asbestos textiles or of articles made in whole or in part of asbestos textiles, or for any other use. A supplier, who uses asbestos textiles which he has produced in the manufacture of any product which is not itself an asbestos textile as defined in paragraph (a) (1), shall be deemed also to be a consumer.

(b) Restrictions on Use and Delivery of Asbestos Textiles. (1) On and after April 1, 1943, no supplier shall deliver asbestos textiles, and no person shall accept delivery of asbestos textiles from a supplier, except upon specific authorization by the Director General for Operations upon application pursuant to paragraph (d) or except as provided in paragraph (c).

(2) Each person specifically authorized to accept delivery of asbestos textiles shall use such asbestos textiles for the purpose for which the authorization was requested, except as otherwise directed by the Director General for Operations.

(3) The Director General for Operations at his discretion may at any time issue special directions to any person with respect to the use, process to final product, delivery, acceptance of delivery, or placing of orders of

asbestos textiles by such person notwithstanding the provision of paragraph (c) hereof, or special directions to any supplier with respect to the kinds of asbestos textiles which he may or must manufacture, and the grades and types of asbestos fiber which he may or must use in the production of asbestos textiles.

(4) Such authorizations and directions will be made to ensure the satisfaction of requirements, direct and indirect, for the defense of the United States and for essential civilian supply; and may also be made in consideration of any possible dislocation of labor, of the problems of transportation, including cross-hauling, and of the necessity of keeping a plant in operation so that it may be able to fulfill war orders and essential requirements and may be issued, and, unless otherwise specified by the Director General for Operations, shall be complied with, without regard to preference ratings.

(c) Small Order Exemption. (1) Any person may accept delivery of 100 pounds or less of asbestos textiles in the aggregate during any one calendar month without specific authorization, provided that such person has not been specifically authorized to accept delivery of any quantity of asbestos textiles during such month; and

(2) Any supplier may deliver asbestos textiles without specific authorization to any person who shall certify to him in writing that he is entitled, pursuant to paragraph (c) (1), to accept delivery, provided that:

(i) No supplier shall deliver in the aggregate in any calendar month pursuant to this paragraph (c), an amount in excess of 5 per cent by weight of his actual shipment of asbestos textiles for the preceding month;

(ii) No supplier shall make deliveries during any calendar month, pursuant to this paragraph (c), if such deliveries will prevent completion of any deliveries which have been specifically authorized for such month;

(iii) Such certification shall be signed by an authorized official, either manually or as provided in Priorities Regulation No. 7 and shall be in substantially the following form:

> The undersigned hereby certifies pursuant to War Production Board Order M–283 that the requested delivery of asbestos textiles plus other deliveries of asbestos textiles heretofore accepted during the month for which delivery is requested does not exceed 100 pounds in the aggregate; and that the undersigned has not been specifically authorized by the War Production Board to accept delivery of any quantity of asbestos textiles during the month for which delivery is requested.
>
> Dated_____
>
> _____
>
> By_____
>
> Authorized Official

(iv) No supplier shall make deliveries, even against such certification, if he knows or has reason to believe that the certification is false; but in the absence of such knowledge or reason to believe, he may rely on such certification.

(3) For the purpose of this paragraph (c), the 100 pounds exemption for each person shall be deemed to extend only to an individual, partnership, association, business trust, corporation, governmental corporation or agency, or other business organization as a unit, and shall not be deemed to extend to each division, plant, store, or purchasing agency of such unit.

(d) Applications and Reports—(*1*) *Consumers.* Each consumer seeking authorization to accept delivery of asbestos textiles during any calendar month shall file application on Form PD–779. Six copies shall be prepared, of which three (with table II left blank) shall be forwarded, not later than the 1st day of the month preceding the month for which authorization for delivery is requested, to the supplier with whom the order or orders described in such application are placed, and two (with table II filled out) shall be sent, not later than the 10th day of the month preceding the month for which authorization for delivery is requested, to the War Production Board. A separate set of forms shall be prepared for each plant location of the applicant and for each supplier from whom the delivery of asbestos textiles is sought.

(*2*) *Suppliers.* Suppliers shall seek authorization to deliver asbestos textiles only to consumers who have filed with them Form PD–779 in triplicate. Each supplier seeking authorization to make such deliveries to any consumer during any calendar month shall fill out all three copies of Form PD–779 received from such consumer, indicating thereon his proposed deliveries during such month to such consumer, and shall file two of such copies with the War Production Board on or before the 15th day of the month preceding the month for which delivery is requested by the consumer.

(*3*) *Other Reports.* All persons affected by this order shall file such other reports as may be requested from time to time by the Director General for Operations.

(e) Special Provisions. (1) Each supplier who consumes all or part of his production of asbestos textiles in the manufacture of any product which is not itself an asbestos textile, as defined in paragraph (a) (1), shall treat the production and consumption parts of his operations as separate divisions, and delivery to himself for consumption shall be deemed delivery, requiring authorization within the meaning of paragraph (b) (1). Each such supplier in his separate capacity as a consumer and as a supplier shall file all the applications and reports required by paragraphs (d) (1) and (d) (2). A supplier who consumes all or any part of his production of asbestos textiles in the manufacture of products which are not asbestos textiles as defined in subparagraph (a) (1) must request allocation only for that type of asbestos textile that immediately precedes the manufacturing process which changes its form beyond that shown in the list of asbestos textiles in paragraph (a) (1).

(2) Each supplier shall notify the War Production Board of the cancellation by a consumer of any authorized delivery or of his own inability to make authorized delivery within 5 days after he has notice of such fact.

(f) Miscellaneous Provisions—(*1*) *Applicability of Priorities Regulations.* This order and all transactions affected thereby are subject to all applicable provisions of the priorities regulations of the War Production Board, as amended from time to time.

(*2*) *Communications to War Production Board.* All reports required to be filed hereunder, and all communications concerning this order, shall, unless otherwise directed, be addressed to: War Production Board, Cork-Asbestos and Fibrous Glass Division, Washington, D. C., Ref: M–283.

(*3*) *Violations.* Any person who willfully violates any provision of this order, or who, in connection with this order, willfully conceals a material fact or furnishes false information to any department or agency of the United States is guilty of a crime, and upon conviction may be punished by fine or imprisonment. In addition, any such person may be prohibited from making or obtaining further deliveries of, or from processing or using, material under priority control and may be deprived of priorities assistance.

Issued this 17th day of March 1943.

CURTIS E. CALDER,
Director General for Operations.

WAR PRODUCTION BOARD SUPPLEMENTARY CONSERVATION ORDER L–41–d—CONSTRUCTION

In accordance with the provisions of § 1075.1, *Conservation Order L–41*, which the following order supplements:

§ 1075.11 Supplementary Conservation Order L–41–d. Conservation Order L–41, as amended, shall not apply to the re-siding of any structure with asbestos siding or the re-roofing of any structure with asbestos roofing material, where any part of the existing siding or roofing, as the case may be, is in need of repainting or other maintenance and repair: *Provided, however,* That no rubber, metal other than fastenings, nor lumber restricted by the provisions of paragraph (c) of Conservation Order M–208 shall be used in such re-siding or re-roofing.

Paragraph (e) of Interpretation No. 1 of Conservation Order L–41 as amended is hereby revoked.

Issued this 16th day of April 1943.

WAR PRODUCTION BOARD,
By J. JOSEPH WHELAN,
Recording Secretary.

WAR PRODUCTION BOARD CONSERVATION ORDER M–79 AS AMENDED OCTOBER 1, 1943—CORK, ASBESTOS, AND FIBROUS GLASS [1]

ASBESTOS

Section 3301.6 [1] (Conservation Order M–79) is amended to read as follows:

§ 3301.6 (Conservation Order M–79)—(a) References to Canadian Grades. References to Canadian grades of asbestos are in accordance with the Canadian Chrysotile Asbestos Classification as revised December 1, 1942, and adopted by the Quebec Asbestos Producers Association March 22, 1943.

(b) Restrictions on the Use of South African Asbestos. (1) No person shall process Rhodesian chrysotile asbestos Grade C&G/1 or C&G/2 or Rhodesian chrysotile asbestos having a fibre length equivalent to that of Rhodesian Grade C&G/1 or C&G/2, except for:

(i) Products covered in Navy Specification No. 17–I–29 (Insulation, Electrical, Asbestos Fibre, Treated and Untreated, dated January 2, 1942, or, as same may be amended), or

(ii) Rovings, lapps, yarns, tapes, and cloth which are approved or required to be of non-ferrous nature by Army, Navy, or Maritime Commission performance or other specifications or underwriters or governmental safety regulations in effect May 1, 1942.

(2) No person shall process amosite asbestos Grades B–1, B–3, D–3, or 3/DM–1, or amosite asbestos having a fibre length equivalent to that of Grades B–1, B-3, D–3, or 3/DM–1, except for:

(i) Amosite woven insulating felt for use on ships, or

(ii) Fireproof insulating board for use on ships, or

(iii) Molded amosite insulations provided, however, that the amount of 3/DM–1, B–3, or D–3 or equivalent length amosite fibre used in such insulations shall not exceed 15 per cent by weight of finished product, or

(iv) Flexible amosite pipe insulation for use on ships.

(c) Restrictions on Canadian Asbestos. On and after November 1, 1943:

(1) No person shall process Canadian crudes or spinning fibre Grades 3F or 3K for asbestos textiles of commercial grade (as defined in paragraph (7) (a) of A. S. T. M. Designation D–299–42).

(2) No person shall accept delivery of Canadian crudes or spinning fibre Grades 3F or 3K for the manufacture of compressed asbestos sheet packing.

(3) No person shall accept delivery of Canadian fibre Grades 3F, 3K, 3R, or 3T for the manufacture of 85% magnesia or other high temperature molded insulations.

(4) No person shall put into process Canadian spinning fibre Grades 3F or 3K at a greater monthly rate than his average monthly consumption for June and July 1943.

(5) No person shall put into process during any one calendar month Canadian spinning fibre Grades 3R or 3T in amount by weight greater than 20 per cent of the finished compressed asbestos sheet packing which he produced during that month.

(6) No person shall process Canadian spinning fibre Grade 3R for textile purposes during any calendar month unless during that month he uses at least one ton of Rhodesian fibre Grade C&G/3 for every five tons of Canadian spinning fibre Grade 3R.

(d) Exemption for Waste Asbestos Materials. Waste or scrap materials produced in the fabrication, spinning, or processing of asbestos fibre, which cannot be reprocessed and used in fabricating, spinning, or processing operations permitted under the foregoing limitations of this order, may be sold or disposed of without restriction under this order.

(e) Reports. The War Production Board may send copies of Form WPB–2916, WPB–2917, or WPB–2918 (formerly PD–251, PD–252, and PD–253) to any person who manufactures any product containing asbestos or who maintains a stock of asbestos. The person receiving the forms shall return them with the required information to the War Production Board on or before the following 10th of the month.

(f) Prohibitions Against Sales or Deliveries. No person shall sell or deliver asbestos fibre or any product made therefrom if he knows or has reason to believe such material or product is to be used in violation of the terms of this order.

(g) Special Directions. The War Production Board at its discretion may at any time issue special directions to any person with respect to his use, processing, delivery, or acceptance of delivery of any grade or type of asbestos, notwithstanding any other provision of this order.

(h) Miscellaneous Provisions—(*1*) *Applicability of Regulations.* This order and all transactions affected thereby are subject to all applicable regulations of War Production Board, as amended from time to time.

(*2*) *Appeals.* Any appeal from the provisions of this order shall be made by filing a letter in triplicate, referring to the particular provision appealed from and stating fully the grounds of the appeal.

(*3*) *Forms.* Forms WPB–2916, WPB–2917, and WPB–2918, referred to in paragraph (e), have been approved by the Bureau of the Budget in accordance with Federal Reports Act of 1942.

(*4*) *Violations.* Any person who willfully violates any provision of this order, or who, in connection with this order, willfully conceals a material fact or furnishes false information to any department or agency of the United States Government is guilty of a crime, and upon conviction may be punished by fine or imprisonment. In addition, any such person may be prohibited from making or obtaining further deliveries of, or from processing or using material under priority control and may be deprived of priorities assistance.

(*5*) *Communications to War Production Board.* All reports required to be filed hereunder, and all communications concerning this order, shall, unless otherwise directed, be addressed to: War Production Board, Cork, Asbestos and Fibrous Glass Division, Washington 25, D. C., Ref.: M–79.

Issued this 1st day of October 1943.

WAR PRODUCTION BOARD,
By J. JOSEPH WHELAN,
Recording Secretary.

[1] Formerly Part 1064; § 1064.1.

WAR PRODUCTION BOARD CONSERVATION ORDER M-123, REVOCATION—ASBESTOS TEXTILES

Section 1172.1 Conservation Order M-123 is hereby revoked. The subject matter of this order is now covered by § 3301.16, Conservation Order M-283.

Issued this 11th day of October 1943.

WAR PRODUCTION BOARD,
By J. JOSEPH WHELAN,
Recording Secretary.

WAR PRODUCTION BOARD CONSERVATION ORDER M-79 AS AMENDED JANUARY 31, 1944—CORK, ASBESTOS, AND FIBROUS GLASS

ASBESTOS

§ 3301.6 (Conservation Order M-79)—(a) References to Canadian Grades. References to Canadian grades of asbestos are in accordance with the Canadian Chrysotile Asbestos Classification as revised December 1, 1942, and adopted by the Quebec Asbestos Producers Association March 22, 1943.

(b) Restrictions on the Use of South African Asbestos. (1) No person shall process Rhodesian Chrysotile Asbestos Grade C&G/1 or C&G/2, or Rhodesian chrysotile asbestos having a fibre length equivalent to that of Rhodesian Grade C&G/1 or C&G/2 except for:

(i) Products covered in Navy Specification No. 17-I-29 (Insulation, Electrical, Asbestos Fibre, Treated and Untreated, dated January 2, 1942, or as same may be amended), or

(ii) Rovings, lapps, yarns, tapes, and cloth which are approved or required to be of non-ferrous nature by Army, Navy, Maritime Commission or War Shipping Administration performance or other specifications or underwriters or governmental safety regulations in effect May 1, 1942.

Provided, however, That one ton of Rhodesian Asbestos Grade C&G/1 and C&G/2 may be used for other textile purposes during any calendar quarter for every five tons of Rhodesian Asbestos Grade C&G/3 used for textile purposes during the same calendar quarter.

(2) No person shall process amosite asbestos Grades B-1, B-3, D-3, or 3/DM-1, or amosite asbestos having a fibre length equivalent to that of Grades B-1, B-3, D-3, or 3/DM-1, except for:

(i) Amosite woven insulating felt for use on ships, or

(ii) Fireproof insulating board for use on ships, or

(iii) Molded amosite insulations provided, however, that the amount of 3/DM-1, B-3, or D-3 or equivalent length amosite fibre used in such insulations shall not exceed 15 per cent by weight of finished product, or

(iv) Flexible amosite pipe insulation for use on ships.

(c) Restrictions on Canadian Asbestos. On and after November 1, 1943:

(1) No person shall process Canadian crudes or spinning fibre Grades 3F or 3K for asbestos textiles of commercial grade (as defined in paragraph (7) (a) of A. S. T. M. Designation D-299-42).

(2) No person shall accept delivery of Canadian crudes or spinning fibre Grades 3F or 3K for the manufacture of compressed asbestos sheet packing.

(3) No person shall accept delivery of Canadian fibre Grades 3F, 3K, 3R, or 3T for the manufacture of 85% magnesia or other high temperature molded insulations.

(4) No person shall put into process Canadian spinning fibre Grades 3F or 3K at a greater monthly rate than his average monthly consumption for June and July 1943.

(5) No person shall put into process during any one calendar month Canadian spinning fibre Grades 3R or 3T in amount by weight greater than 20 per cent of the finished compressed asbestos sheet packing which he produced during that month.

(6) No person shall process Canadian spinning fibre Grade 3R for textile purposes during any calendar quarter unless during that quarter he uses at least one ton of Rhodesian Fibre Grade C&G/3 for textile purposes for every five tons of Canadian Spinning Fibre Grade 3R.

(d) Exemption for Waste Asbestos Materials. Waste or scrap materials produced in the fabrication, spinning, or processing of asbestos fibre which cannot be reprocessed and used in fabricating, spinning, or processing operations permitted under the foregoing limitations of this order, may be sold or disposed of without restriction under this order.

(e) Reports. The War Production Board may send copies of Form WPB-2916, WPB-2917, or WPB-2918 (formerly PD-251, PD-252, and PD-253) to any person who manufactures any product containing asbestos or who maintains a stock of asbestos. The person receiving the forms shall return them with the required information to the War Production Board on or before the following 10th of the month.

(f) Prohibitions Against Sales or Deliveries. No person shall sell or deliver asbestos fibre or any product made therefrom if he knows or has reason to believe such material or product is to be used in violation of the terms of this order.

(g) Special Directions. The War Production Board at its discretion may at any time issue special directions to any person with respect to his use, processing, delivery or acceptance of delivery of any grade or type of asbestos, notwithstanding any other provision of this order.

(h) Miscellaneous Provisions—(*1*) *Applicability of Regulations.* This order and all transactions affected thereby are subject to all applicable regulations of War Production Board, as amended from time to time.

(*2*) *Appeals.* Any appeal from the provisions of this order shall be made by filing a letter in triplicate, referring to the particular provision appealed from and stating fully the grounds of the appeal.

(*3*) *Forms.* Forms WPB-2916, WPB-2917, and WPB-2918, referred to in paragraph (e), have been approved by the Bureau of the Budget in accordance with Federal Reports Act of 1942.

(*4*) *Violations.* Any person who willfully violates any provision of this order, or who, in connection with this order, willfully conceals a material fact or furnishes false information to any department or agency of the United States Government is guilty of a crime, and upon conviction may be punished by fine or imprisonment. In addition, any such person may be prohibited from making or obtaining further deliveries of, or from processing or using material under priority control and may be deprived of priorities assistance.

(*5*) *Communications to War Production Board.* All reports required to be filed hereunder, and all communications concerning this order, shall, unless otherwise directed, be addressed to: War Production Board, Cork, Asbestos and Fibrous Glass Division, Washington 25, D. C., Ref.: M-79.

Issued this 31st day of January 1944.

WAR PRODUCTION BOARD,
By J. JOSEPH WHELAN,
Recording Secretary.

WAR PRODUCTION BOARD CONSERVATION ORDER M–79 AS AMENDED DECEMBER 8, 1944—CORK, ASBESTOS, AND FIBROUS GLASS

ASBESTOS

§ 3301.6 Conservation Order M–79—(a) References to Canadian Grades. References to Canadian grades of asbestos are in accordance with the Canadian Chrysotile Asbestos Classification as revised December 1, 1942, and adopted by the Quebec Asbestos Producers Association March 22, 1943.

(b) [Revoked Dec. 8, 1944.]

(c) Restrictions on Canadian Asbestos. On and after November 1, 1943: (1) No person shall process Canadian crudes or spinning fibre Grades 3F or 3K for asbestos textiles of commercial grade (as defined in paragraph (7) (a) of A. S. T. M. Designation D–299–42).

(2) No person shall accept delivery of Canadian crudes or spinning fibre Grades 3F or 3K for the manufacture of compressed asbestos sheet packing.

(3) No person shall accept delivery of Canadian fibre Grades 3F, 3K, 3R, or 3T for the manufacture of 85% magnesia or other high temperature molded insulations.

(4) No person shall put into process Canadian spinning fibre Grades 3F or 3K at a greater monthly rate than his average monthly consumption for June and July 1943.

(5) No person shall put into process during any one calendar month Canadian spinning fibre Grades 3R or 3T in amount by weight greater than 20 per cent of the finished compressed asbestos sheet packing which he produced during that month.

(6) No person shall process Canadian spinning fibre Grade 3R for textile purposes during any calendar quarter unless during that quarter he uses at least one ton of Rhodesian Fibre Grade C&G/3 for textile purposes for every five tons of Canadian Spinning Fibre Grade 3R.

(d) Exemption for Waste Asbestos Materials. Waste or scrap materials produced in the fabrication, spinning or processing of asbestos fibre which cannot be reprocessed and used in fabricating, spinning, or processing operations permitted under the foregoing limitations of this order, may be sold or disposed of without restriction under this order.

(e) Reports. The War Production Board may send copies of Form WPB–2917 or WPB–2918 to any person who manufactures any product containing asbestos or who maintains a stock of asbestos. The person receiving the forms shall return them with the required information to the War Production Board on or before the following 10th of the month.

(f) Prohibitions Against Sales or Deliveries. No person shall sell or deliver asbestos fibre or any product made therefrom if he knows or has reason to believe such material or product is to be used in violation of the terms of this order.

(g) Special Directions. The War Production Board at its discretion may at any time issue special directions to any person with respect to his use, processing, delivery, or acceptance of delivery of any grade or type of asbestos, notwithstanding any other provision of this order.

(h) Miscellaneous Provisions—(*1*) *Applicability of regulations.* This order and all transactions affected thereby are subject to all applicable regulations of War Production Board, as amended from time to time.

(*2*) *Appeals.* Any appeal from the provisions of this order shall be made by filing a letter in triplicate, referring to the particular provision appealed from and stating fully the grounds of the appeal.

(*3*) *Forms.* Forms WPB–2917 and WPB–2918, referred to in paragraph (e), have been approved by the Bureau of the Budget in accordance with Federal Reports Act of 1942.

(*4*) *Violations.* Any person who willfully violates any provision of this order, or who, in connection with this order, willfully conceals a material fact or furnishes false information to any department or agency of the United States Government is guilty of a crime, and upon conviction may be punished by fine or imprisonment. In addition, any such person may be prohibited from making or obtaining further deliveries of, or from processing or using material under priority control and may be deprived of priorities assistance.

(*5*) *Communications to War Production Board.* All reports required to be filed hereunder, and all communications concerning this order, shall, unless otherwise directed, be addressed to: War Production Board, Cork, Asbestos and Fibrous Glass Division, Washington 25, D. C., Ref.: M–79.

Issued this 8th day of December 1944.

WAR PRODUCTION BOARD,
By J. JOSEPH WHELAN,
Recording Secretary.

WAR PRODUCTION BOARD CONSERVATION ORDER M–283 AS AMENDED JANUARY 4, 1945—CORK, ASBESTOS, AND FIBROUS GLASS [1]

ASBESTOS TEXTILES

Section 3301.16 [1] *Conservation Order M–283* is amended to read:

§ 3301.16 Conservation Order M–283—(a) Definitions. (1) "Asbestos textiles" means any material initially produced from the mineral asbestos by means of a carding operation and includes all such material in the following forms subsequent to the carding operation, including scrap:

Carded fiber.
Plain roving (underwriter's and commercial).
Plain roving (above underwriter's grade).
Reinforced roving.
Cable filler.
Lapps.
Yarn—single.
Yarn—plied.
Yarn—metallic.
Cloth—1¼ pounds per square yard and lighter, all weaves.
Cloth—heavier than 1¼ pounds per square yard, non-metallic, plain weave.
Cloth—heavier than 1¼ pounds per square yard, metallic, plain weave.
Cloth—all weights, metallic and non-metallic other than plain weave.
Tape—.010 to .025" thick.
Tape—1/32" thick and up.
Cord—plain or treated.
Tubing—woven or braided.

(2) "Supplier" means any person who produces asbestos textiles from the mineral asbestos by means of a carding operation.

(3) "Consumer" means any person who purchases or accepts delivery of asbestos textiles from a supplier for resale, or use in the manufacture of other forms of asbestos textiles or of articles made in whole or in part of asbestos textiles, or for any other use. A supplier, who uses asbestos textiles which he has produced in the manufacture of any product which is not itself an asbestos textile as defined in paragraph (a) (1), shall be deemed also to be a consumer.

(4) "Implements of war" means combat end products, complete for tactical operations (including, but

[1] Formerly Part 1172, § 1172.3.

not limited to, aircraft, ammunition, armament, weapons, ships, tanks and military vehicles), and any parts, assemblies, and materials to be incorporated in any of the foregoing items being produced for the Army or the Navy of the United States, the Maritime Commission, the War Shipping Administration, Veterans Administration, or for any foreign government pursuant to the act approved March 11, 1941, entitled "An Act to Promote the Defense of the United States" (Lend-Lease Act), where the use of any asbestos textiles to the extent employed is required by the latest issue of government specifications (including performance specifications, unless otherwise directed by the War Production Board) applicable to the contract, subcontract, or purchase order. The term does not include facilities or equipment used to manufacture the foregoing items.

(b) Restrictions on Delivery and Use. (1) No supplier shall deliver or use asbestos textiles and no person shall accept delivery of asbestos textiles from a supplier, except as specifically authorized in writing by War Production Board, upon application pursuant to paragraph (d).

(2) War Production Board may from time to time issue special directions to any person with respect to his use, processing to final product, delivery, acceptance of delivery, or placing of orders, of asbestos textiles, notwithstanding the provision of paragraph (c), or special directions to any supplier with respect to the kinds of asbestos textiles which he may or must manufacture, and the grades and types of asbestos fiber which he may or must use in the production of asbestos textiles.

(3) No supplier shall deliver any asbestos textiles to any person if he knows or has reason to believe that such person would receive or use it in violation of the terms hereof, nor may any person deliver or accept delivery of any item which he knows or has reason to believe was manufactured in violation of the terms hereof.

(4) Each supplier shall notify the War Production Board of his inability to make authorized delivery, or of cancellation by a consumer of any authorized delivery, within 5 days after he has notice of such fact.

(c) Small Order Exemption. Specific authorization shall not be required for:

(1) Any person to accept delivery of 500 pounds or less of asbestos textiles in the aggregate from all sources during any calendar month, provided that he has not been specifically authorized to accept delivery of any quantity of asbestos textiles during such month; and

(2) Any supplier to deliver 500 pounds or less of asbestos textiles to any person in any calendar month, provided that:

(i) No supplier shall deliver in the aggregate in any calendar month, pursuant to this paragraph (c), an amount in excess of 5 per cent by weight of his actual shipment of asbestos textiles for the preceding month;

(ii) No supplier shall make deliveries during any calendar month, pursuant to this paragraph (c), if such deliveries will prevent completion of any deliveries which have been specifically authorized for such month.

(3) For the purposes of paragraphs (c) (1) and (c) (2) above, the term "person" means usual purchasing unit, whether plant, distributing agency, corporation, or other legal entity.

(d) Applications and Reports—(*1*) *Consumers.* Each consumer seeking authorization to accept delivery of asbestos textiles during any calendar month shall file application on Form WPB–2137 as prescribed in that form.

(*2*) *Suppliers.* Suppliers shall seek authorization to deliver asbestos textiles only to consumers who have filed with them WPB–2137 as prescribed in that form.

(3) Applications for allocations of plain roving, reinforced roving, cable filler, and lapps for incorporation into Navy cable shall be made on a calendar quarterly basis on Form WPB–2137.2 as prescribed therein, beginning with the first quarter of 1945.

NOTE: Subparagraph (4) formerly (3) redesignated Jan. 4, 1945.

(4) War Production Board may from time to time issue special instructions with respect to the method or time of filing or content of WPB Form 2137.

(e) Separation of Functions. Each supplier who consumes all or part of his production of asbestos textiles in the manufacture of any product which is not itself an asbestos textile, as defined in paragraph (a) (1), shall treat the production and consumption parts of his operations as separate divisions, and delivery to himself for consumption shall be deemed delivery, requiring authorization within the meaning of paragraph (b) (1). Each such supplier in his separate capacity as a consumer and as a supplier shall file all the applications and reports required by paragraphs (d) (1), (d) (2), and (d) (3). A supplier who consumes all or any part of his production of asbestos textiles in the manufacture of products which are not asbestos textiles as defined in paragraph (a) (1) must request allocation only for that type of asbestos textile that immediately precedes the manufacturing process which changes its form beyond that shown in the list of asbestos textiles in paragraph (a) (1).

(f) Restrictions on Manufacture of List A Products. No person shall use any asbestos textile in the manufacture of any item, or part for an item, on List A.

(g) Restrictions on Manufacture of List B Products. On and after the governing date specified in List B, no person in the manufacture of any item on List B shall use any asbestos textile which is either of a grade (in terms of percentage of asbestos content) higher than the grade specified in List B, or is of a cut finer than the cut specified in List B.

(h) [Revoked Jan. 4, 1945.]

(i) Miscellaneous provisions—(*1*) *Applicability of Regulations.* This order and all transactions affected hereby are subject to all applicable War Production Board regulations, as amended from time to time.

(*2*) *Forms. Forms WPB–2137 and WPB–2137.2* referred to in paragraph (d) have been approved by the Bureau of the Budget in accordance with Federal Reports Act of 1942.

(*3*) *Violations.* Any person who willfully violates any provision of this order, or who, in connection with this order, willfully conceals a material fact or furnishes false information to any department or agency of the United States government, is guilty of a crime, and upon conviction may be punished by fine or imprisonment. In addition, any such person may be prohibited from making or obtaining further deliveries of, or from processing or using, material under priority control, and may be deprived of priorities assistance.

(*4*) *Communications to War Production Board.* All reports required to be filed hereunder, and all communications concerning this order, shall, unless otherwise directed, be addressed to: War Production Board, Cork, Asbestos and Fibrous Glass Division, Washington 25, D. C., Ref.: M–283.

Issued this 4th day of January 1945.

WAR PRODUCTION BOARD,
By J. JOSEPH WHELAN,
Recording Secretary.

RESTRICTED USES OF ASBESTOS TEXTILES UNDER CONSERVATION ORDER M-283 AS AMENDED OCTOBER 11, 1943

LIST A

1. Theatre curtains and scenery.
2. Vibration eliminators (except for implements of war).
3. Gun covers.
4. Radiator hose (except for implements of war).
5. Ammunition containers.
6. Fire stops in automotive vehicles, buses, or trucks.
7. Covering for heat insulation, except:

(i) As cuffs not over 12 inches long on pipe covering ends next to flanges or fittings where pipe temperature may under normal operating conditions exceed 500 degrees.

(ii) Where outside covering is next to hot metals such as steam boilers or auxiliaries.

(iii) On downcomer piping inside boiler casing.

(iv) For making portable flanges and fitting covers.

8. Yarn for heaters and heater accesories (except for implements of war, except for electric heater cords to the extent permitted under Order L-277 as from time to time amended, and except for heater cords to be used in connection with electric soldering irons).
9. Filter sacks for liquids.
10. Parachute flare shields.
11. Clutch facing for automotive vehicles (except for implements of war), in accordance with numbers assigned by the Brake Lining Manufacturers Association in B. L. M. A. Catalog as shown in the 1939 edition, the 1940 supplement to the 1939 edition, and the 1941 edition, to-wit:

416	900	967	1033
506	902A	967A	1047
516	905	968	1047A
614	905A	968B	1051
620	905D	969	1052
621	905E	975	1053
621A	905F	979	1056
628	909	980	1057
629	909A	982	1057A
636	909B	985	1057B
637	929B	985A	1057C
638	929D	987	1058
718	930-1	988	1059
719B	940	988A	1059A
732	941A	990	1059B
736A	946	990A	1068
736B	953A	991	1072
738	953C	991A	1142B
821B	953D	991B	1142C
827	953E	993	1154A
859	954	993A	1169
862A	955	994	1169A
862B	955A	995	1170
880	955B	999	1173
891	956	1005A	1181
896A	956A	1007A	
898	966	1008A	

12. Brake lining in widths less than 2 inches or in thickness less than ¼ inch (except for implements of war and except for B. L. M. A. Nos. 336 and 341A).

LIST B

Item	Governing date	Grade (max. % of asbestos)	Minimum permissible cut
1. Laminated plastics	February 14, 1943	Underwriters	
2. Mechanical packing or gasket material made of asbestos textile material which has been graphited, friction treated, or otherwise treated with an adhesive or impregnating substance, for use as, or for use in the manufacture of, mechanical packings or gaskets (except that produced from blue asbestos fiber, and except for valve rings, seamless boiler gaskets, and implements of war)	October 18, 1943	Commercial	10
3. Friction material	October 18, 1943	Commercial	10

WAR PRODUCTION BOARD CONSERVATION ORDER M-79 AS AMENDED MARCH 20, 1945—CORK, ASBESTOS, AND FIBROUS GLASS

ASBESTOS

The fulfillment of requirements for the defense of the United States has created a shortage in the supply of asbestos for defense, for private account, and for export; and the following order is deemed necessary and appropriate in the public interest and to promote the national defense:

§ 3301.6 Conservation Order M-79—(a) References to Canadian Grades. References to Canadian grades of asbestos are in accordance with the Canadian Chrysotile Asbestos Classification as revised December 1, 1942, and adopted by the Quebec Asbestos Producers Association March 22, 1943.

(b) [Revoked Dec. 8, 1944.]

(c) Restrictions on Canadian Asbestos. On and after November 1, 1943: (1) No person shall process Canadian crudes or spinning fibre Grades 3F or 3K for asbestos textiles of commercial grade (as defined in paragraph (7) (a) of A. S. T. M. Designation D-299-42).

(2) No person shall accept delivery of Canadian crudes or spinning fibre Grades 3F or 3K for the manufacture of compressed asbestos sheet packing.

(3) No person shall accept delivery of Canadian fibre Grades 3F, 3K, 3R, or 3T for the manufacture of 85% magnesia or other high temperature molded insulations.

(4) No person shall put into process Canadian spinning fibre Grades 3F or 3K at a greater monthly rate than his average monthly consumption for June and July 1943.

(5) No person shall put into process during any one calendar month Canadian spinning fibre Grades 3R or 3T in amount by weight greater than 20 per cent of the finished compressed asbestos sheet packing which he produced during that month.

(6) No person shall process Canadian spinning fibre Grade 3R for textile purposes during any calendar quarter unless during that quarter he uses at least one

ton of Rhodesian Fibre Grades C&G/1, C&G/2, and C&G/3 in the aggregate for textile purposes for every five tons of Canadian Spinning Fibre Grade 3R.

(d) Exemption for Waste Asbestos Materials. Waste or scrap materials produced in the fabrication, spinning, or processing of asbestos fibre which cannot be reprocessed and used in fabricating, spinning, or processing operations permitted under the foregoing limitations of this order, may be sold or disposed of without restriction under this order.

(e) Reports. The War Production Board may send copies of Form WPB–2917 or WPB–2918 to any person who manufactures any product containing asbestos or who maintains a stock of asbestos. The person receiving the forms shall return them with the required information to the War Production Board on or before the following 10th of the month.

(f) Prohibitions Against Sales or Deliveries. No person shall sell or deliver asbestos fibre or any product made therefrom if he knows or has reason to believe such material or product is to be used in violation of the terms of this order.

(g) Special Directions. The War Production Board at its discretion may at any time issue special directions to any person with respect to his use, processing, delivery, or acceptance of delivery of any grade or type of asbestos, notwithstanding any other provision of this order.

(h) Miscellaneous Provisions—(1) *Applicability of Regulations.* This order and all transactions affected thereby are subject to all applicable regulations of War Production Board, as amended from time to time.

(2) *Appeals.* Any appeal from the provisions of this order shall be made by filing a letter in triplicate, referring to the particular provision appealed from and stating fully the grounds of the appeal.

(3) *Forms.* Forms WPB–2917 and WPB–2918, referred to in paragraph (e), have been approved by the Bureau of the Budget in accordance with Federal Reports Act of 1942.

(4) *Violations.* Any person who willfully violates any provision of this order, or who, in connection with this order, willfully conceals a material fact or furnishes false information to any department or agency of the United States Government is guilty of a crime, and upon conviction may be punished by fine or imprisonment. In addition, any such person may be prohibited from making or obtaining further deliveries of, or from processing or using, material under priority control and may be deprived of priorities assistance.

(5) *Communications to War Production Board.* All reports required to be filed hereunder, and all communications concerning this order, shall, unless otherwise directed, be addressed to: War Production Board, Cork, Asbestos and Fibrous Glass Division, Washington 25, D. C., Ref.: M–79.

Issued this 20th day of March 1945.

WAR PRODUCTION BOARD,
By J. JOSEPH WHELAN,
Recording Secretary.

WAR PRODUCTION BOARD CONSERVATION ORDER L–41–d, REVOCATION—CONSTRUCTION

Section 1075.11 Supplementary Conservation Order L–41–d is revoked.

Issued this 29th day of May 1945.

WAR PRODUCTION BOARD,
By J. JOSEPH WHELAN,
Recording Secretary.

WAR PRODUCTION BOARD CONSERVATION ORDER M–283 AS AMENDED AUGUST 11, 1945—CORK, ASBESTOS, AND FIBROUS GLASS

ASBESTOS TEXTILES

§ 3301.16 Conservation Order M–283—(a) Definitions. (1) "Asbestos textiles" means any material initially produced from the mineral asbestos by means of a carding operation and includes all such material in the following forms subsequent to the carding operation, including scrap:

Carded fiber.
Plain roving (underwriter's and commercial).
Plain roving (above underwriter's grade).
Reinforced roving.
Cable filler.
Lapps.
Yarn—single.
Yarn—plied.
Yarn—metallic.
Cloth—1¼ pounds per square yard and lighter, all weaves.
Cloth—heavier than 1¼ pounds per square yard, non-metallic, plain weave.
Cloth—heavier than 1¼ pounds per square yard, metallic, plain weave.
Cloth—all weights, metallic and non-metallic other than plain weave.
Tape—.010 to .025" thick.
Tape—1/32" thick and up.
Cord—plain or treated.
Tubing—woven or braided.

(2) "Supplier" means any person who produces asbestos textiles from the mineral asbestos by means of a carding operation.

(3) "Consumer" means any person who purchases or accepts delivery of asbestos textiles from a supplier for resale, or for use in the manufacture of other forms of asbestos textiles or of articles made in whole or in part of asbestos textiles, or for any other use. A supplier, who uses asbestos textiles which he has produced in the manufacture of any product which is not itself an asbestos textile as defined in paragraph (a) (1) shall be deemed also to be a consumer.

(4) "Implements of war" means combat end products, complete for tactical operations (including, but not limited to, aircraft, ammunition, armament, weapons, ships, tanks, and military vehicles), and any parts, assemblies, and materials to be incorporated in any of the foregoing items being produced for the Army or the Navy of the United States, the Maritime Commission, the War Shipping Administration, Veterans Administration, or for any foreign government pursuant to the act approved March 11, 1941, entitled "An Act to Promote the Defense of the United States" (Lend-Lease Act), where the use of any asbestos textiles to the extent employed is required by the latest issue of government specifications (including performance specifications, unless otherwise directed by the War Production Board) applicable to the contract, subcontract, or purchase order. The term does not include facilities or equipment used to manufacture the foregoing items.

(b) Restrictions on Delivery and Use. (1) No supplier shall deliver or use asbestos textiles and no person shall accept delivery of asbestos textiles from a supplier, except as specifically authorized in writing by War Production Board, upon application pursuant to paragraph (d). Even though asbestos textiles have been allocated by the War Production Board for incorporation into friction materials for new civilian passenger cars and trucks, they may not be used for that purpose if to do so will interfere with the production of implements of war or with the filling of rated

orders for which asbestos textiles have been allocated by the War Production Board.

(2) War Production Board may from time to time issue special directions to any person with respect to his use, processing to final product, delivery, acceptance of delivery, or placing of orders, of asbestos textiles, notwithstanding the provision of paragraph (c), or special directions to any supplier with respect to the kinds of asbestos textiles which he may or must manufacture and the grades and types of asbestos fiber which he may or must use in the production of asbestos textiles.

(3) No supplier shall deliver any asbestos textiles to any person if he knows or has reason to believe that such person would receive or use it in violation of the terms hereof, nor may any person deliver or accept delivery of any item which he knows or has reason to believe was manufactured in violation of the terms hereof.

(4) Each supplier shall notify the War Production Board of his inability to make authorized delivery, or of cancellation by a consumer of any authorized delivery, within 5 days after he has notice of such fact.

(c) Small Order Exemption. Specific authorization shall not be required for:

(1) Any person to accept delivery of 500 pounds or less of asbestos textiles in the aggregate from all sources during any calendar month provided that he has not been specifically authorized to accept delivery of any quantity of asbestos textiles during such month; and

(2) Any supplier to deliver 500 pounds or less of asbestos textiles to any person in any calendar month, provided that:

(i) No supplier shall deliver in the aggregate in any calendar month, pursuant to this paragraph (c), an amount in excess of 5 per cent by weight of his actual shipment of asbestos textiles for the preceding month;

(ii) No supplier shall make deliveries during any calendar month, pursuant to this paragraph (c), if such deliveries will prevent completion of any deliveries which have been specifically authorized for such month.

(3) For the purposes of paragraphs (c) (1) and (c) (2) above, the term "person" means usual purchasing unit, whether plant, distributing agency, corporation, or other legal entity.

(d) Applications and Reports—(1) *Consumers.* Each consumer seeking authorization to accept delivery of asbestos textiles during any calendar month shall file application on Form WPB–2137 as prescribed in that form.

(2) *Suppliers.* Suppliers shall seek authorization to deliver asbestos textiles only to consumers who have filed with them WPB–2137 as prescribed in that form.

(3) Applications for allocations of plain roving, reinforced roving, cable filler, and lapps for incorporation into Navy cable shall be made on a calendar quarterly basis on Form WPB–2137.2 as prescribed therein, beginning with the first quarter of 1945.

(4) War Production Board may from time to time issue special instructions with respect to the method or time of filing or content of WPB Form 2137.

(e) Separation of Functions. Each supplier who consumes all or part of his production of asbestos textiles in the manufacture of any product which is not itself an asbestos textile, as defined in paragraph (a) (1), shall treat the production and consumption parts of his operations as separate divisions, and delivery to himself for consumption shall be deemed delivery, requiring authorization within the meaning of paragraph (b) (1). Each such supplier in his separate capacity as a consumer and as a supplier shall file all the applications and reports required by paragraphs (d) (1), (d) (2), and (d) (3). A supplier who consumes all or any part of his production of asbestos textiles in the manufacture of products which are not asbestos textiles as defined in paragraph (a) (1) must request allocation only for that type of asbestos textile that immediately precedes the manufacturing process which changes its form beyond that shown in the list of asbestos textiles in paragraph (a) (1).

(f) Restrictions on Manufacture of List A Products. No person shall use any asbestos textile in the manufacture of any item, or part for an item, on List A.

(g) Restrictions on Manufacture of List B Products. On and after the governing date specified in List B, no person in the manufacture of any item on List B shall use any asbestos textile which is either of a grade (in terms of percentage of asbestos content) higher than the grade specified in List B, or is of a cut finer than the cut specified in List B.

(h) [Revoked Jan. 4, 1945.]

(i) Miscellaneous Provisions. (*1*) *Applicability of regulations.* This order and all transactions affected hereby are subject to all applicable War Production Board regulations, as amended from time to time.

(*2*) *Forms.* Forms WPB–2137 and WPB–2137.2, referred to in paragraph (d), have been approved by the Bureau of the Budget in accordance with Federal Reports Act of 1942.

(*3*) *Violations.* Any person who willfully violates any provision of this order, or who, in connection with this order, willfully conceals a material fact or furnishes false information to any department or agency of the United States Government, is guilty of a crime, and upon conviction may be punished by fine or imprisonment. In addition, any such person may be prohibited from making or obtaining further deliveries of, or from processing or using, material under priority control, and may be deprived of priorities assistance.

(*4*) *Communications to War Production Board.* All reports required to be filed hereunder, and all communications concerning this order, shall, unless otherwise directed, be addressed to: War Production Board, Cork, Asbestos and Fibrous Glass Division, Washington 25, D. C., Ref.: M–283.

(*5*) *Appeals.* Any appeal from the provisions of this order must be made by letter in triplicate addressed to the War Production Board, Cork, Asbestos and Fibrous Glass Division, Washington 25, D. C., Ref.: M–283, referring to the particular provision appealed from, stating fully the grounds of the appeal and setting forth the necessary supporting information. The supporting information shall include:

1. The List A or B product for which the asbestos textiles will be used;
2. The period of time, not exceeding one calendar quarter, for which relief is requested;
3. The monthly schedule of the amount of asbestos textiles which would be required in the production of the List A or B product;
4. The type of asbestos textile to be used and the grade and cut.

Ordinarily consideration will be given only to those appeals where compliance by the appellant or another would work an exceptional and unreasonable hardship on the manufacturer or user of the List A or B product which is not suffered generally by others in the same industry or activity.

Issued this 11th day of August 1945.

WAR PRODUCTION BOARD,
By J. JOSEPH WHELAN,
Recording Secretary.

RESTRICTED USES OF ASBESTOS TEXTILES UNDER CONSERVATION ORDER M-283 AS AMENDED AUGUST 11, 1945

LIST A

1. Theatre curtains and scenery.
2. Vibration eliminators (except for implements of war).
3. Gun covers.
4. Radiator hose (except for implements of war).
5. Ammunition containers.
6. Fire stops in automotive vehicles, buses, or trucks.
7. Covering for heat insulation, except:

(i) As cuffs not over 12 inches long on pipe covering ends next to flanges or fittings where pipe temperature may under normal operating conditions exceed 500 degrees.

(ii) Where outside covering is next to hot metals such as steam boilers or auxiliaries.

(iii) On downcomer piping inside boiler casing.

(iv) For making portable flanges and fitting covers.

8. Yarn for heaters and heater accessories (except for implements of war and except for electric heater cords).
9. Filter sacks for liquids.
10. Parachute flare shields.
11. Clutch facing for automotive vehicles (except for implements of war and except in the production of new passenger cars and trucks authorized by the War Production Board), in accordance with numbers assigned by the Brake Lining Manufacturers Association in B. L. M. A. Catalog as shown in the 1939 edition, the 1940 supplement to the 1939 edition, and the 1941 edition, to-wit:

416	900	967	1033
506	902A	967A	1047
516	905	968	1047A
614	905A	968B	1051
620	905D	969	1052
621	905E	975	1053
621A	905F	979	1056
628	909	980	1057
629	909A	982	1057A
636	909B	985	1057B
637	929B	985A	1057C
638	929D	987	1058
718	930–1	988	1059
719B	940	988A	1059A
732	941A	990	1059B
736A	946	990A	1068
736B	953A	991	1072
738	953C	991A	1142B
821B	953D	991B	1142C
827	953E	993	1154A
859	954	993A	1169
862A	955	994	1169A
862B	955A	995	1170
880	955B	999	1173
891	956	1005A	1181
896A	956A	1007A	
898	966	1008A	

12. Brake lining in widths less than 2 inches or in thickness less than ¼ inch (except for implements of war and except for B. L. M. A. Nos. 336 and 341A and except in the production of new passenger cars and trucks authorized by the War Production Board).

LIST B

Item	Governing date	Grade (max. % of asbestos)	Minimum permissible cut
1. Laminated plastics	February 14, 1943	Underwriters	
2. Mechanical packing or gasket material made of asbestos textile material which has been graphited, friction treated, or otherwise treated with an adhesive or impregnating substance, for use as, or for use in the manufacture of, mechanical packings or gaskets (except that produced from blue asbestos fiber, and except for valve rings, seamless boiler gaskets, and implements of war)	October 18, 1943	Commercial	10
3. Friction material	October 18, 1943	Commercial	10

WAR PRODUCTION BOARD PRIORITIES REGULATION 31 AS AMENDED AUGUST 1945—REGULATIONS APPLICABLE TO THE OPERATION OF THE PRIORITIES SYSTEM

BLANKET REVOCATION OF CERTAIN WPB ORDERS

Section 944.52, *Priorities Regulation 31*, is amended in the following respects:

By adding the following orders to the list of orders revoked:

List of orders revoked and effective date of revocation

BUILDING MATERIALS

Sec. 3284.26, L–303 **Metal Insect Screen Cloth**, August 23, 1945.

CORKS, ASBESTOS, AND FIBROUS GLASS

Sec. 3301.1, M–8–a **Cork**, August 23, 1945.
Sec. 3301.16, M–283 **Asbestos Textiles**, August 31, 1945.

PAPER

Sec. 3270.27, L–261 **Grocers and Variety Bags**, August 23, 1945.
Sec. 3281.91, L–279 **Paper Shipping Sacks**, August 23, 1945.
Sec. 3270.28, L–304 **Specialty Bags (Paper)**, August 23, 1945.

Issued this 23d day of August 1945.

WAR PRODUCTION BOARD.
By J. JOSEPH WHELAN.
Recording Secretary.

WAR PRODUCTION BOARD CONSERVATION ORDERS M–79, ASBESTOS, AND M–283, ASBESTOS TEXTILES, REVOCATION

Conservation Orders M–79, Asbestos, and M–283, Asbestos Textiles, were revoked by Priority Regulation 31 dated August 29, 1945. The effective dates of revocation were August 20, 1945, for M–79, and August 31, 1945, for M–283.

POST WORLD WAR II CONTROLS

As a shortage of spinning fibers developed during the Korean conflict the National Production Authority issued Order M–96 on January 17, 1952, restricting the application of asbestos of spinning grades to direct military and essential civilian uses. The text of M–96 follows.

NATIONAL PRODUCTION AUTHORITY ORDER M–96—SPINNING GRADES OF CHRYSOTILE ASBESTOS FIBRE

This order is found necessary and appropriate to promote the national defense and is issued pursuant to the Defense Production Act of 1950, as amended. In the formulation of this order, there has been consultation with industry representatives, including trade association representatives, and consideration has been given to their recommendations.

Sec.
1. Purpose of this order.
2. Definitions.
3. Allocations and directives.
4. Prohibitions on use.
5. Limitations on use.
6. Exemptions.
7. Request for adjustment or exception.
8. Records and reports.
9. Communications.
10. Violations.

AUTHORITY: Sections 1 to 10 issued under sec. 704, 64 Stat. 816, Pub. Law 96, 82d Cong.; 50 U. S. C. App. Sup. 2154. Interpret or apply sec. 101, 64 Stat. 799, Pub. Law 96, 82d Cong.; 50 U. S. C. App. Sup. 2071. Sec. 101, E. O. 10161, Sept. 9, 1950, 15 F. R. 6105; 3 CFR, 1950 Sup.; sec. 2, E. O. 10200, Jan. 3, 1951, 16 F. R. 61; secs. 402, 405, E. O. 10281, Aug. 28, 1951, 16 F. R. 8789.

Section 1. Purpose of This Order. The purpose of this order is to conserve and provide for the use of spinning grades of chrysotile asbestos fibres so that the limited supply shall be used first to fill directly military and essential civilian uses. It prohibits the use of certain grades of spinning fibre for any other than certain specified end uses, and it limits the use of such fibres in the production of certain end use products.

Sec. 2. Definitions. As used in this order:

(a) "Person" means any individual corporation, partnership, association, or any other organized group of persons, and includes any agency of the United States Government or any other government.

(b) "Spinning grades of chrysotile asbestos fibre" means any one or more of the following spinning grades: (1) Rhodesian chrysotile asbestos Grade C and G1, C and GP1, C and G2, C and GP2, and C and G3; (2) Canadian Crude No. 1, Crude No. 2, crude run of mine, crude sundry, 3F, 3K, 3R, 3T, and 3Z; (3) Arizona Crude No. 1 and Crude No. 2; and (4) chrysotile asbestos fibre from any other sources equivalent to any of the above grades.

(c) "Base period" means the period from January 1, 1948, to December 31, 1950.

(d) "NPA" means the National Production Authority.

Sec. 3. Allocations and Directives. NPA from time to time may allocate one or more spinning grades of chrysotile asbestos fibre and specifically direct the manner and quantities in which deliveries to particular persons or classes of persons or for particular uses or classes of uses shall be made or suspended; and NPA from time to time may issue specific directives to any person as to the source, destination, consignee, amount, or use of such fibres to be delivered to or acquired by such person.

Sec. 4. Prohibitions on Use. On and after February 1, 1952, no person shall accept delivery of or use any spinning grades of chrysotile asbestos fibre for any purpose other than processing into carded fibre, sliver, rovings, lapps, yarns, tapes, or cloths.

Sec. 5. Limitations on Use. (a) On and after February 1, 1952, no person shall put into process or use in any month spinning grades of chrysotile asbestos fibre for any end use specified in Schedule A of this order in excess of the percentage specified in Schedule A of his average monthly use of such fibre for such end use during the base period, nor shall any person use yarn or cloth made from spinning grades of chrysotile asbestos fibre for any end use specified in Schedule A of this order in excess of the percentage specified in Schedule A of his average monthly use of such yarn or cloth for such end use during the base period.

(b) On and after February 1, 1952, no person shall put into process or use in any month Canadian grade 3Z chrysotile asbestos fibre in the production of 85 per cent magnesia or other high temperature insulations in excess of his average monthly consumption of such grade for such purpose during the calendar year 1950. Each producer of such insulation shall report to NPA monthly by letter the amount of his use of Canadian grade 3Z for such manufacture during the preceding month. Such report shall be filed not later than the tenth day of the month commencing with March 1952, and not later than the tenth day of each subsequent month thereafter.

Sec. 6. Exemptions. The provisions of sections 4 and 5 of this order shall not apply to:

(a) The use of Canadian grade chrysotile asbestos fibre in the production of compressed sheet packing or electrolytic paper;

(b) Spinning grade chrysotile asbestos waste or scrap materials produced in the fabrication, spinning, or processing of such asbestos fibre which cannot be reprocessed and used in fabricating, spinning, or processing operations permitted under the provisions of this order;

(c) The acceptance of delivery of spinning grades of chrysotile asbestos fibre directly from a foreign source for the sole purpose of resale in the same form and grade;

(d) Any person who uses 100 pounds or less of spinning grades of chrysotile asbestos fibre during a calendar month.

Sec. 7. Request for Adjustment or Exception. Any person affected by any provision of this order may file a request for adjustment or exception upon the ground that his business operation was commenced during or after the base period, that any provision otherwise works an undue or exceptional hardship upon him not suffered generally by others in the same trade or industry, or that its enforcement against him would not be in the interest of the national defense or in the public interest. In examining requests for adjustment or exception claiming that the public interest is prejudiced by the application of any provision of this order, consideration will be given to the requirements of the public health and safety, civilian defense, and dislocation of labor and resulting unemployment that would impair the defense program. Each request shall be in writing, by letter in triplicate, and shall set forth all pertinent facts, the nature of the relief sought, and the justification therefor.

Sec. 8. Records and Reports. (a) Each person participating in any transaction covered by this order shall

make and preserve, for at least 3 years thereafter, accurate and complete records of receipts, deliveries, inventories, production, and use, in sufficient detail to permit the determination, after audit, whether each transaction complies with the provisions of this order. This order does not specify any particular accounting method and does not require alteration of the system of records customarily used, provided such records supply an adequate basis for audit. Records may be retained in the form of microfilm or other photographic copies instead of the originals by those persons who, at the time such microfilm or other photographic records are made, maintain such copies of records in the regular and usual course of business.

(b) All records required by this order shall be made available for inspection and audit by duly authorized representatives of the National Production Authority, at the usual place of business where maintained.

(c) Persons subject to this order shall make such records and submit such reports to the National Production Authority as it shall require, subject to the terms of the Federal Reports Act of 1942 (5 U. S. C. 139–139F).

Sec. 9. Communications. All communications concerning this order shall be addressed to the National Production Authority, Washington 25, D. C., Ref: NPA Order M–96.

Sec. 10. Violations. Any person who willfully violates any provision of this order, or any other order or regulation of NPA, or who willfully furnishes false information or conceals any material fact in the course of operation under this order, is guilty of a crime and upon conviction may be punished by fine or imprisonment or both. In addition, administrative action may be taken against any such person to suspend his privilege of making or receiving further deliveries of materials or using facilities under priority or allocation control and to deprive him of further priorities assistance.

NOTE: All reporting and record-keeping requirements of this order have been approved by the Bureau of the Budget in accordance with the Federal Reports Act of 1942.

This order shall become effective January 17, 1952.

NATIONAL PRODUCTION AUTHORITY,
BY JOHN B. OLVERSON,
Recording Secretary.

SCHEDULE A OF NPA ORDER M–96

End use	*Percentage*
Theatre safety curtains	50
Gun covers	50
Ironing board covers	50
Passenger car woven brake linings less than ¼ inch thick by 2 inches wide (except for automatic transmissions)	50
Oil burner wicking (except for direct military orders)	70

NATIONAL PRODUCTION AUTHORITY ORDER M–96, REVOCATION—SPINNING GRADES OF CHRYSOTILE ASBESTOS FIBRE

NPA Order M–96 (18 F. R. 1814) is hereby revoked. This revocation does not relieve any person of any obligation or liability incurred under NPA Order M–96 as originally issued or as thereafter amended, nor deprive any person of any rights received or accrued under said order prior to the effective date of this revocation.

(64 Stat. 816, Pub. Law 429, 82d Cong.; 50 U. S. C. App. Sup. 2154)

This revocation is effective May 12, 1953.

NATIONAL PRODUCTION AUTHORITY,
BY GEORGE W. AUXIER,
Executive Secretary.