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Asbestos

by

OLIVER BOWLES.

ASBESTOS

THE SILK *of the* MINERAL KINGDOM

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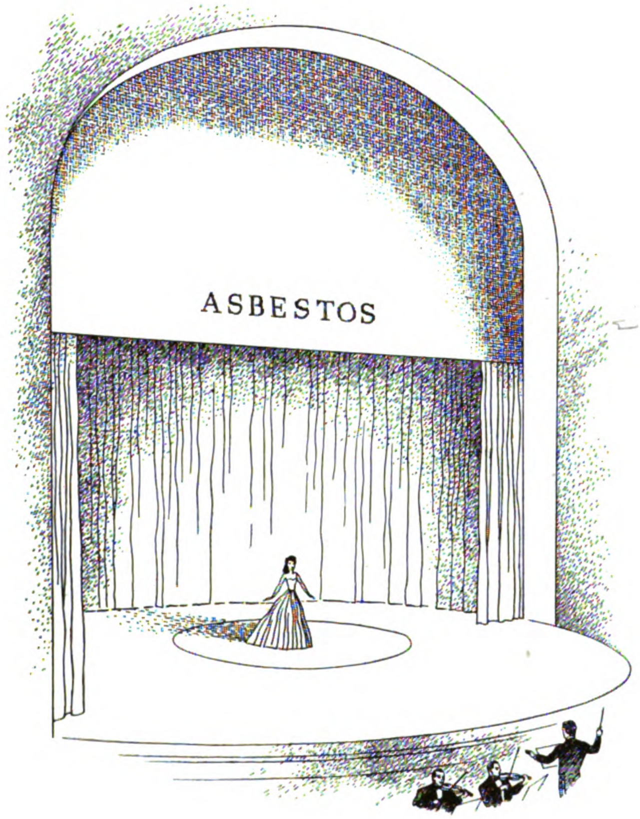


by

OLIVER BOWLES

Preface

Of all the gifts of Nature that serve mankind today, none has a more fascinating history, and few have as many important uses as asbestos.

The story of asbestos through the ages is quite vague and disconnected, and to many people the word asbestos means hardly more than a fireproof curtain in a theater.

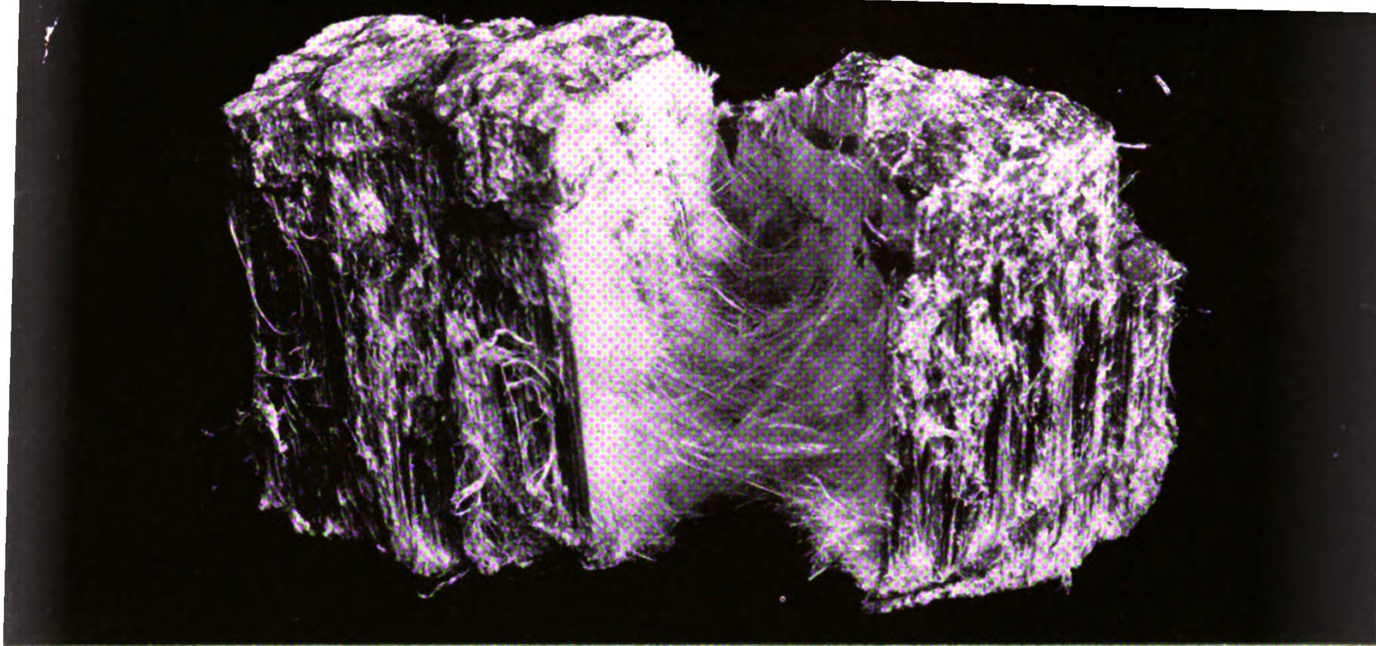
With this in mind—and with the thought that the story of this unique substance may be of interest or help not only to students, teachers and academic research workers, but to business executives, manufacturers, distributors of asbestos products and the public generally—Dr. Oliver Bowles has outlined the salient facts about "the silk of the mineral kingdom" in the following pages.

By reason of his long experience as a trained observer and the exhaustive studies he has made in connection with his work as Chief of the Nonmetal Economics Division of the United States Bureau of Mines, Dr. Bowles is widely recognized as one of the foremost authorities on this subject. It is, therefore, gratifying to me and my associates to publish his treatise and send it on its mission of industrial education.

HERBERT ABRAHAM
President, The Ruberoid Co.

December, 1946

Contents



Chapter I

ANIMAL, VEGETABLE OR MINERAL?

To the scientist, asbestos is a physical paradox, being both fibrous and crystalline. It is a rock that may be spun into yarn—a yarn that can be woven into a soft flexible cloth that will not burn. Asbestos thus becomes a connecting link joining the animal and vegetable kingdoms with the realm of minerals.

The other natural fibrous materials that may be so utilized by humanity are wool from the sheep's fleece, silk from the cocoon of a caterpillar, and cotton from the farmer's field crops.

The wool of commerce derived from flocks of sheep reared and grazed by herders on plains and mountains, and the millions of bales of cotton picked in southern fields, are produced by nature shortly before they are utilized by industry. Silk likewise makes a rapid journey from its Oriental cocoon to American fabric. Contrasted with these animal and vegetable fibers that have a brief and ephemeral existence, the mineral fibers of asbestos were created millions of years ago by obscure and mysterious processes, and hidden away in the dark recesses of the earth until uncovered by the miner and put to human use. No mulberry tree, herder's flock, cotton plant, or any other propagating organism is needed to furnish asbestos fibers.

Supplies that are probably adequate to meet all prospective needs throughout the entire span of future human history have already been produced in Nature's factory, awaiting only the discovery of additional rocky storehouses as the demands of industry continue to develop.

A Boon To Humanity

This strange fibrous mineral is to many people merely a curiosity, furnishing museum specimens illustrating Nature's whimsical and freakish tendencies. From the scientific viewpoint alone asbestos is remarkable, but combined therewith are innumerable practical applications which are proving of inestimable value to mankind.

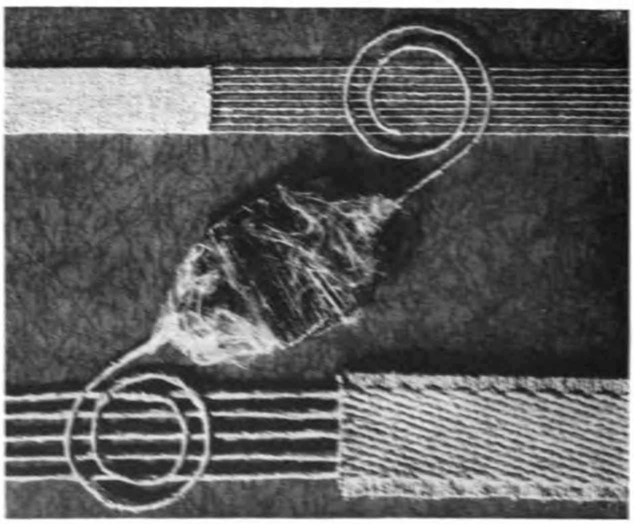
The secret of the great usefulness of asbestos lies in its unique combination of qualities—its fibrous structure, its fire resistance, its flexibility, its strength, its imperviousness to water, and its resistance to chemical action and decay.

So indispensable has asbestos become, that we make almost constant use of it as we go about our daily business or pleasures.

In the brake linings and clutch facings that make possible the combined speed and safety of the modern automobile, in the fireproof roofs and walls that today protect so many of our homes and factories, in materials that insulate buildings from heat and cold, in the fireproof curtains in theatres, and projection rooms that safeguard us at the "movies"—in these and countless other ways, asbestos brings greatly increased safety and comfort.

Blast furnaces and steel mills, electric power stations and gas plants, railroads, ships, pipe-lines, and factories of almost every description, depend in some degree on asbestos for their operation. From among these few examples alone it will be seen that asbestos is one of the important contributors to the machine age.

Contrasted with these outstanding uses are others as humble as pads for use on ironing boards



From crude asbestos to finished fireproof fabrics.

and for the protection of tablecloths and table tops, range-boiler jackets, refrigerator linings, supports for cooking vessels on gas stoves, and materials for protecting wooden walls and floors from scorching by heaters or furnaces. Such articles function as fire protectors, fuel conservers or heat insulators; they are modest but efficient, non-spectacular but utilitarian.

Between these extremes is a vast field where asbestos supplies innumerable needs.

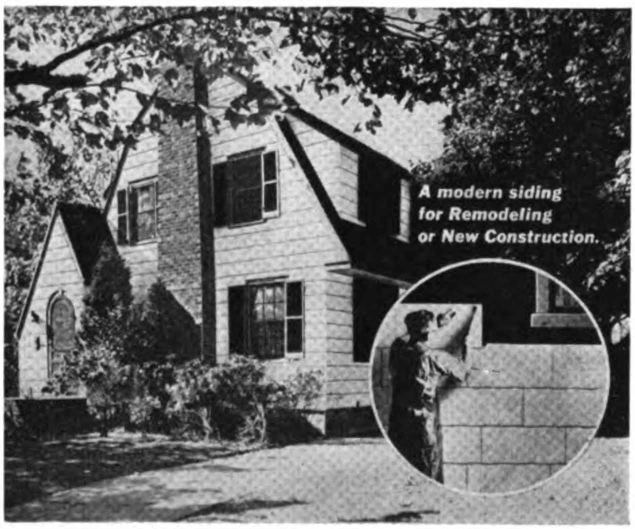
Asbestos Fights The Fire Demon

The terrible scourge of fire that every year costs many lives and destroys property valued at many millions of dollars would be mitigated if asbestos building materials and asbestos fire protectors were more widely used. To limit the ravages of fire, every community of even moderate size has its fire department, and here again asbestos occupies a prominent place. Asbestos gloves, shoes, clothing and helmets safeguard not only firemen but many types of industrial workers in dangerous situations.

Rural communities, too, find important uses for asbestos. Numerous sheds, barns and garages are built with asbestos-cement smooth or corrugated siding, and the asphalt roofing on such structures may be resurfaced and weather-proofed with asphalt-asbestos paint. Homes, churches and schools throughout the country are protected with asbestos-cement roof shingles and sidings.

Asbestos Fundamental To Industry

In factories large and small, asbestos is indispensable. Gaskets on steam boilers, asbestos packings of many sorts on steam engines and other mechanical equipment, asbestos blankets and many other heat-insulation products that conserve fuel, are among the many applications of this remarkable mineral in industry. For instance, many miles of asbestos insulation are used to cover underground steam pipes leading from central heating



Asbestos-cement sidewalls combine beauty with durability and fire protection.

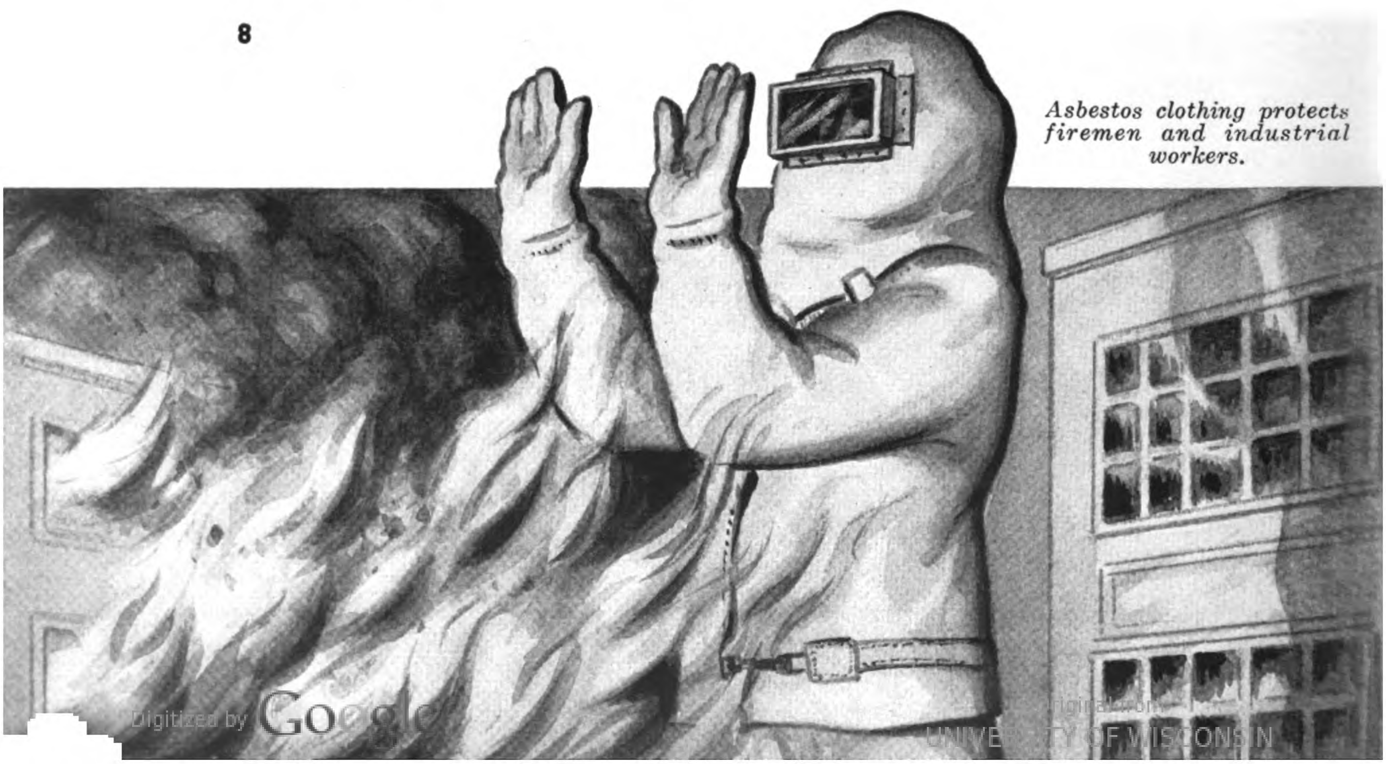
plants. Asbestos is used to encase electrical wires or cables, and to make chemically resistant pipes and conduits. In the chemical laboratory asbestos fibers are used for acid filters. Steam locomotives are blanketed with asbestos products to prevent heat radiation, and their steam pipes are muffled in asbestos.

During the recent war when the Burma Road was cut off by the Japanese, the Chinese sugar-refining industry languished because filter aids could not be obtained. It was soon found, however, that short-fiber asbestos from local deposits served as an excellent filter to clarify the syrup.

From these few instances will be seen the important place this strange mineral occupies in our social, economic and industrial life.

Asbestos Goes To War

Asbestos was classed as a highly strategic mineral during World War II. Friction materials for automotive transport and mobile artillery were of great importance, but the most insistent call was for Navy cable coverings. Asbestos, which combines fire resistance with electrical insulation and flexibility, served admirably for such uses. Lightweight flexible asbestos insulation was of primary importance on naval and maritime ships. Woven asbestos fabrics were invaluable for lagging over insulation on submarines and other vessels. Special types of asbestos paint were used to prevent corrosion of guns and other military equipment used under the extreme climatic conditions of northern Africa. The rapid deterioration and fire hazard of camouflage devices consisting of vegetable or animal fabrics was overcome by the ingenious development of asbestos sheets that defied the effects of climate, vermin or conflagration.



Asbestos clothing protects firemen and industrial workers.

Chapter II

SOME MYSTERIES OF NATURE'S LABORATORY

Of the thousand or more minerals described in textbooks, one has the distinction of being named after the characteristics of a snake, for it is called serpentine. It was so named because massive forms of the mineral, which is generally dark green, are commonly spotted and mottled with yellows and light greens that resemble the markings of a reptile. This green, waxlike mineral, a hydrous magnesium silicate, is of common occurrence in many parts of the world, but in certain localities the vagaries of Nature caused it to assume a fibrous structure known as chrysotile asbestos, which constitutes the principal commercial type of asbestos.

Massive serpentine, which might be called the cocoon of chrysotile asbestos, has the doubtful distinction of being one of the most useless of all minerals. Occasionally solid masses have a decorative pattern, sometimes crossed with white veinlets of calcite or magnesite; and if such material will take a good polish, it may find use as the ornamental marble known as

"verde antique." Otherwise, massive serpentine is a mineral that human ingenuity has failed to apply to any useful purpose.

Tunneling is required in some asbestos mining operations.

Is Synthetic Asbestos Merely A Dream?

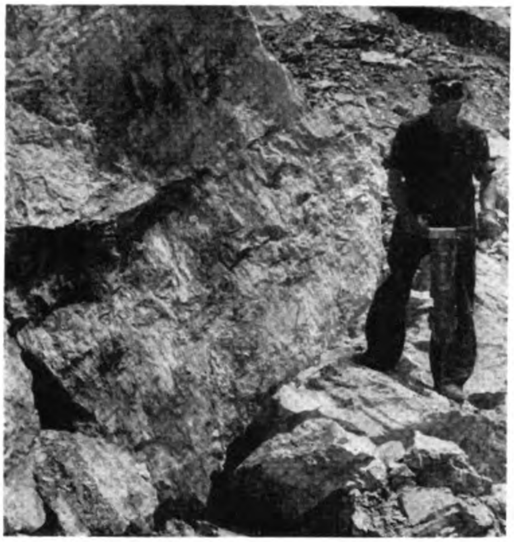
Here is another paradox — a widely distributed massive mineral, occasionally assuming a peculiar fibrous form, suggests a fundamental problem for the research chemist and the engineer. How can useless, massive serpentine be converted into the valuable fibrous variety of serpentine? No chemical change is required — merely a change in the structure of the mineral. It may appear to be an easy problem, but no genius has yet been able to devise a fiberizer or a spinning wheel that will convert massive serpentine into filaments of mineral silk.

But, one asks, could not intensive study be devoted to a simulation of Nature's process—to first learning Nature's method and then following it as closely as possible? Nature employs three important tools, namely, pressure, temperature and time. With powerful machines, man may approach the attainment of pressures like those exerted upon rocks deep within the earth, and with modern furnaces he may obtain temperatures that will melt rocks into white-hot liquids, but when he tries to simulate the time factor he is all but helpless.

Nature is never hurried. A million-year period is but as a day or an hour in the realm of natural geological processes. Hence, dependence for adequate quantities of this essential mineral must be placed on the natural supply. Diligent search must be made for that one-millionth of one percent of all serpentine that Nature has freakishly converted from a rugged boulder into a silky mass.

Nature's Way With Asbestos

What were the peculiar conditions under which chrysotile asbestos was formed? The formation of the serpentine was a preparatory step. The original tough, green rock in the Canadian and several other important asbestos



Serpentine rock containing asbestos fiber.

areas consisted essentially of olivine, classified chemically as a magnesium silicate. Through long ages of metamorphism (and metamorphism means simply a "change of form") the olivine was altered to serpentine, involving a considerable increase in the volume of the rock. The resulting expansion caused numerous irregular fractures, which had an important bearing on the development of chrysotile asbestos.

During ensuing ages a new set of peculiar conditions arose, causing some of the serpentine to assume a thread-like form. Most of the chrysotile fibers are found in veins varying from razor-edge dimensions up to two inches or greater in thickness, with the fibers running *across* the vein from wall to wall. Generally, therefore, the length of the fiber is governed by the width of the vein.

Much study has been devoted to the origin of the Canadian deposits, and several theories have been advanced. The most plausible explanation is that hot liquids and vapors deep within the earth penetrated the pores of the massive serpentine, dissolved and carried it into the fissures caused by its expansion. In these fissures the serpentine was deposited in the columnar form that we call chrysotile asbestos, and as the fibers or columns grew, they gradually pushed the walls further apart. No one knows for a certainty just what were the conditions of temperature and pressure, or the manner of the solutions during the millions of years the process was in operation.

The transformation from massive to fibrous form was influenced, no doubt, by intrusions of molten rock, for both in Canada and Rhodesia the serpentine rock was cut by granite dikes, a name given to fissures through which molten rock flowed and solidified. However mysterious and uncertain the process, it evidently was duplicated in many parts of the world. It is not uncommon to find stringers of asbestos, too minute and too widely separated to be of commercial value, in areas of barren serpentine.

These strange processes were not surface phenomena, since they took place deep within the earth, under conditions of intense subterranean pressure and heat. Why is it, then, that we find asbestos-bearing rock outcropping at the surface of the earth? Has some mighty upheaval lifted it from unknown depths and spread it out where mankind can find and utilize it? The rocks bear no evidence of such upheaval, as apparently they have been virtually undisturbed since the asbestos-filled fissures were formed. In Canada and various other localities the explanation is very simple. An ice-age prevailed in a geologic period later than that during which the asbestos was formed. Great glaciers and ice sheets moved slowly over the surface for countless seasons, tearing loose the rocks and carrying the debris southward, where it was deposited as glacial till. This glacial scouring, supplemented by erosion, carried away millions of tons, even cubic miles of rock, leaving exposed on mountains or in valleys, masses that originally existed far below the surface.

The Irresistible Squeeze In The Rocks Of Vermont

Most of the commercial chrysotile deposits of the world consist of irregular veins in serpentine. In some localities, however, notably near Eden, Vermont, cross-fiber veins are rare, most of the asbestos occurring in a form known as "slip fiber." The serpentine rock was fractured under intense pressure deep within the earth, and the broken masses grinding and pressing against each other, then sliding over each other, developed smooth surfaces known as "slickensides," which are covered with a layer of asbestos fiber.

The Witches' Caldron

Chrysotile occurrences in Arizona, and in the Carolina district of the Transvaal, South Africa, are entirely different in origin from those in Canada, Rhodesia and Soviet Russia. Flat-lying siliceous magnesian limestones were altered by igneous intrusions, that is, by contact with hot molten rock flowing through underground channels. This steaming caldron, a sort of witches' brew, had the effect of combining the silica and magnesia of the limestone to form serpentine, some of which assumed the characteristic filamented structure of cross-fiber veins following the bedding planes of the limestone.

Marco Polo reported on asbestos.

Chapter III

ASBESTOS IN ANCIENT HISTORY

Because so little is known about asbestos, some may be inclined to class this marvelous mineral with radio, television, or other remarkable contrivances of modern times, but it must not be presumed that asbestos is a recent discovery, for it was known more than 2000 years ago.

Early Roman History

The earliest use of asbestos is attributed to the Romans, who probably obtained their supply from the Italian Alps. They termed the Italian variety "amianthus" from the Greek word "amiantos" which means unstained or undefiled, terms which probably referred to the cleansing of asbestos cloth by throwing it in a fire. The Roman naturalist, Pliny (23 to 79 A.D.), refers to the use of "a rare and costly cloth" for the funeral garments of kings, as well as for napkins which were cleaned by fire.

Early Greek History

Hippocrates, the celebrated Greek physician (460 B.C.) prescribed the use of asbestos as a medicine. In the year 450 B.C., Callimachus, a famous Greek sculptor and originator of the Corinthian column, was given the task of constructing a lamp to burn at the feet of Athena. The Greek geographer Strabo (63 B.C. to 24 A.D.) and the Greek historian Plutarch (about 46 A.D.) also mentioned these lamps, terming them "perpetual" because their wicks were made of asbestos fiber.

Early French History

Charlemagne, King of the Franks from 768 to 814 A.D., averted one war by means of an asbestos tablecloth. When the savage hordes of Harun-al-Rashid threatened invasion of his empire, he called a peace conference. In the presence of the ambassadors, he threw his tablecloth into the fire and when he drew it out and exhibited it to them unharmed, they went back home and advised Al-Rashid to avoid war with one who could summon to his aid the powers of magic.

Early Russian History

About 400 years later, in 1250, Marco Polo, while traveling through Siberia, saw textiles that resisted fire. He was informed that they were made of the skins of salamanders, lizard-like animals that the ancients claimed could live in fire, but he traced the origin of this strange fabric to native asbestos-bearing rock and learned how its fibers were obtained and prepared.

17th, 18th and 19th Centuries

The history of asbestos for the next 400 years is a blank, but in 1676, at a meeting of the Royal Society of London, a Chinese merchant exhibited a handkerchief of "salamander's wool" or "linum asbesti." In 1679 mention was made of an asbestos napkin belonging to Ferdinand III, exhibited in Vienna, Austria.

William Lithgow, a Scotsman, writing about the minerals of Cyprus early in the 17th Century, referred to "the admirable stone amiante whereof they make linnen cloth that will not burn, being cast into the fire, but serveth to make it neat and white."

Russian asbestos, discovered in the Ural Mountains between 1710 and 1720, was used for making certain textiles.

Italy has been called the "cradle of the asbestos industry" because the manufacture of asbestos products such as thread, fabrics and paper had its real beginning in that country as the result of studies and experiments begun in 1808. Several plants were in operation between 1860 and 1875.

The year 1877 was the milepost that marked the end of what may be termed the ancient history of asbestos, for in that year the famous deposits near Thetford and Coleraine, in the Province of Quebec, Canada, were discovered. A well-organized and firmly-established asbestos mining industry had its beginning at that time, and thereafter its growth was phenomenal.

Chapter IV

CHARACTERISTICS OF CHRYSOTILE ASBESTOS

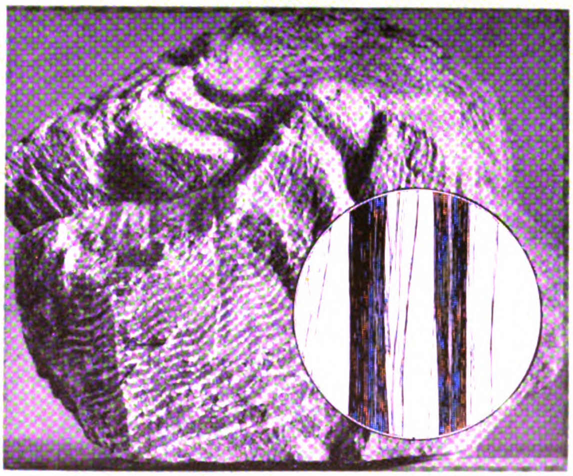
Many uses of asbestos have already been mentioned. What are the physical and chemical qualities that adapt it to use?

Its Physical Characteristics

Canadian or Vermont chrysotile asbestos as it occurs in the rock is green, and Arizona fiber is amber, but when the fibers of either variety are separated they are white, resembling the finest grades of cotton. How fine are the fibers of asbestos? In this respect the mineral fibers differ greatly from fibers of animal or vegetable origin. Each filament of cotton, wool or silk is of uniform thickness and is indivisible into finer sizes. The ultimate fineness of asbestos fiber on the other hand is unknown. It may be subdivided again and again, until a fineness is attained that is limited only by the delicacy of the machinery used and the skill of manipulation. Some Canadian fibers are found to be so thin that 3300 of them side by side occupy the space of an inch. These fine asbestos fibers have a flexibility and strength comparable with those of silk. They will not burn, and they will withstand moderately high temperatures without disintegration.

Its Chemical Composition

Chemically, chrysotile is a hydrous magnesium silicate expressed by the formula $H_4Mg_3Si_2O_9$. It is moderately resistant to chemical agents,



Specimen of serpentine rock. Circle inset shows asbestos fiber formation.

although some other varieties of asbestos are superior to chrysotile in this respect.

Its Commercial Value

The value of chrysotile depends greatly upon the *length* of the fibers. Fiber veins 3/8 inch or more in width are commonly loosened from the rock with hammers. Fibers thus obtained are known as "crudes." These are the highest grades of asbestos and are adapted primarily for use in textiles. The shorter fibers are separated from the accompanying rock by a milling process, hence are termed "mill fibers." They are graded by length, and the designation of the grades indicates the principal uses. The longest are classed as spinning fibers, followed by grades suitable for producing 85% magnesia, compressed sheets, shingle stock, paper stock, cement stock, floats and shorts.

How To Evaluate An Asbestos Deposit

Chrysotile asbestos deposits, consisting of irregular cross-fiber veins, which are perhaps the most peculiar mineral occurrences in the world, are noteworthy in still another respect, since ordinary methods of testing or assaying are inapplicable to them.

In descriptions of commercial mineral deposits the terms "ore" and "gangue" are used, the "ore" being the valuable mineral and the "gangue" the valueless barren rock that surrounds the ore. Thus copper ore may be surrounded by a gangue of barren granite. In chrysotile asbestos deposits, however, we have the unique situation of an ore vein of serpentine in a gangue of serpentine, the valuable mineral and the worthless rock consisting of the same substance, the only difference being that the one is fibrous and the other massive.

How can one judge the commercial possibilities of a chrysotile deposit? First by establishing the quality of the fiber, and then in determining how much asbestos of the different grades is recoverable from a ton of rock. Laboratory equipment designed merely to separate fiber from rock may give quite misleading results. No test tubes or delicate scales, no chemicals or intricate laboratory equipment, may be successfully used to solve this problem. All our preconceived ideas of ore testing must be discarded. The only reliable means of determining the commercial recovery of fiber from asbestos-bearing rock is to run a few tons through a commercial mill, and classify and weigh the fiber obtained. The weight of asbestos fiber recovered will run between 3% and 8% of the weight of rock with which it is associated. Core-drilling is employed to determine the extent of the deposit.

Chapter V

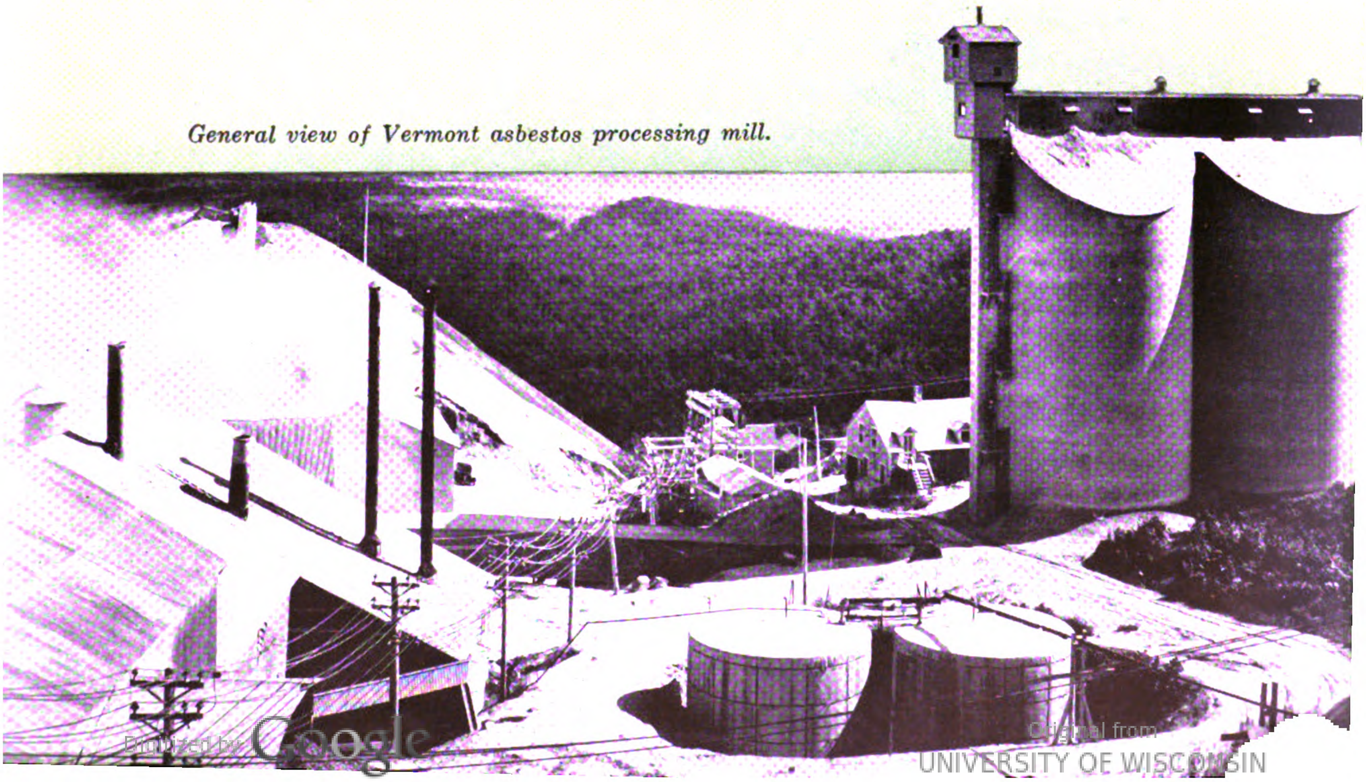
U. S. SOURCES OF CHRYSOTILE ASBESTOS

The manufacture of a wide range of asbestos products is an important industry in the United States, of greater size than in any other country. Asbestos products made in 1939 were valued at nearly $98,000,000. More than 400,000 tons of asbestos are needed annually to supply 70 large manufacturers and innumerable small users with their necessary raw materials. To obtain this supply we must depend upon foreign sources, for domestic deposits contribute only 3 to 6 percent of our requirements. The United States, so favored in many respects, is Nature's ill-treated stepchild insofar as asbestos is concerned. Two States only, Vermont and Arizona, are consistent producers of chrysotile. Deposits are known in several other states, but up to the present time they have not been developed economically.

Asbestos In Vermont

One important deposit is situated on rugged Belvidere Mountain near Hyde Park in northern Vermont, having been discovered by a woodsman in

General view of Vermont asbestos processing mill.



1892. Most of the fiber is suitable for making asbestos-cement shingles and many other products, but not for textiles.

In 1944, a new quarry was opened on the opposite side of the mountain. An overhead traveling cableway carries the asbestos-bearing rock a mile and a quarter over the mountain to the mill. Bucket cars, each holding a ton of rock, are automatically loaded at a rate of two every minute and are dumped at the upper terminal.

In this Vermont deposit are considerable quantities of unusually long slip fiber, some of it up to 12 inches in length—so long, in fact, that it cannot be handled with ordinary equipment. Nature, while parsimonious elsewhere in the United States, is actually perverse in Vermont. After arduous search for long-fiber chrysotile outside of Arizona, a supply at last was found, but the fiber proved to be *too* long.

Asbestos In Arizona

Long-fiber chrysotile, much of it of excellent quality, is obtained at several points in Gila County, Arizona. The original deposit was discovered in 1872 by a pioneer settler, during a battle with a band of Indians. Most of the deposits are 40 to 60 miles from the railroad, and the long haul to markets, together with the high cost of mining, discourage sale of all but the high-priced fibers. The shorter grades are for the most part unutilized. Production in Arizona rarely exceeds a few hundred tons a year, but efforts are being made to increase the output of the high quality fibers of this region.

Sundry Deposits

Chrysotile was mined in a small way many years ago near Cliff Lake, Madison County, Mont. Small mines were opened also on Casper Mountain, Natrona County, Wyo.

California has many chrysotile deposits scattered throughout at least 16 counties. Although a small output has been recorded for almost every year since 1887, no large-scale operations are in prospect.

Scientific Exploration Needed

The only important discoveries in the United States up to the present time have been purely accidental, and have no connection with either prospector or miner. The woodcutters and the warriors having done their part, it is now up to the geologists, prospectors and miners to demonstrate that scientific methods of exploration can succeed in supplementing purely fortuitous methods of discovery. There is a crying need for a larger supply of domestic asbestos.

Chapter VI

CHRYSOTILE ASBESTOS AROUND THE WORLD

Asbestos In Canada

From Thetford in the French-speaking province of Quebec, Canada, rumors arose in 1877 that mountains of "pierre a coton" (cotton stone) had been found. Up to that time the barren hillsides of Coleraine Township had furnished only a precarious livelihood for the French "habitant" immortalized in the poems of William Henry Drummond. Charles Webb owned a tract of land near Danville, which he offered to James Gifford in 1870 for $50, but the offer was refused because the land was too rocky to be fenced for a pasture. The rocks which prevented the planting of fence posts possessed unsuspected value, for that barren field is now the site of a mine that has produced asbestos valued at many millions of dollars.

For a time the new discovery created little interest, but mining began on a small scale in 1878 and 50 tons were shipped that year. The phenomenal growth of the industry during succeeding years need not be recited here. Production in 1943, the record year, reached more than 467,000 tons valued at about $23,000,000. The discovery of valuable asbestos deposits in these areas was the foundation on which was built the far-reaching asbestos-products industries of the United States.

The area of asbestos-bearing serpentine in Quebec covers many square miles, and drill holes sunk to great depths show little if any change in the quality or quantity of fiber in the deep-seated rocks. The reserves appear, therefore, to be very extensive. The mines of the region are several hundred feet deep and are operated with the most modern methods and equipment. This area has been the source of approximately 90 percent of the asbestos used in the United States.

Asbestos In Africa

To find the chrysotile asbestos deposits next in importance to the Canadian, one must travel half way around the world to central Africa. In the barren wastes of the Bulawayo District, Southern Rhodesia, the Shebani mine was opened in 1916 and was operated under difficulty for twelve years. Most of the work was done with native labor, water was scarce, and food, supplies and machinery had to be shipped from distant points. Transportation was the most serious handicap, for it required the use of 7000 oxen and 400 wagons to convey mine products and supplies over many miles of poor roads to the nearest railway. A sixty-three-mile railway to the mine, completed in 1928, vastly improved conditions.

This mine has been a prolific producer, providing as much as 1200 tons of fiber a month. The asbestos occurs in cross-fiber veins in serpentine, closely resembling the Quebec deposits, and is of high quality. The reserves are said to be extensive and large shipments have been made to the United States annually for many years.

Other chrysotile asbestos mines in Southern Rhodesia of lesser importance are the Kings, Gath's, Birthday, Nil Desperandum, Pangani, and Croft. Production in Rhodesia began in 1908 with an output of 55 tons and in the peak year, 1942, it reached 62,332 tons valued at more than £1,800,000.

The Transvaal in the Union of South Africa also is a producer of chrysotile. Small quantities are obtained in the Carolina District, and the Barberton area has produced large supplies. The New Amianthus mine, developed about 1921, uncovered a remarkably rich deposit which, unfortunately, was limited in size. By 1937 it was nearly worked out, but the loss from this locality was compensated by successful development of a large source of supply in adjacent Swaziland. The Havelock mine in this area bears promise of supplying large quantities of high-grade chrysotile for many years. In 1944 it produced more than 32,000 tons.

Soviet Russian Deposits

Rivaling the thick warm fur of the Russian bear, the silky asbestos of the Bajenova district in the Ural Mountains furnishes a heat-insulating medium of superior quality. The deposits were discovered about 1710, and systematic development began in 1885, where chrysotile occurs in cross-fiber veins in serpentine as in Canada. The deposits are very extensive and production has reached as much as 95,000 metric tons a year.

The U.S.S.R. has the distinction of being the only large asbestos-producing country that is also a large consumer. Before World War II more than half of the production was used in domestic factories that furnished a wide range of asbestos products. In pre-war years the bulk of the exports was consigned to Germany. Exports to the United States fluctuate greatly, but have, in certain years, exceeded 4,000 tons.

Italian Chrysotile

Italy, as stated previously, has been called the cradle of the asbestos industry, because commercial uses were nurtured and coddled into existence in that country. Although we owe much of the pioneer work on asbestos utilization to Italian investigators, the asbestos industry of that country never advanced to any material extent. Short-fiber chrysotile is obtained from the Balangero mine in Torino, but the country produces less than its own requirements.

A Mountain Of Short Fibers In Cyprus

Chrysotile asbestos occurs in short-fiber veins on Mount Troodos on the

Ox teams were once an important part of transportation system in South African mines.

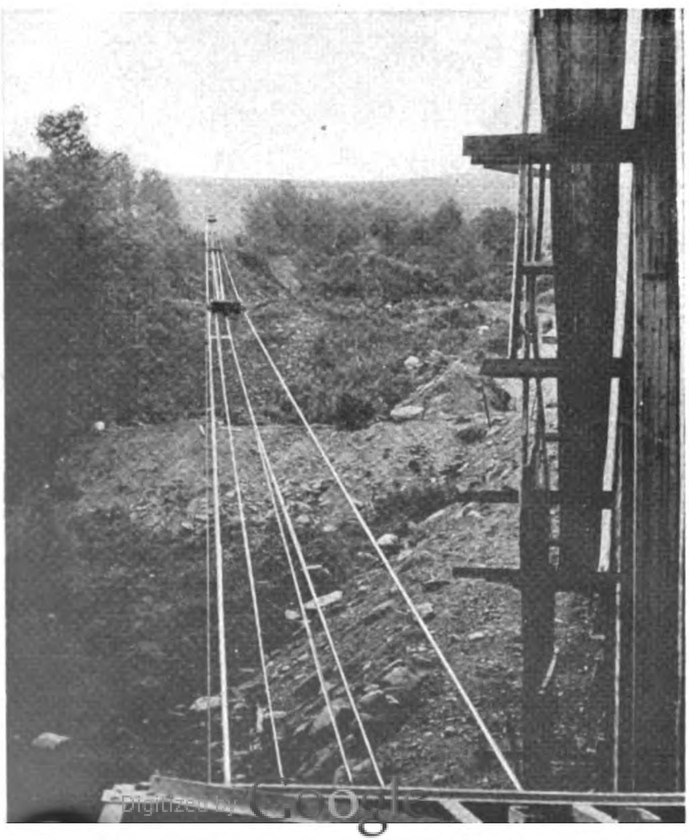
Island of Cyprus in the Mediterranean Sea. Most of the product, which consists chiefly of "shingle stock" is shipped to England, but low water-transportation rates permit shipments to the United States under peace-time conditions.

Scattered Deposits In Other Countries

Quite a number of chrysotile asbestos deposits are known in Australia. Fiber of good quality has been mined in the Roeburne, Nullagine and Marble Bar districts of Western Australia, near Cowell in South Australia, and at several points in Queenland, New South Wales and Tasmania.

Many deposits are reported in China, and short-fiber chrysotile has been worked quite extensively in Finland. High-grade chrysotile of spinning quality is obtained about 125 miles northwest of Madras, India. In 1946 a new mine and mill began operation near Tinaquillo, Venezuela. The most recent important discovery is in Newfoundland, which deposit may be an extension of the occurrences in Quebec.

It will thus be seen that Canada, the Union of South Africa (including Swaziland), Rhodesia, and the U.S.S.R., are the principal sources of world supply of chrysotile asbestos, and it is noteworthy that three of the four are in British dominions. The United States, although at present far in the rear as a producer, is making substantial progress toward increasing the output of its short fiber in Vermont and its longer grades of fibers in Arizona.



Aerial tramway in Vermont carries asbestos ore over mountain to processing mill.

Chapter VII

THE AMPHIBOLE FAMILY

The story of asbestos is not alone the story of chrysotile, for this mineral has relatives which are, as in all family circles, a heterogenous group. Its more important relatives have the family name, *amphibole,* including the following species:

Amosite is an iron-magnesium silicate discovered in 1907 in northeastern Transvaal on the property of a company known as Asbestos Mines of South Africa. The name, amosite, was derived from the initials of the company: a-m-o-s-a.

Amosite, quite different from chrysotile, is noted for its exceptionally long fibers, which may attain lengths of 12 to 15 inches. Because of their extreme length, the fibers cannot be spun on standard machines, as they are somewhat harsher and weaker than those of chrysotile. It was found, however, that amosite has other important uses. It can, for example, be fluffed into a feathery mass that weighs only 9½ pounds per cubic foot when fabricated into a mattress, which makes an excellent heat insulator. Thus it has high value around the power plants of warships where effective heat insulation must be combined with minimum weight. Such mattresses, being removable, are of special value around flanges and joints where packings or gaskets must be replaced at times. Amosite has peculiar properties of low density when fully opened or fiberized, which make it ideal for insulating underground steam pipes. An important use is in making "85-percent magnesia" mentioned later.

Crocidolite, meaning "woolly stone," is another unique variety of amphibole which, because of its distinctive color, is commonly known as "blue asbestos." Discovered between 1803 and 1806 in the Cape of Good Hope, Union of South Africa, blue asbestos was at first regarded largely as a curiosity, a fibrous mineral with a freakish color; but it was not destined to remain in idleness, for it was found to have certain superior qualities for special uses. Because of its high strength it is preferred over other varieties for making asbestos-cement pressure-pipe. Long blue fibers find special uses in the manufacture of gas masks, which are of the utmost importance both in peace and war.

Blue asbestos occurs in the Cape of Good Hope, in a belt of banded iron-stones about 30 miles wide and 240 miles long, stretching from near Prieska northward beyond Kuruman. Smaller deposits occur in the Pietersburg district of the Transvaal. It is known to exist in only one place and in small quantity on the North American continent (Providence County, R. I.).

A deposit of blue asbestos has been worked in a small way in the Department of Cochabamba, Bolivia. Small deposits are located near Hawker and Robertstown, New South Wales, Australia, and extensive deposits of excellent quality in the Hamersley Ranges of Western Australia.

Tremolite, another variety of amphibole asbestos, derives its name from the location of the first described deposits, in the Tremolo Valley of the Italian Alps. The Italian deposits are extensive, and considerable quantities of fiber have been exported to the United States. They occur in three areas: (1) in the mountains, 8000 to 9000 feet above sea level in the Susa Valley of Western Torino, (2) in the Aosta Valley in northeastern Torino, and (3) near Sondrio in northern Lombardy. The fibers, although weaker than chrysotile, are remarkably resistant to chemical action, and hence have wide use as a medium for filtering acids and other chemicals in laboratories and commercial plants. Tremolite is also mined in a small way in California, and in the Kobuk River district of Alaska.

Anthophyllite might be called the black sheep of the amphibole family. Its fibers, sometimes many inches long, frequently raise hopes of fabulous wealth in the minds of those unfamiliar with asbestos, but such hopes vanish when it is learned that the fibers lack strength and flexibility and will crumble at a mere touch. Its limited uses consume only a few hundred tons a year.

"Mountain Leather" and *"Mountain Cork"* represent still other of Nature's vagaries with respect to asbestos. They consist of tough sheets or spongy, porous masses of matted fibers. Deposits found in Alaska or elsewhere are too small for commercial use.

Actinolite and *Horneblende.* Gray, dark green or black splintery varieties of amphibole known by these names are occasionally fibrous, but are so weak and brittle that they rarely find commercial use.

Transporting asbestos rock, blasted down from quarry face.

Chapter VIII

MINING AND MILLING ASBESTOS

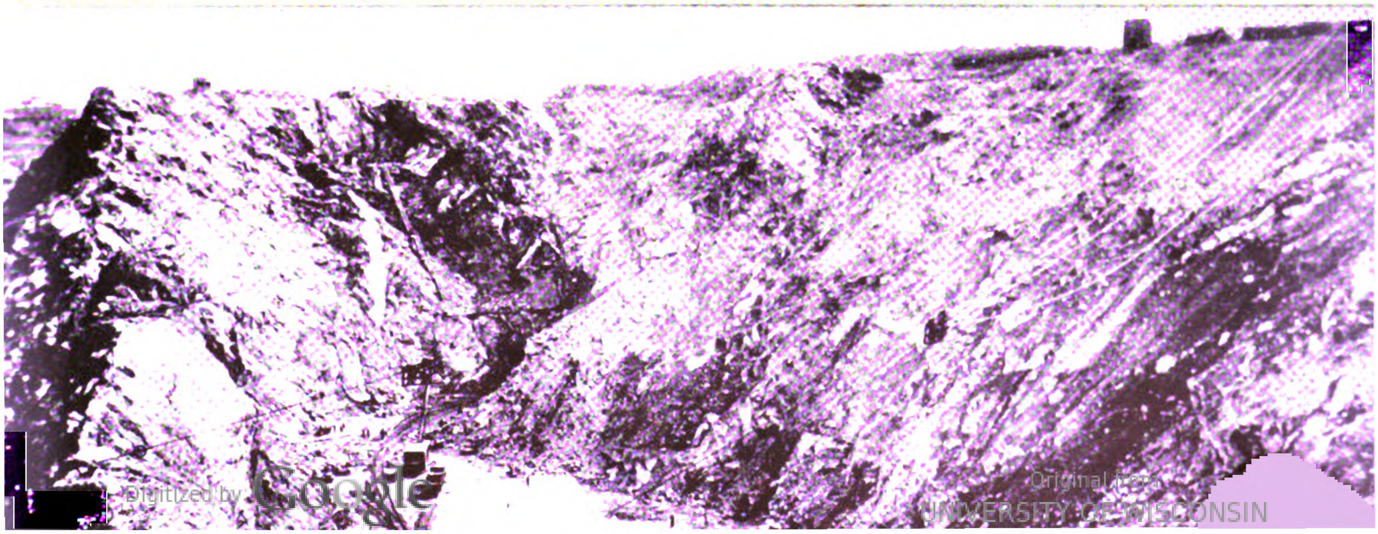
The general concept of a mine is a deep shaft at the bottom of which are dark subterranean workings where miners blast out the ore and send it to the surface for recovery of its valuable mineral content. In its broad sense, mining of asbestos deposits includes many variations of this well-known type, including virtually every kind of hard-rock mining known.

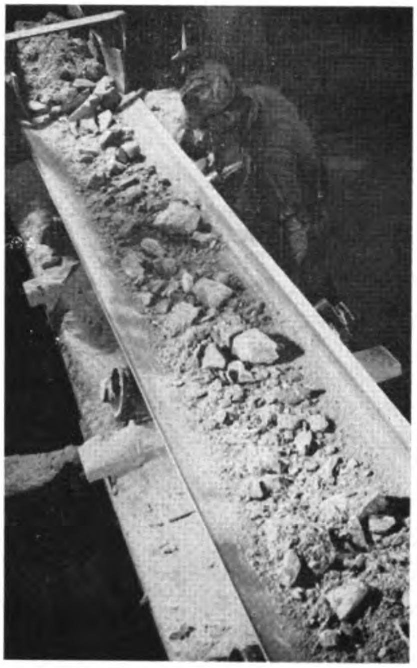
Mining Methods

Not only is asbestos recovered from deep shafts, but from open pits like stone quarries, from gopher-hole workings where surface outcrops are attacked, from tortuous underground tunnels following irregular veins, and, recently, by a complicated system known as block-caving. The latter method now followed in some Canadian mines is, like asbestos itself, somewhat of a paradox, because the miner at a depth of 500 or even 1000 feet, works a great mass of fiber-bearing rock from the bottom, letting it collapse as its supporting base is removed. This method of "digging a well from the bottom" may seem difficult if not impossible to the layman, but in practice it has been highly successful. The general objective, of course, is to excavate the fiber-bearing rock by the most convenient method and at minimum cost.

Many of the African deposits of amosite and blue fiber are mined in small open pits or shallow underground workings scattered over wide areas.

General view of large open-pit asbestos mine.





Belt conveyors carry crushed asbestos rock to various processing operations.

Chrysotile deposits in serpentine are generally exploited by means of large well-organized mines or open pits. The Arizona bedded veins must be uncovered by driving tunnels in the dolomite.

Extracting The Fiber From The Rock

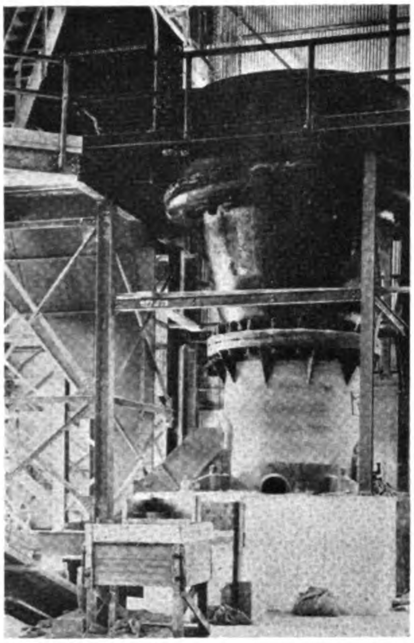
When fragments of asbestos-bearing rock are removed from the mine, the next step is to separate the waste rock from the fiber. Where large cross-fiber veins occur, this is relatively simple, for the miner may sledge the rock apart and separate the fiber masses by hand, a process known as "hand cobbing." Most of the fiber veins are too narrow to be separated profitably by hand, so that the rock must be sent to a mill where by mechanical means a satisfactory separation may be accomplished, but this is not a simple process.

As already stated, serpentine is hard and tough and the mill operator has learned from experience that he must use discretion in separating delicate fibers from a tough matrix, since if the rock is manhandled too roughly, the fibers are broken into shorter lengths with consequent serious reduction in their value. Special types of mills called "jumbos" or "cyclones" have been designed to separate the fiber with maximum efficiency.

The mixture of rock fragments and asbestos is then passed over shaking screens. The smaller sizes of serpentine rock and the shorter fibers pass through the screen openings and are carried away for further treatment. The coarser rock fragments and longer fibers remain on the screen, and the shaking action brings the fiber to the surface of the bedded particles.

At this stage in the milling process, asbestos maintains its record of being one of the strangest and most surprising members of the mineral king-

Veins of asbestos fiber in Vermont deposits.



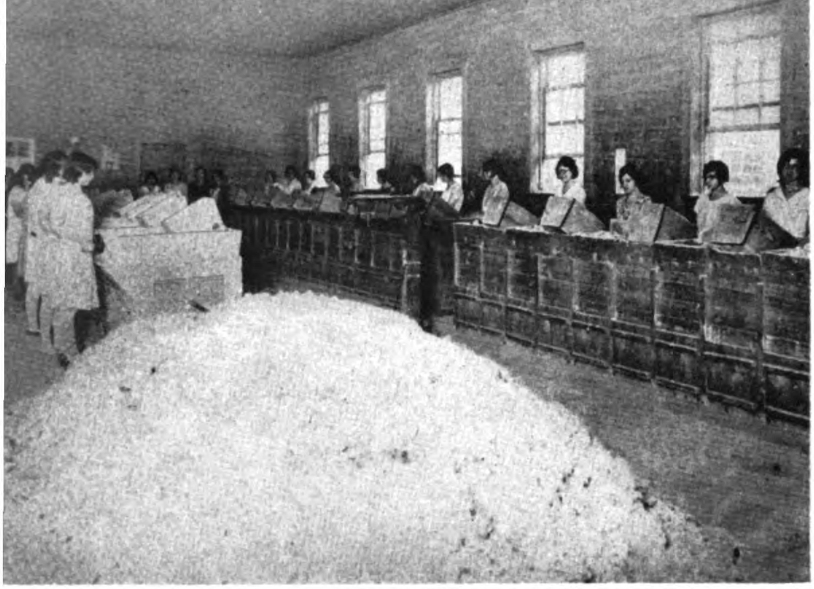
Gyratory primary crusher.

dom, for to deal properly with the idiosyncrasies of this peculiar mineral the mill operator has been obliged to call to his aid that well-known household appliance, the vacuum-cleaner. Asbestos mills are the only ore-dressing mills in the world that employ modified vacuum-cleaners as an important part of their standard equipment. A suction hood extending across the screen at its lower end is placed a few inches above the screen surface. A powerful fan creates an air suction that lifts the surface layer of fluffy asbestos fiber and carries it away to a collecting chamber. Screens of progressively smaller mesh, all equipped with vacuum hoods, follow in series, and the rejected rock fragments in which fibers are still locked are returned to the mill for further disintegration.

The separated fibers are classified by length into standard commercial grades named according to the uses for which they are best adapted, as for example, spinning or textile fiber, magnesia and compressed sheet fiber, shingle fiber, paper fiber, and cement fiber. The finished asbestos, which resembles cotton or wool, is packed in jute bags ready for delivery.

In Canada, the recovered fiber comprises only about 6 percent of the total rock mined, and the worthless serpentine about 94 percent. Thus waste serpentine has accumulated in veritable mountains through the years and lies in idleness awaiting the magic of some inventive genius who may yet find a use for it.

From shaking screens the asbestos fiber is removed by air suction into collectors.



Hand "cobbing" of asbestos fiber.

Oddly enough, although fireproofness is an outstanding quality of asbestos, "No Smoking" signs are always prominent around asbestos workings. The reason is not that the asbestos might take fire, but that dropped match sticks or cigarette stumps might be collected with the fiber and shredded in the mills, thus contaminating a fireproof product with highly inflammable material. Similarly, great care is taken around mine and mill to avoid the use of wooden railway ties, mine timbers and other wooden members, fragments of which might pass through crushers.

Wide Variations In Fiber Value

The value of asbestos fibers varies greatly, depending upon length, strength and flexibility. The amphibole varieties, with the exception of amosite and blue, generally command prices as low as $20 a short ton or less, because they lack the strength required for major uses. Tremolite, however, because of its special filter uses made possible by its resistance to chemical action, may command prices as high as $400 to $500 a ton. Amosite ranges from $120 to $140, and the shorter grades of blue from $140 to $150 a ton. Chrysotile asbestos values range from $12 to as high as $750 a ton, depending upon fiber length and strength. Following are typical market quotations per ton for Canadian chrysotile: Crude No. 1, $700 to $750; crude No. 2, $150 to $350; spinning fibers, magnesia and compressed sheet fibers, $110 to $200; shingle stock, $50 to $80; paper stock, $40 to $45; cement stock, $20 to $26; floats and shorts, $12 to $20.

Chapter IX

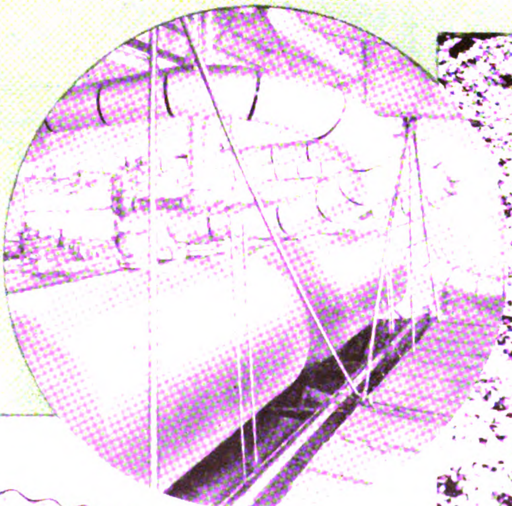
MANIFOLD USES OF ASBESTOS

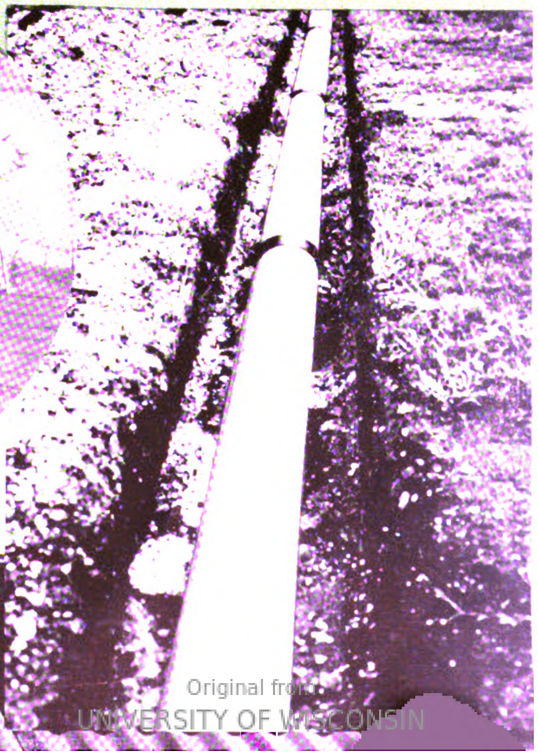
Quite a number of the uses of asbestos have already been mentioned, but the subject has by no means been exhausted.

There are three principal groups of asbestos products: textiles, heat insulators and building materials, and a miscellaneous series unrelated to the main groups. Even the principal general classifications are not clear-cut and distinct, but overlap to some extent. Thus a textile may be used for heat insulation, and certain heat insulators are also employed in building construction.

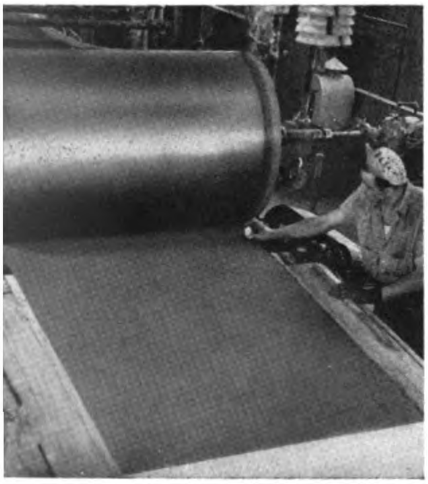
Under the general heading of textiles are included yarns, listings, tape, rope, cord, wick, and thread. The largest textile use is the manufacture of woven brake linings and clutch facings for automotive machinery. The length of woven bands produced in an average year would form a strip reaching around the equator. Other important textile products are gaskets, packings, theatre curtains, and firemen's and industrial workmen's suits and gloves.

Extreme right — asbestos-cement pipe. In circle—asbestos industrial pipe and boiler insulation. Below—Roofing a factory with corrugated asbestos-cement sheets.





Fireproof Asbestos Paper.



Asbestos-cement sheets coming off the forming machine.

•

Asbestos yarns, tapes and brake linings have innummerable uses in modern industry.

Among the heat-insulating products are pipe-insulation of many kinds, some composed of corrugated asbestos paper (the so-called air-cell type) and others known as "85 percent magnesia" (a basic magnesium carbonate containing about 15 percent by weight of asbestos fiber). Other products are blankets for lagging steam boilers, millboard, table mats and pads, linings for stoves and refrigerators, and asbestos-cement boiler insulation.

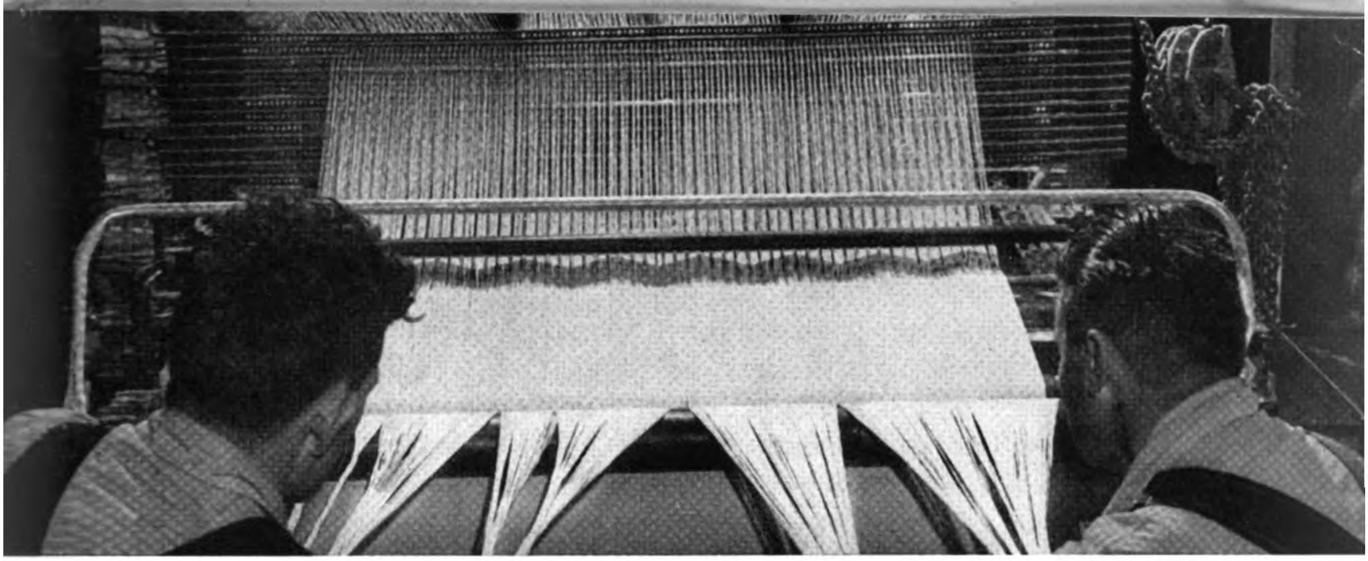
The principal asbestos building materials contain 75 to 85 percent portland cement, and 14 to 25 percent short fiber asbestos. Such asbestos-cement products are made into flat or corrugated sheets for siding or roofing, wallboard, floor tile, and roofing shingles or sidings.

Among the miscellaneous products are asbestos-cement pipe, molded brake-linings, electrical tapes, compounded packings and acid filters. Scores of other products could be listed.

Fabrics Fashioned From Rock

Asbestos is the only mineral that may be fabricated into finished products by using spindles, looms and other equipment similar to that employed in making cotton or woolen goods. At the textile mill, asbestos is further fiberized and freed from rock impurities. Thus prepared, the fibers are first carded into a blanket, then separated into rovings which are wound on a Jack spool, and spun into yarn by processes almost identical with those employed in cotton or wool textile mills. Yarn may be made into thread, cord or rope. Metallic yarns are made by adding strands of fine brass, copper or lead wire to the strands of asbestos, and are employed mainly in the manufacture of packings and automobile brake-linings.

Yarns are placed on looms and woven into fabrics by well-known processes. The cloth thus made is manufactured into a great variety of products such as theatre curtains, fireproof clothing, gloves, woven packings, and, most important of all, brake-linings.



Winding asbestos yarn on beam preparatory to weaving.

In Great Britain during World War II, asbestos suits, hoods, gloves and shoes, were worn by firemen and air wardens as a protection in fighting the fires caused by incendiary bombs.

Unburnable Paper

Lovers of old documents have dreamed of an indestructible paper on which valuable records could be traced and thus preserved for posterity. This idea found expression many years ago in the manufacture of a new kind of paper, made of asbestos fibers instead of the usual highly inflammable rags or wood fiber. Unfortunately, although the asbestos paper withstood the fire test admirably, the ink used in the writings burned away, leaving the sheets blank. No way has yet been found to make asbestos ink.

However, numerous important uses for asbestos paper have been found. Its manufacture has become a great industry, since its valuable properties are heat and sound insulation, combined with incombustibility. At present more asbestos paper is made in a day than was manufactured annually 35 years ago.

Asbestos is unique in that it is the only mineral that can be formed into paper, having the further advantage that it can be processed on a regular, standard paper machine. Asbestos is mixed with water to form a thin slurry which is agitated thoroughly by a drum covered with slats. Starch or other binder is added, and the sheet is formed in the usual manner. The freshly formed asbestos paper is then passed between rollers to squeeze out the water, dried on hot cylinders and wound into rolls. An important use of the paper is to make air-cell pipe-covering, in which case alternate corrugated and flat sheets are laminated to make two-ply, three-ply or thicker sections.

Millboard is generally classed with paper, for it really is a thick asbestos paper, just as cardboard is regarded as a thick wrapping paper.

Asbestos-Cement Roofs And Walls

Burning cinders falling on wooden shingles, or blowing into cracks between wooden clapboards, have caused many disastrous fires. To guard against such hazards to life and property, men of enterprise and creative ability set to work to devise roofing shingles and sidings that would be absolutely fireproof. The phenomenal development of that versatile product, portland cement, has paved the way for the desired products. Slabs made of cement alone were too brittle and weak unless made undesirably thick, but it was found that if asbestos fibers were added, the strength and resilience would be so enhanced that thin slabs could be used satisfactorily. To fabricate these products by the so-called "wet process," portland cement and asbestos fiber are mixed with water, agitated thoroughly in a beater, and pumped to a so-called "Hatschek" machine (named after the inventor) that builds up sheets in successive laminations to any thickness desired.

Shingles are also made by the so-called "dry process." Asbestos and cement are mixed dry, then spread on a belt conveyor and sprayed with water. Rollers compress the mixture to the desired thickness, and a rotary cutter separates the sheets into shingles or sidings which are then compacted in a hydraulic press at 20,000 pounds per square inch. They are then cured, trimmed and punched for nailing.

Asbestos-cement wallboard and siding are made similarly only in larger slabs. Corrugated sheets are made by passing the freshly formed flat sheets between corrugated rollers. Thousands of squares of asbestos-cement roof shingles, and millions of square feet of asbestos-cement siding are used in the United States every year.

Hydraulic pressing of freshly formed corrugated asbestos-cement sheets.

During World War II, when the defense program was attaining larger and larger proportions, and when priorities were placing growing restrictions on the use of metals, makers of asbestos-cement products devised means of

Trimming and nail-punching asbestos-cement shingles.

fabricating not only roofs and siding, but such lumber substitutes as sills, studding, beams, sheets, plates and rafters that required only small metal attachments. Thus an entire building can be made of asbestos-cement building materials, and such a structure will defy every possible attack of weather, storm, fire, incendiary bombs, corrosion, termites or decay. Furthermore, the sheets can be sawed, nailed, perforated and even enameled and polished.

Asbestos-Cement Pipes And Conduits

The comforts and conveniences of home and business, together with the demands of industry, require thousands of miles of water pipes in a wide range of sizes. Asbestos-cement pipes are attaining increasing use in many countries.

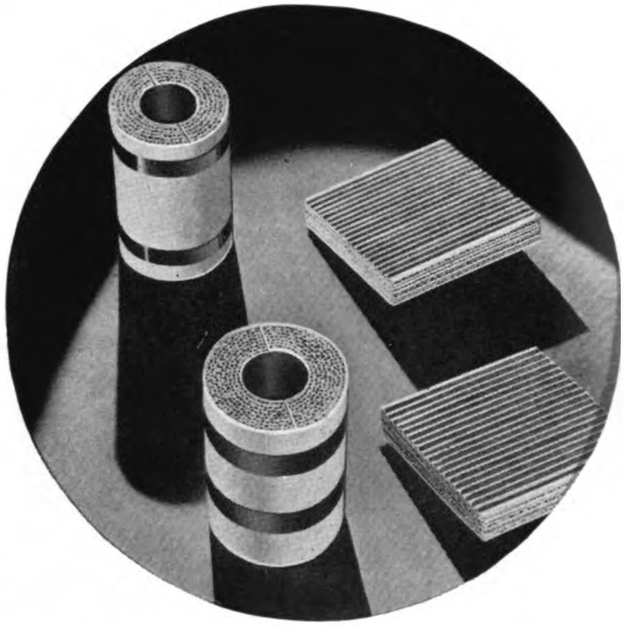
The initial steps in the process of making pipe and conduits are similar to those employed in making sheets. In one method of pipe manufacture, a slurry of asbestos, cement and water is collected on a felt-covered belt, and the water removed by suction. The sheet is then wound on a rotating metal cylinder having an outside diameter equal to the inside diameter of the pipe to be made. After it has been built up to the desired thickness, it is dried and cured. Such pipe is becoming popular for water lines as it does not rust or corrode, is impervious and free from electrolytic action when buried in the earth, is light, elastic, strong, resistant to compression, traction or shock, is unaffected by temperature changes, and is easy to cut to any desired length.

A recent use of asbestos fiber is its employment in admixture with sulfur for making pipes, or for lining steel pipes. Sulfur has remarkably high resistance to chemical action, and the asbestos fiber gives it the desired strength.

Asbestos-Magnesia Insulation

A light fluffy form of magnesium carbonate combined with asbestos fibers makes an excellent heat insulator for steam pipes. One of the chief difficulties that had to be met in making this product was to obtain the magnesia.

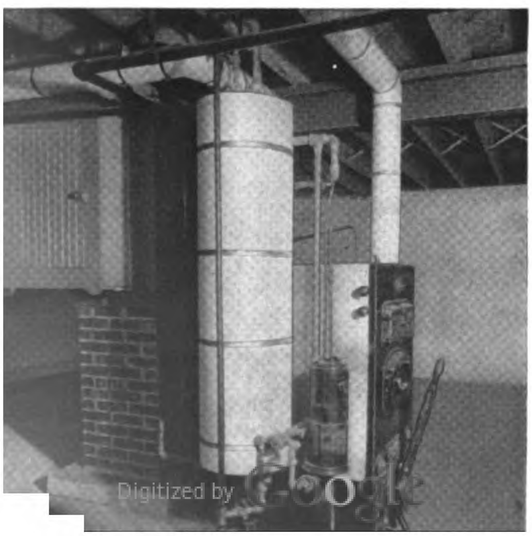
It is commonly recovered from the mineral dolomite, which is a double carbonate of calcium and magnesium. By means of a complex chemical treatment the magnesia is separated from the calcium compound, in the form of a light, fine-grained basic magnesium carbonate. Sometimes, however, this magnesium carbonate is obtained from bitterns, the residual brines at salt works, or may even be extracted from ocean water. To the magnesium compound, by whatever means prepared, about 15 percent by weight of chrysotile or amosite asbestos is added, and the mixture agitated thoroughly in water. The solids are collected on a filter press and are cast in the form of pipe insulation, generally from 1 to 4 inches thick. The trimmed half-cylinders are then cut in lengths and enclosed in canvas jackets. The pair of half cylinders may be fitted around a steam pipe and the joint sealed. This insulation is an excellent conserver of heat. Magnesia-asbestos blocks are also used for this purpose.



Asbestos air-cell pipe coverings and insulating blocks.

Compounded Packings

Packings are used to prevent escape of steam or compressed air around the moving parts of machinery. Compounded packings are made of asbestos mixed with fillers and binders. Ordinary fillers 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 tank and pipe coverings conserve household hot water supply.

Cable Coverings

Although chrysotile is a distinct mineral of definite chemical composition, and therefore presumably the same wherever found, it usually contains small percentages of impurities that may have a definite influence on its use. For instance, Canadian chrysotile contains a small percentage of magnetic iron oxide (magnetite). Pure chrysotile is a good electrical insulator, presenting a barrier to the electrical current, but the minute grains of magnetite in Canadian chrysotile furnish a series of stepping stones over which the alert electrical current finds a pathway. Canadian fiber, therefore, is not adapted for making electrical tapes or wire coverings exposed to high-voltage currents. Rhodesian chrysotile, and that found in Arizona, are very low in iron, and therefore are preferred for such uses. Wire coverings made of low-iron asbestos fibers, rather than of rubber or other organic compounds, greatly reduce the fire hazard.

Insulating Cements

Insulation of furnaces and hot-air or steam pipes in homes, business establishments and factories, is highly desirable to conserve fuel and promote comfort and health. Insulating cements commonly consist of short-fiber asbestos which may contain enough finely divided matter to serve as a binder, or plastic clay may be added for this purpose. The fibers used for such cements are the shortest and lowest-priced grades.

Molded Articles

Short fiber asbestos mixed with gilsonite or synthetic resins and vegetable oil, may be compressed in molds to make so-called "asphalt" floor tiles and numerous electrical fittings and household appliances. The molded articles may be baked and then polished.

Chemical Filters

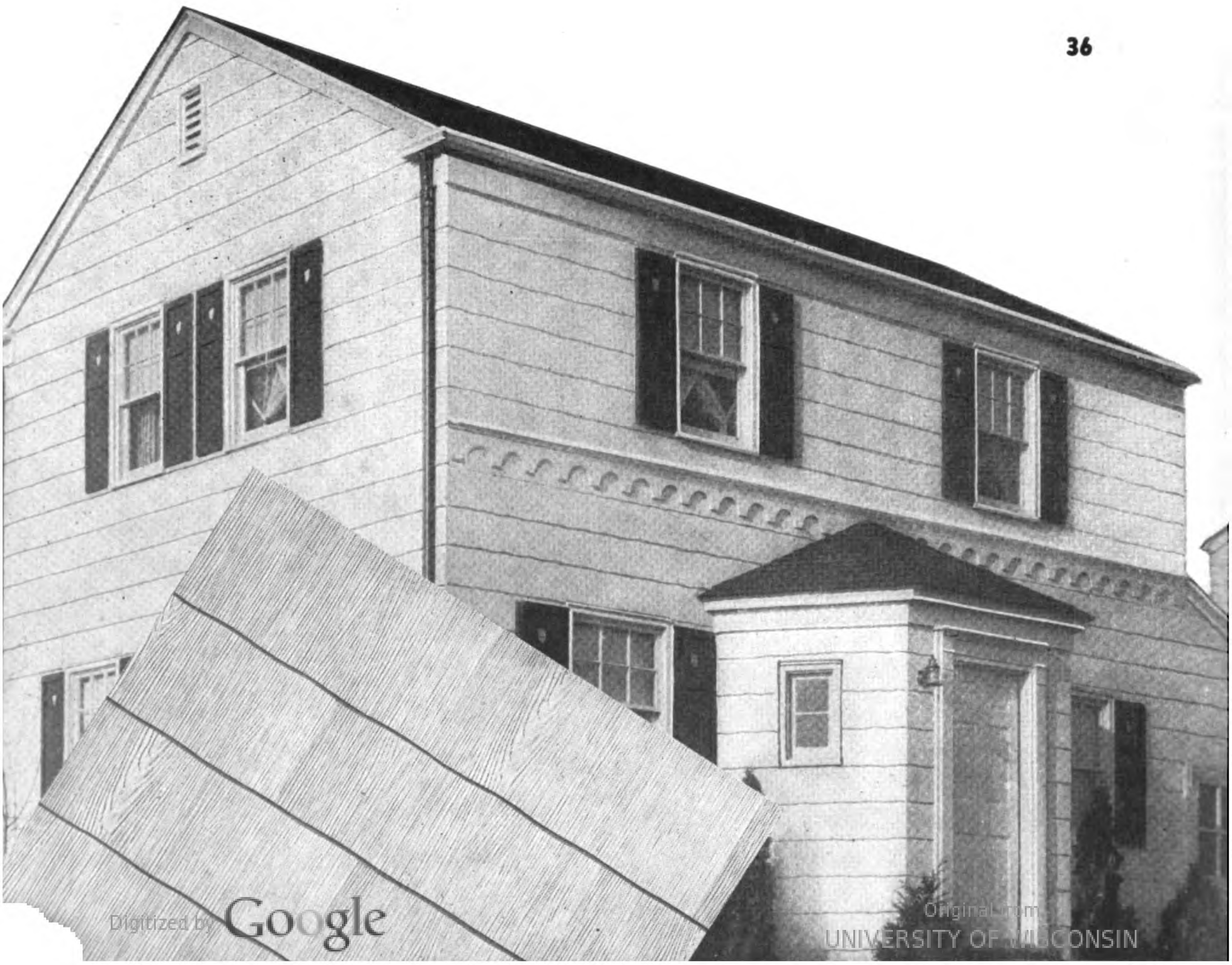
Every student of chemistry who has taken a course in quantitative analy-

Asbestos fabrics printed in attractive colors for decorative use provide new safeguards against fire.

sis is familiar with the basic principle which involves precipitation of one compound while all others remain in solution. The precipitated solid is then separated by collecting it on a filter paper. These familiar circular papers are unaffected by most filtrates (a name given to the solution which passes through the filter paper), but in some laboratory work or in commercial plants, strong acids or other corrosive chemicals must be filtered, and their action is so severe that they would burn up and destroy ordinary filter paper. Tremolite asbestos which is highly resistant to chemical action, is a satisfactory filtering medium for such strong solutions. To remove small quantities of soluble impurities that may be present, the fiber is boiled for several hours in strong acid. After thorough washing and drying, following such treatment, the filter fibers resemble snow-white wool.

Conclusion

The story of asbestos, as briefly outlined here, is truly a dramatic tale of a spinnable, unburnable rock, created in Nature's marvelous factory by processes that man cannot simulate, but which, after all the countless ages



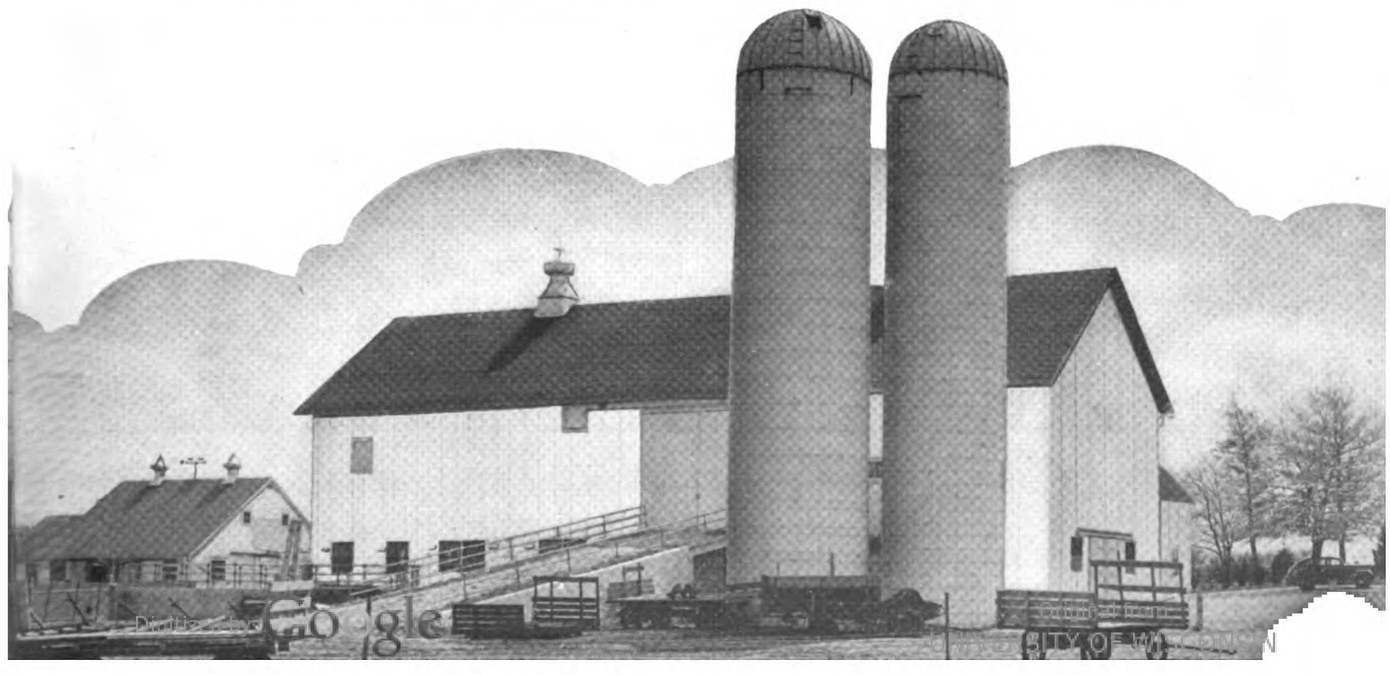
that have elapsed since its inception, remains a mineral silk, undecayed and unaltered by time or weather, waiting with infinite patience in its secluded rocky home for the miner to uncover it and adapt it to human use.

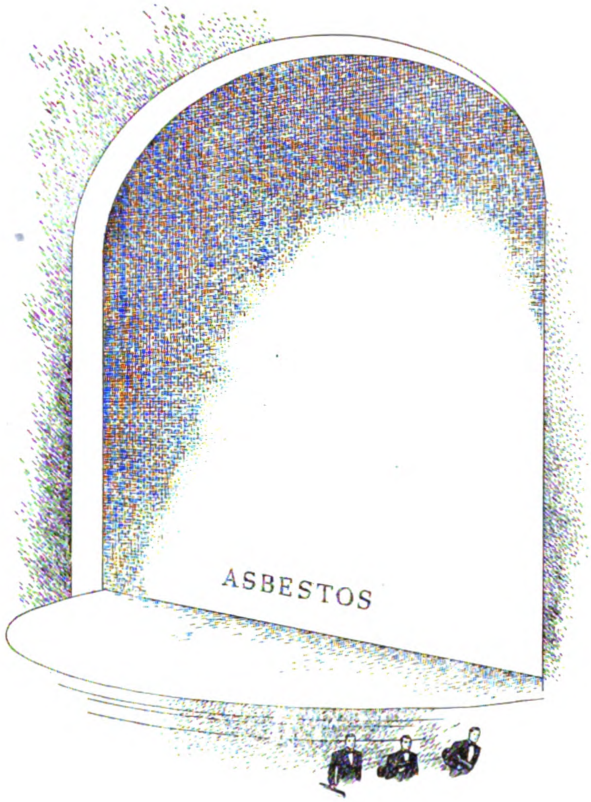
Surely we owe a debt of gratitude to this faithful servant of mankind, this mysterious earth substance that serves in so many important ways—by providing raw material for innumerable appliances that add to the comfort, safety, happiness and convenience of all of us, by promoting an automobile age, by conserving unnumbered tons of fuel, by saving multitudes of people from death or injury by fire, and by protecting property valued at billions of dollars from the ravages of conflagration, corrosion and decay.

One out of every six fires in this country originates outside the building—from flying sparks or other exposure to fire off the premises.

Picture on opposite page shows attractive home safeguarded with modern asbestos-cement siding—fireproof, rotproof, termite-proof.

Barn shown below has sidewalls of fireproof asbestos-cement building board.





In the hope that the story of asbestos may be of some interest or value, this booklet is sent to you with the compliments of the publishers—

The RUBEROID Co.

Manufacturers of asbestos and asphalt building and insulating products

500 FIFTH AVENUE, NEW YORK 18, N. Y.

Divisional Offices and Plants

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Publisher's Note

In October, 1946, the publisher of this booklet, The Ruberoid Co., rounded out sixty years of effort devoted to a single purpose—that of improving the conditions of shelter in every phase of American life—in homes, factories, schools, churches, offices and public buildings.

In its initial small plant the company developed, in 1892, the first roll of ready-to-lay prepared asphalt roofing ever made, marking the birth of an important new American industry. Later, entering the field of asbestos building products, Ruberoid became a pioneer in the development of roofings, sidings and insulating materials of asbestos and asbestos-cement. Today the company operates an asbestos mine in Vermont and eleven large factories in the United States, provides employment for approximately 4,000 persons, and is represented by over 10,000 distributors in virtually every section of the country.

In presenting this booklet, it has been the company's desire to pay tribute to all who have had part in adapting asbestos to its many important uses in the world of today.

●

Acknowledgements

Grateful acknowledgement is made to the following for permission to use various illustrations shown in this booklet:

Bureau of Mines, U. S. Department of the Interior
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Johnson's Company

Some Ruberoid Asbestos Products

SHINGLES AND SIDINGS OF ASBESTOS-CEMENT

ROLL ROOFINGS WITH ASBESTOS BASE

STONEWALL ASBESTOS-CEMENT BUILDING BOARD

CORRUGATED SHEETS OF ASBESTOS-CEMENT FOR ROOFING AND SIDING INDUSTRIAL BUILDINGS

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