Asbestos Manufactured Products and Uses

Proximity to the Canadian asbestos mines which produce 75 percent of the world's supplies, has made the United States the greatest manufacturer and consumer of this rock fibre's products. The short lengths of fibre are manufactured into heat insulators for covering pipes, boilers, etc., also for lining buildings, stoves, etc. The long fibre is woven into various kinds of cloth fabrics used in tapes, packings, gaskets, filters, etc. Asbestos is indispensable to the automotive industries in which it is employed in huge quantities for brake band linings and clutch faces. Details of manufacturing these products are supplied by this illuminating article.

CREATION of a market in which the demand by far exceeds the visible supply has been the result of prodigious efforts and the generous investments of American asbestos miners and manufacturers. These men look back with pride to a time but 50 years ago, when asbestos was practically unknown in the Western Hemisphere and the inhabitants of the earth apparently felt no urgent need for this marvelous product of nature. But, to-day, after an estimated 100 million has been invested in the industry throughout the world, there is constant talk of shortages of the raw material.

Ancients Used Asbestos for Shrouds

The ancients are said to have taken advantage of the peculiar characteristics of asbestos when they used it for two practical purposes; woven into shrouds for the cremation of their kings, it prevented the human ashes from becoming contaminated by the wood ashes of the funeral pyre, and made into wicks, it kept the oil-filled lamps of their sanctuaries burning and required practically no attention. Charlemagne astounded his courtiers by throwing his asbestos table cloth into the fire place and then withdrawing it clean and unharmed. In 1676 a merchant from China exhibited a handkerchief made of "Salamanders' Hair" (an old name for asbestos) before a meeting of the Royal Society in London. Thus, we find asbestos still a curiosity at the end of the 17th Century. Towards the close of the 18th Century a factory for the production of asbestos was established in Russia, but the demand for the material was so small that the industry disappeared. But with the discovery of rich deposits in Canada and Italy came the foundation of substantial asbestos manufacturing enterprises, and to-day this fibre, the only commercial mineral fibre in existence, is recognized as one of the most essential commodities in the industrial market of the world. The industry, however, has by no means reached the height of its development, for new applications of asbestos are being sought and found constantly.

Chrysotile and Amphibole Varieties

The word "asbestos" is derived from the Greek mean-

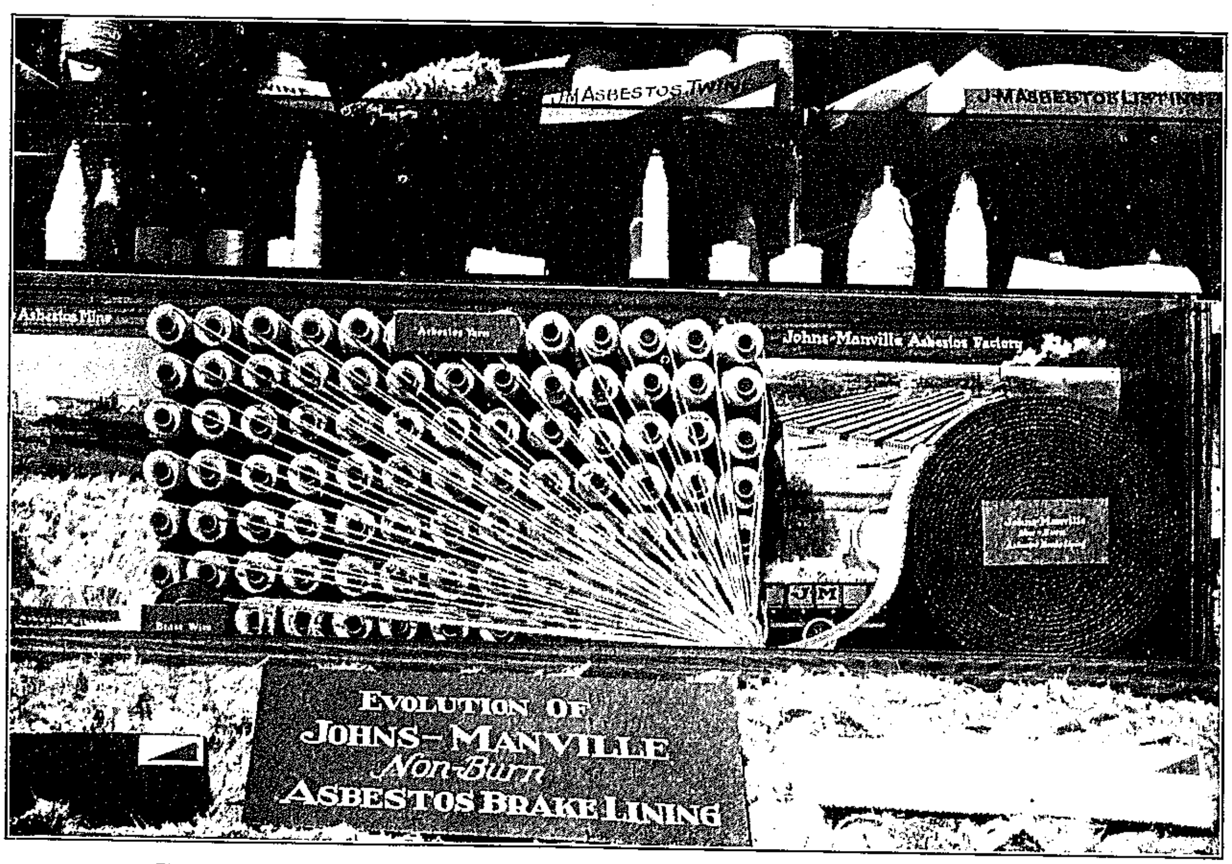

Fig. 1. Brake lining manufacture as epitomized by window display of the Johns-Manville Co., New York.

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ing "unquenchable" which may be stretched to mean "inconsumable" or "incombustible." The two principal varieties of the mineral are known as chrysotile and amphibole asbestos, are fibrous in structure and vary in color from pure white to yellow, pink, green, blue, brown and many intermediate and mottled shades. The chief constituents of these two types are silica, magnesia, alumina and ferrous oxide and their specific gravities vary from 2.5 to 3.02, the amphibole variety usually ranging around the lower figure. The following chemical analyses shown in Table I give the general run of these two varieties.

The essential difference in the composition of amphibole and chrysolite asbestos is the amount and condition of the water present. Chrysotile asbestos, usually known as the fibre of commerce, contains from 12 to 15 percent of water in combination with other constituents and begins to disintegrate and lose its strength when heated at about 750 degrees centigrade. The amphibole variety, on the other hand, contains only about 5 percent of chemically combined water and stands up well under considerably higher temperatures, but its exceedingly brittle fibres prohibit its use for weaving or spinning purposes. This variety is usually ground up, formed into a paste and manufactured into heat insulating materials and heat resisting compounds.

It is generally believed that all asbestos deposits had at one time the same large percentage of water, and that some have been subjected to great heat since their formation so that their compositions have been thus modified in various degrees by losing a greater or lesser percentage of water.

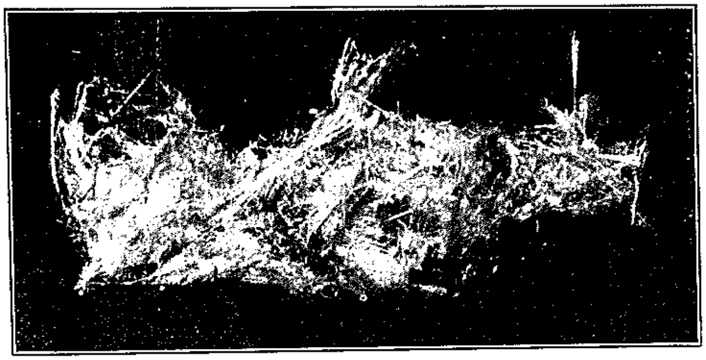


Fig. 2. Shredded asbestos fibre ready for carding. This is the condition of the fibres shown in Fig. 3 after milling. Photo by courtesy of H. W. Johns-Manville Co., New York.

Examination of asbestos fibres under the microscope reveals the fact that they are absolutely straight, without twists or regularities such as give cotton, silk and wool fibres their exceptional spinning qualities. Due to this peculiarity, progress in the manufacturing of asbestos textiles was impeded for a long time. This difficulty, however, has been overcome and it is now possible to produce strong asbestos thread weighing only about one ounce to the hundred yards.

Asbestos deposits occur in many places on the globe, but it is unfortunate that only the material obtained from Canada, Rhodesia, Arizona, South Africa and Russia is of the quality generally suitable for manufacturing purposes and does not entail too great mining and transportation difficulties. Previous to the discovery of the large Canadian deposits in 1878, practically all the asbestos used throughout the world came from Italy, but the mining conditions encountered in that country kept the cost of production so high that its marketing for general use was prohibited.

No. 1 extra long | No. 1 | No. 2 | No. 3 | Mill Fibre

Fig. 3. Actual comparative lengths of asbestos spinning fibres. Rock fibres like these are prepared for spinning by mechanically disintegrating into fibres, graded by air blasts into the condition shown in Fig. 2. Illustration by courtesy of the United States Asbestos Co., Manheim. Pa.

More than three-fourths of the world's supply of asbestos is derived from Canada where it occurs in a relatively narrow zone extending from about 40 miles south of Quebec to, and a short distance across the United States border. Its commercial extraction in this zone is only possible at certain localities, among which the principal ones are Thetford, Black Lake, East Broughton, and Danville.

Table I Analyses of Asbestos Varieties

BLUE CAPE ASBESTOS (AMPHIBOLE)

	Percent
Magnesium oxide, MgO	2.3
Silica, SiO_2	51.1
Iron Oxide, FeO	35.8
Soda, Na_2O	6.8
Water, H_2O	3.9

CANADIAN CHRYSOTILE ASBESTOS

	Percent
Magnesium Oxide, MgO	40.37
Silica, SiO_2	39.05
Alumina, Al_2O_3	3.67
Iron Oxide, FeO	2.41
Water of Constitution, H_2O	14.48

ARIZONA CHRYSOTILE ASBESTOS

	Percent
Magnesium Oxide, MgO	41.85
Silica, SiO_2	41.35
Iron Oxide, FeO	0.69
Alumina, Al_2O_3	0.91
Calcium Oxide, Lime, CaO	0.07
Water of Constitution, H_2O	11.96
Water, Hygroscopic, H_2O	1.38

The Canadian asbestos output for the year 1880 was 380 tons as compared with 132,564 tons in the pre-war year 1913. During the war period there was a general scarcity of asbestos along with an increased demand so that, although the 1918 production reached 143,743 tons, prices trended skyward and the same grade of short or mill stock fibre that sold for from $10 to $20 per ton in 1913 brought from $40 to $50 per ton in 1918 while the highest grade or No. 1 crude which was selling at from $300 to $400 per ton just previous to the outbreak of the war brought from $800 to $950 per ton in 1918. Last year's output totaled 136,199 tons.

American asbestos is found in 16 different states but the total production for 1918 reached only 800 tons, the greater part of which came from Arizona, California and Maryland.

The Chrysotile, or commercial variety of asbestos, occurs in veins or pockets with the fibres, which, as shown in Fig. 3, vary from a fraction of an inch to about 4½ inches in length, running perpendicular or nearly perpendicular to the enclosing layers of hard semi-volcanic serpentine. Despite the difficulties encountered by bad-weather and a long winter season, Canadian deposits are nearly all worked as open quarries because the irregularity of the veins require the removal of practically the entire mass of rock. Frequently the extraction of one ton of asbestos ore involves the handling of from 10 to 20 tons of waste.

The finest pieces are first treated by hand with hammers to remove the external impurities, a process known as "cobbing," which leaves the fibres as shown in Fig. 3. The material is then run through crushers, dried by centrifugal machinery and fiberized to break the fibre into threads in a similar manner to beating flax and hemp. The lower grades are put through the same process without the initial hand treatment. The fiberized asbestos goes to a "cyclone" which agitates it with violent blasts of air and finally blows the lighter silken fibres one way and the coarser ones another, while the dust and refuse drop out below. From the "cyclone" the fine fibres fall into a shaker where they undergo another agitating and separating process and are lifted by powerful fans into various compartments according to grades. The milling process is thus completed and the crude asbestos which now looks as shown in Fig. 2, is stored in bags and ready for industrial use.

With the world's largest source so near at hand, the United States has naturally become the largest importer of asbestos and the largest manufacturer of asbestos products. From a total of 134,108 tons of this mineral imported in 1917 into the United States, 131,525 tons came from Canada. This tonnage was equivalent to 92 percent of the entire Canadian production.

The important characteristics of asbestos which make it indispensable in the arts are its fibrous structure, its electrical insulating property and its remarkable resistance to heat, acids and alkalies. Its industrial applications may be conveniently divided into two classes: one in which the very short, brittle and waste fibres are utilized, and the other, which may be termed the textile class, in which the longer, more flexible fibres of greater tensile strength are employed.

Short Fibre Used for Heat Insulations

The largest part of the world's production of the shorter grade fibres is used for the manufacture of coverings like those shown in Fig. 4 for steam pipes and boilers where advantage is taken of the heat insulation property of asbestos. When air is properly confined in volumes so small that no heat can be carried away by it through convection, it forms a most efficient heat insulation. Fibrous asbestos constitutes a very ready vehicle for building up a mass of small air spaces, and its insulation value is due to the air caught among these fibres. There are great varieties of pipe and boiler coverings on the market among which the most promi-

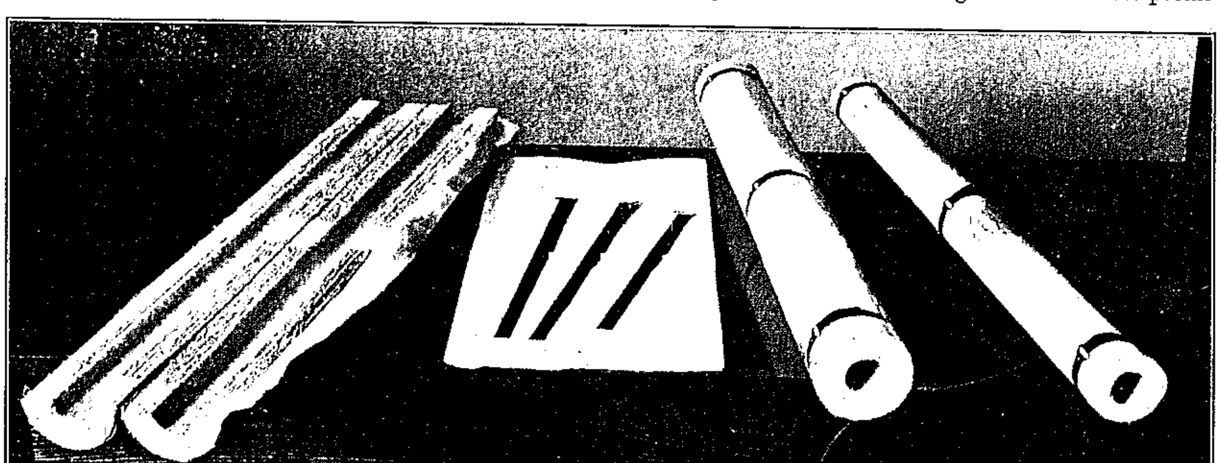


Fig. 4. Type of sectional asbestos pipe covering. Made by the Franklin Manufacturing Co. Franklin, Pa.

nent are: the asbestos felt covering, the asbestos air cell covering as shown in Fig. 7, which is made up of successive layers of plain and corrugated asbestos felt, and the popular 85 percent magnesia covering in which from 10 to 15 percent of asbestos is used as a binder. A number of these coverings are made in sections three feet long, split lengthwise and connected by means of iron bands or canvas, as shown in Fig. 4, in order to facilitate easy application and removal.

for such purposes as molded electrical insulations, heat resisting paints and roofing material. In this connection, the product marketed as "ebony asbestos wood" by the H. W. Johns-Manville Co. of New York, should be of particular interest. Besides taking the place of slate, porcelain and alberine stone in panels for switchboards, switch boxes, fuse blocks and other electrical equipment, it has made an ideal material for table and sink tops in the chemical laboratory, where it has been found

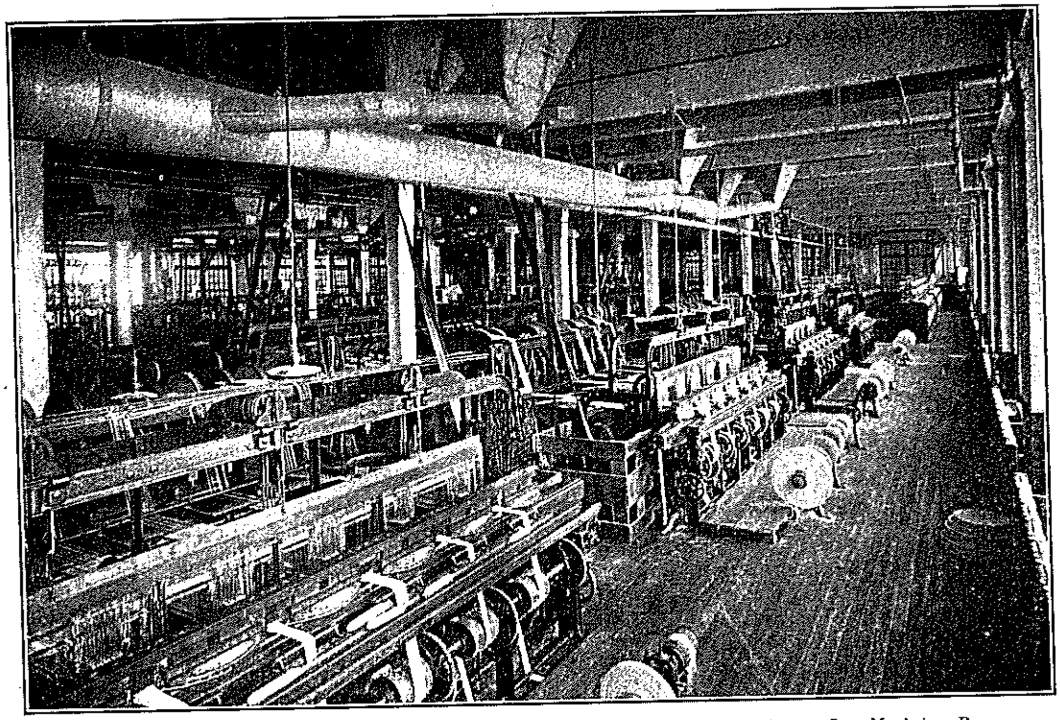


Fig. 5. Weaving room of the brake lining department of the United States Asbestos Co., Manheim, Pa.

practically impervious to various acids and alkalies.

Another markedly increased demand for asbestos in the chemical laboratory is being created by its popular use as a filter in the replacement of filter paper. For this purpose a mat made of finely ground asbestos fibre is used in conjunction with a platinum crucible having a porous bottom and known as the "Gooch" crucible. Asbestos freed from iron is especially valuable in this connection because it is neutral in reaction and does not contaminate or change the acidity or the alkalinity of the material which is being filtered through it.

Another important outlet for short fibres is found in the manufacture of asbestos millboards which are made up of asbestos fibre with a small percentage of cementing, or sizing material, built up in laminations similar to cardboard in sheets usually 42 inches by 48 inches and from 1/16 to ½ inch in thickness. This material is furnished in two degrees of hardness, one known as regular and the other as hard, the hard receiving a special treatment which renders it suitable for building construction.

Besides being marketed in this form, sheet asbestos is furnished in continuous roll form resembling paper in thickness from about 1/100 to ⅛ of an inch. Thicknesses up to and including 1/16 of an inch are spoken of as asbestos paper, while those measuring 3/32 and ⅛ of an inch are known as rollboard. Paper and rollboard are furnished in rolls 36 inches wide weighing approximately 100 pounds each. They consist almost entirely of asbestos fibre, and on account of their lightness and flexibility and their mineral composition, they are of great value for fire protection and insulation for hot pipes and boiler parts which it is not convenient to cover with sectional insulation.

Millboards and papers are used to line the inner and outer walls of doors, sides, tops and bottoms of stoves and ranges. The value of this material as a protection against fire is shown by the fact that 50,000 tons are used each year in building construction alone.

Numerous other applications of the shorter fibres are commonly used in composition with other materials,

ASBESTOS WOVEN FABRICS AND MANUFACTURE

Long fibre asbestos, known to the trade as "crudes" is used in the manufacture of asbestos yarns and cloths. Such fibres, after leaving the crushers, are carefully cleaned of foreign matter and carded by modern carding machines consisting of a series of rollers, the action of which is compared by one authority to the combing and brushing of one's hair. This operation is required because it is necessary to lay the fibres as nearly parallel as possible before they can be spun into a thread. After the material is carded, it is transferred to a spinning machine where the fibres are twisted into a thread forming asbestos yarn. In order to standardize the numbering of asbestos yarns in a manner similar to that used for vegetable fibre yarns, a table was adopted by asbestos manufacturers in 1907, in which the number indicates how many lengths of 100 yards weigh one pound. Thus No. 2 indicates that 200 yards weigh one pound. Owing to the fact that single yarns lack uniformity, all asbestos yarns are sold as ply yarns, and as many strands as may be desired can be twisted into one thread up to 6 or 8 ply. For certain purposes such as automobile brake band linings and special types of packings, very fine brass wire, usually .007 or .008 of an inch diameter is utilized in the twisting or doubling operation.

Asbestos tape was first employed about the year 1900 by electrical manufacturers to replace cotton tapes which were used to wrap armature and field coils and which cannot withstand continous temperatures much above the boiling point of water. Asbestos tape, when wound on coils, is coated with an organic cement and is not subject to destruction by temperatures reached in practical service. Such tape is especially beneficial in heavy service apparatus, such as rolling mills, traction and crane motors, lifting magnets and other machinery which is in constant danger of being burned out. Tapes for this purpose are generally woven 0.025 and 0.015 of an inch thick. The most common style of asbestos tape, known to the trade as "asbestos listing," is sold in rolls three inches wide and is used extensively in wrapping lead cables in underground conduit work and in covering steam pipes.

Asbestos Packings and Gaskets

A most popular and rapidly growing application of asbestos is witnessed in its employment in the manufacture of packing for high pressure steam engines both land and marine. When this material was first utilized for this purpose, it was condemned because certain impurities in the raw material used were not removed and caused the piston rods of the engines to be scored by the packing. Another fault developed in the use of such packing was due to the fact that it became hard in service. This condition was at one time erroneously attributed to asbestos itself, when, as a matter of fact, it was due entirely to the quality of the rubber cement used as an adhesive after the packing was cut, folded and pressed into shape. In this connection, Cirkel, in his elaborate and authoritative treatise on asbestos says:

"Whatever the material may be which is used for this purpose (packing), it is a matter of primary importance that, under the action of steam or heat, it shall retain its smooth, slippery condition; and its nature remains unaltered, however high the pressure or velocity of the steam to which it may be subjected. The characteristic qualities of asbestos admirably fit it for such purposes as these: its adherent lubricating property rendering it additionally valuable; since by its use perfectly pure piston packing can now be produced, through which the rod slides with a minimum of friction. Other important features are: (1) that it does not require frequent renewing; (2) regularity in the motion of the piston is preserved; (3) all the machinery connected with it runs with perfect smoothness, and (4) its elastic nature keeps the joints tight longer than any other kind of packing."

In order to give packings for ordinary temperatures a certain amount of resiliency, this material has been made with cores of especially compounded rubber, as shown in Fig. 6. Other types of packing of both the metallic and non-metallic cloth varieties are made with lubricated flax cores, where it is essential that the packing be continuously lubricated in service. Another type uses a core of lead tubing when it is necessary to have the lubricant flow through the center of the packing to keep it constantly lubricated. These packings are constructed to meet unusual heat requirements.

A simpler variety known as sheet packing, is produced by coating an asbestos fabric with rubber thus enabling it to hold its form and not unravel when cut into desired shapes and sizes. This material finds application in the joints of pipes through which steam, liquids or gases are conveyed. The rubber serves another purpose in that it cures while in actual service, thus becoming part of the joint itself and curtailing the possibilities of leakage. This sheet is sold in rolls either plain, or graphited on one side, in thicknesses from 1/32 to 1/8 of an inch and weighing from 5 to 12 pounds per square yard.

An asbestos wick packing, made from roving, is used

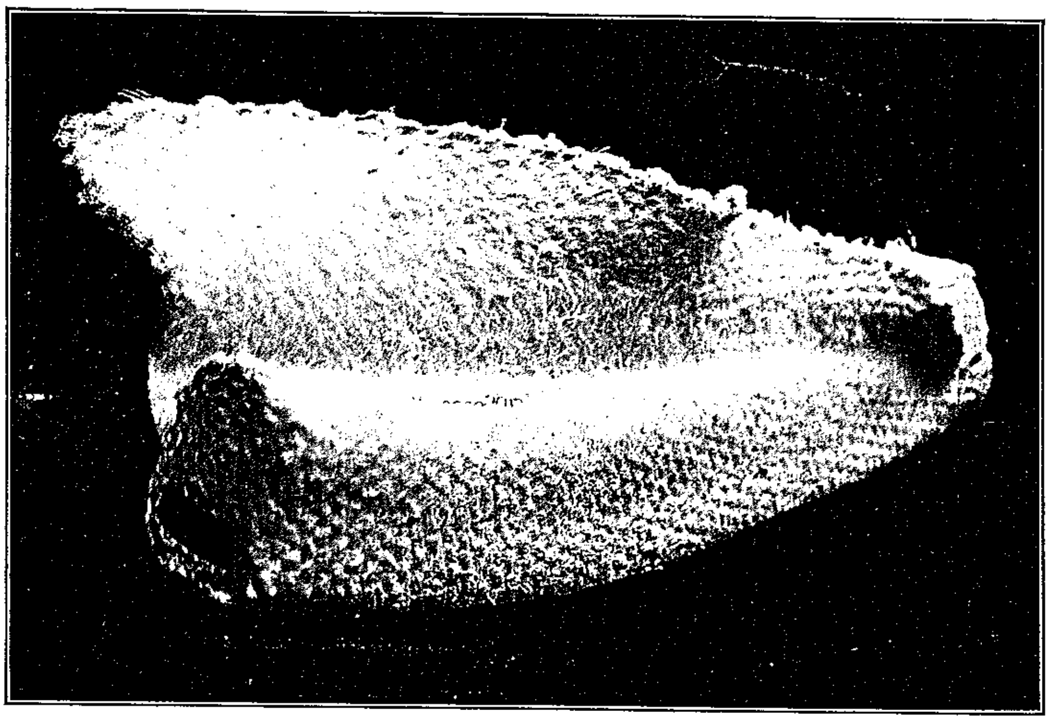


Fig. 6. Section of resilient asbestos packing with a cushion of rubber in the back of the packing. Photo by courtesy of the United States Asbestos Co., Manheim, Pa.

for wire wiping and for general dry heat conditions where there is very little if any steam pressure.

Asbestos gaskets are manufactured in all shapes of the same material as sheet packing and are used on boilers for the manholes, handholes and mud drums. They are also utilized like asbestos sheeting in joints on steam pipes, in steam and internal combustion engines and in air brake cylinders of railway locomotives.

Asbestos Used in Automotive Industries

Asbestos has deservedly become a necessity to the good and welfare of the automotive industry; so that the development of the asbestos industry is correctly spoken of in terms of the progress of automobile manufacture. Thus far no better material than especially prepared asbestos metallic cloth has been discovered for use as a brake band lining, and a majority of the motor car manufacturers are using this same material for clutch facings as shown in Fig. 9. In other words the automobile starts and stops with asbestos. It is also utilized in hoisting engines, in cranes, and in fact wherever a high coefficient of friction together with a heat and fire resisting quality are required.

Fig. 7. Type of asbestos air cell pipe covering made by H. W. Johns-Manville Co., New York.

For such purposes a long fibre asbestos yarn twisted with brass wire as suggested by Fig. 1, but whose actual manufacture is shown in Fig. 5. (This process weaves the wire and asbestos into a tight compact mass and impregnates it with a waterproof binder to prevent absorption of moisture.) Another variety is made of asbestos cloth coated with rubber, folded, stitched together and compressed into the desired shape either by rolls or large hydraulic presses. Asbestos brake lining similar to that shown in Fig. 8 is made in nine widths ranging from one to four inches while thickness ranges from 1/8 to 1/4 inch and weights vary correspondingly from 7½ to 50 pounds per 100-foot length.

In the production of automobile tires, one manufacturer uses asbestos fabric as a breaker strip on the theory that this material is much more resistant to heat than any cotton fabric and will, therefore, increase the life of the tire. Another tire manufacturer utilizes strips of asbestos cloth as a liner in the rubber curing molds to protect the surface of the rubber from the high temperature employed in these molds. Such strips are used repeatedly until they are worn out.

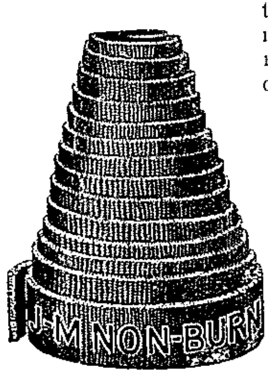


Fig. 8. Automobile asbestos brake lining.

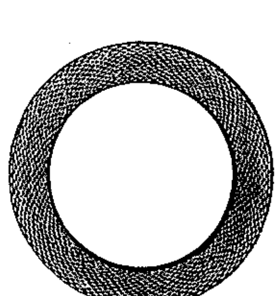


Fig. 9. Clutch facing made of impregnated asbestos fabric.

The universal development of the chemical industry has given birth to new asbestos applications among which are its use in the form of pure asbestos cloth for diaphragms of oxygen apparatus and in combination with portland cement and other substances for the diaphragms of caustic soda cells. Both this cloth and fibres of which mention in this connection has previously been made, are employed extensively for filtering acids, alkalies, fruit juices and other fluids because asbestos, which is an absolutely neutral substance, will not contaminate or effect the original chemical composition of the material being filtered.

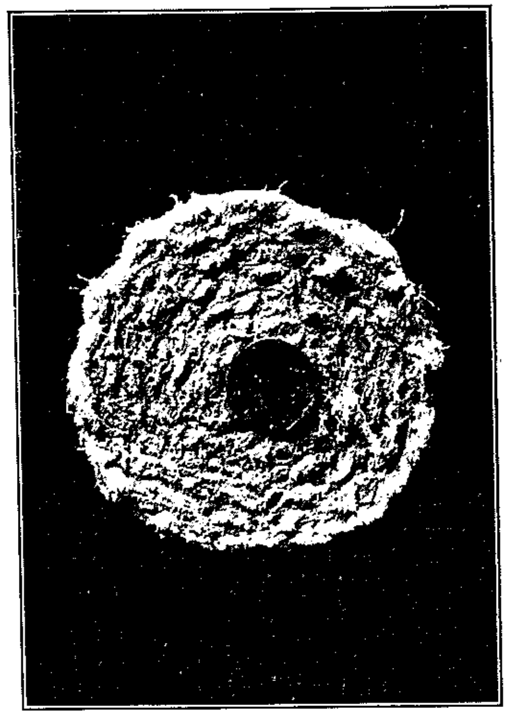


Fig. 10. Asbestos packing carrying a solid center core of rubber used to give the material resiliency. Illustration by courtesy of the United States Asbestos Co., Manheim, Pa.

Miscellaneous Applications to Industry

Building construction offers asbestos a wide range of applications among which are included roofing shingles, asbestos protected metal, tiling for floors, wall plaster and paints. Not only its fireproofing qualities but also its ability to preserve an even temperature in the building erected have gained for asbestos wide-spread recognition in this field.

Even in the household, asbestos has become a necessity. Here it is found made into table mats that protect the polished surfaces of table from the injurious effects of hot dishes, and into baking sheets, stove mats and flat iron holders.

At the theatre the audience is confronted by the word "Asbestos" painted across a large curtain woven of this material and hung there to protect patrons from the hazards of fire which might find an easy start in the complicated electrical equipment and inflammable properties behind the footlights.

Recent enactment of stringent safety legislation and increases in workmen's compensation rates have created a large demand for asbestos clothing such as suits, aprons, masks and gloves for use both by welders and by men employed in metallurgical and chemical plants where they are exposed to high temperatures, acids and alkalies. The importance of asbestos to many manufacturers is now manifest—obviously it must be included within their list of essential raw materials.

Asbestos---How It Is Mined, Spun and Used

By F. H. Mason

In the following is presented a concise summary of the outstanding features of asbestos production and utilization. The author is a Canadian authority on the raw materials of the Dominion.

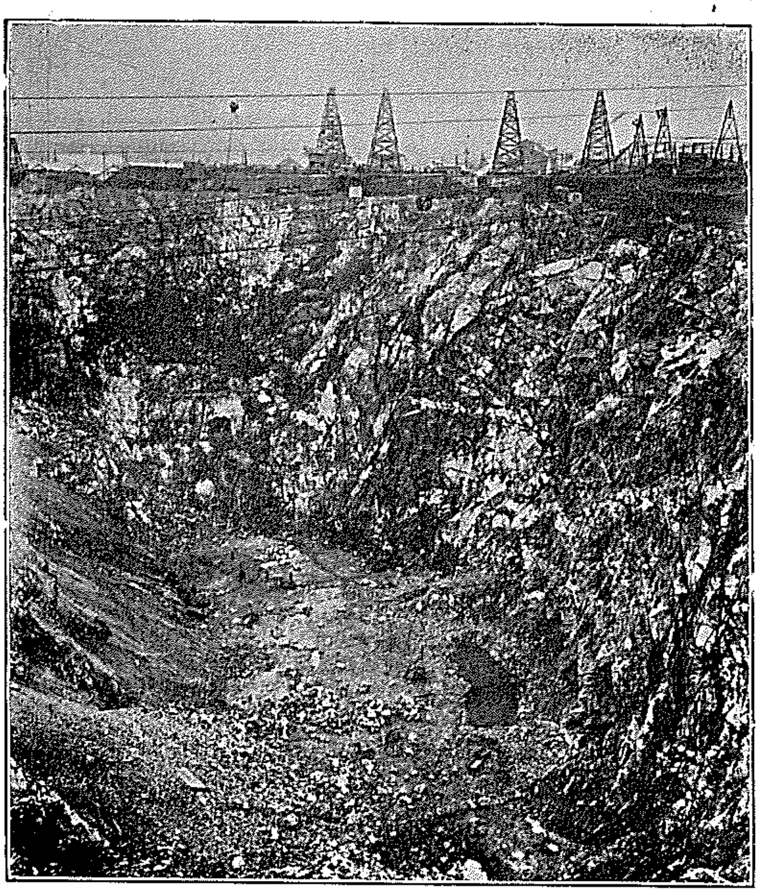
THE use of asbestos as a material from which to weave fireproof cloth was known to the early Romans, the wealthy of whom are said to have used asbestos cloths for winding sheets, and such a sheet is still preserved among the curiosities at the Vatican. The use of asbestos for this purpose, however, was not, as has been suggested, to protect the wearer from the rigors of the hereafter, but rather as a convenient method of preserving the ashes after cremation, which was the usual method of disposing of the bodies of the wealthy in those days.

The art of spinning all asbestos yarn was not known at that period, as no suitable mineral for the purpose had been discovered. The ancient cloths, therefore, were made of yarn composed of asbestos and some organic fibre, such as linen, to give it strength. When subjected to fire the organic matter was burned, but the mineral matter remained intact. The mineral was found in the Italian Alps, and is known as hornblende or amphibole asbestos; it is quite different from the mineral that is used in the manufacture of asbestos cloth today, being harsher and more brittle.

The art of weaving a yarn composed of asbestos and organic fibre, which, as has been said, was known to the ancients, appears to have been lost, for there is no mention of asbestos in the literature of the middle ages, and, though an attempt was made to manufacture cloth from asbestos found in the Ural mountains in the middle of the eighteenth century, it was not seriously revived until 1877, when an asbestos of a different character was found near Thetford, in the Province of Quebec. This mineral, which is known to the mineralogist as chrysotile, has a pliable silky fibre of great strength, and, therefore, is readily spun into yarn that can be woven into cloth.

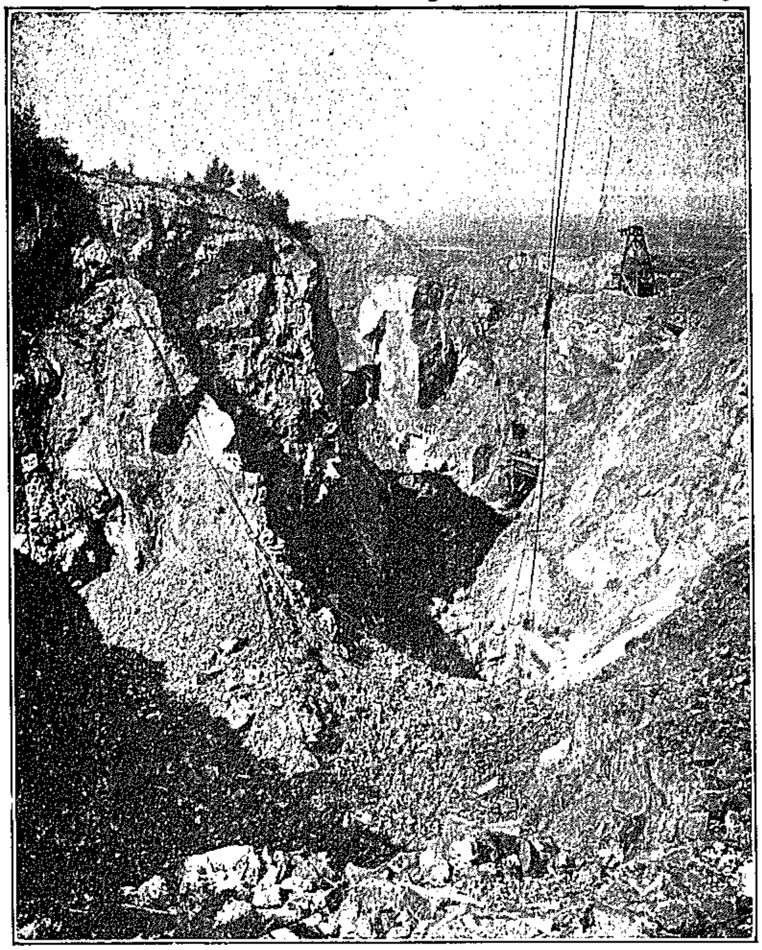
Chrysotile asbestos is found in a belt of serpentine rock that parallels the Quebec Central Railway for about 50 miles, in the neighborhood of Broughton, Thetford and Black Lake, and outcrops again for a few miles near Brompton, some 30 miles southwest of the larger deposit. So far as is known, the belt is comparatively narrow, averaging between one and two miles in width, but the country is heavily wooded, and in places there is a considerable overburden of alluvium, so it has been impossible to define its limits. In fact, so dense is the forest that it is likely the mineral would not have been discovered, but for forest fires that swept the district, leaving the rock exposed in places, and the subsequent weathering of the asbestos readily disclosed the nature of the mineral.

Asbestos is found only in some sections of the belt; other, and often adjoining, sections being quite barren. The deposition of the asbestos seems to have been influenced by the intrusion of granite, which fissured the surrounding rock and left spaces in which the asbestos was deposited. Asbestos occurs in veins and veinlets, ranging from the thickness of a piece of paper up to four, and in rare instances, 5 in. These veins sometimes parallel each other and sometimes criss-cross in all directions. The origin of the mineral is still a matter of doubt, but the general opinion tends toward the theory that the granite intrusions caused extensive fissuring of the serpentine, and the fissures subsequently have been filled by asbestos obtained from the serpentine wall rock, the wall rock being, broadly speaking, of the same chemical composition as the asbestos, though occurring in an entirely different physical form. The fact that the larger veins frequently have a parting in the centre and that the parting often contains fragments of wall rock would seem to support the theory that the



Asbestos quarry, King pit, Shetford, Quebec. Photo by Dr. R. Harvie, Department of Mines, Geological Survey, Dominion of Canada.

veins had been built up from the walls toward the center; a theory that further is supported by the fact that, except where there has been a subsequent rock movement, the fibre of the asbestos always is at right angles to the walls of the veins. However, as the theory of its origin is not yet thoroughly established, the genesis of asbestos may well be dismissed in an article of this nature without further comment. It is sufficient that asbestos has been, and is, found in sufficient quantity in this comparatively limited area to have provided in the neighborhood of 85 per cent of the world's output of the mineral.



Manhattan pit, Asbestos Corporation of Canada, Black Lake, Quebec. Note entrance to tunnel and underground workings to right of picture. Photo by Dr. R. Harvie, Department of Mines, Geological Survey, Dominion of Canada.

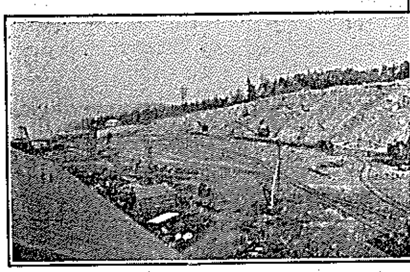
To those used to the mining of other minerals, the methods of mining—or rather quarrying, for nearly all of the workings are open pits—asbestos at first sight may seem to be crude and haphazard, but it must be remembered that asbestos is an unusual mineral, and methods of exploration and exploitation that are applicable to other minerals are not applicable to it. Thus, practically no exploration is done before a pit is started. Diamond drilling, now used so much in exploring for other minerals, is impracticable in the case of asbestos, because the fibrous nature of the mineral clogs the drill, and tends to tear the diamonds out of the bit. Preliminary shaft sinking and drifting has been found to be equally unsatisfactory because of the uneven distribution of the asbestos in the rock. The methods usually adopted, therefore, are to strip off the overburden at some point where it is fairly shallow, select a spot where there is a promising concentration of asbestos-bearing rock, start a pit, and widen and deepen it in the directions in which the rock is the richest. To be profitable, the rock should contain certainly not less than six per cent of marketable fibre, and if after a fair amount of exploration work has been done, the pit is found to run below this amount, it is abandoned, and another pit is started at some more promising point. Many abandoned pits are to be seen in the serpentine belt.

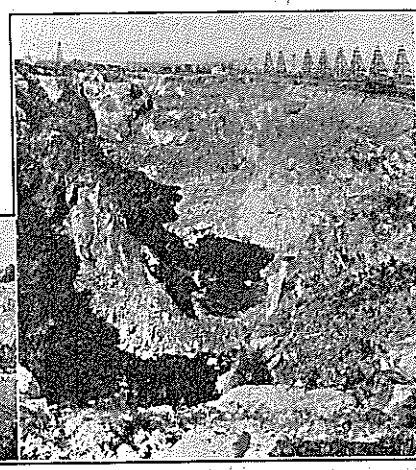
When a favorable location has been found, the method of procedure depends pretty much upon the financial strength of operators. Small concerns generally follow the trend of the profitable rock, and leave the unprofitable rock alone. Quarries, therefore, often assume curious and quaint shapes, often having pillars of barren or unprofitable rock sticking up in all directions. In the early stages of opening a pit the rock usually is hauled up an incline by a winding engine, but as depth is gained this ceases to be practicable, and generally the method is replaced by either a boom derrick or a cable derrick. Boom derricks are used only by small concerns, as the scope of their operations are too limited. They are designed on exactly the same lines as those used in the erection of large buildings, and their principle is familiar to everyone. Cable derricks are the feature of the landscape in the serpentine belt. A cable is stretched from a derrick to some point on the opposite side of the pit, where it is securely anchored. These cables are from one and a half to 2 in. in dia., and from 100 to 500 ft. long. There is a winding engine near the derrick, and a carrier, suspended from the cable and operated by a running cable and a system of pulleys conveys a bucket or platform, as the case may be, to any desired point along the cable, whence it is lowered into the pit, loaded with asbestos rock, hauled up again, and the rock is discharged into cars near the derrick. Some of the larger concerns have many of these derrick cables across their pits.

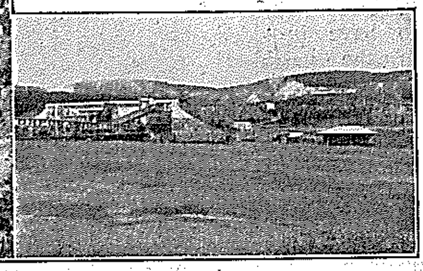
Having selected a site, the large companies usually strip the overburden, which ranges from 2 to 25 ft. in thickness, with a steam shovel, and then the pit is sunk systematically by a series of terraces, both the asbestos-bearing and the barren rock being removed at the same time. It readily will be seen that for large-scale operations a number of irregularly shaped pillars of barren rock left in the pit would hamper work; all the rock, therefore, is removed, the profitable rock being segregated from the unprofitable; the latter is conveyed to the surface and placed on waste-dumps, that grow to immense proportions, and, with the derricks, form the principle feature of the landscape.

Up to the present, none of the pits have been sunk to a greater depth than 225 ft., although in mining chrome iron ore, which occurs in the serpentine belt, asbestos has been found at a depth of 400 ft. below the surface.

During the last few years, some of the larger concerns have been changing their methods of operation, and a certain amount of underground mining is now being done from the bottoms of the pits, tunnels being driven into profitable rock. This has the advantage that it allows work to be continued during bad weather, when outside work would be impossible. The cable derrick system of haulage has its disadvantages. In some of the larger quarries as many as 10 or 12 cable-derricks are in operation, and they necessitate as many different hoisting units, with their concomitant expense. Moreover, no matter how much care is exercised, there always is a certain amount of danger to the men below from falling rock, and, should anything happen to the carrier grave disaster might result. To avoid the possibility of such disasters, Bell's Asbestos Company took the initiative, and sank an inclined shaft or slope, to connect the floor of its quarry, 196 ft. below the surface, with its mill, 1,100 ft. away. All the rock from the quarry is now hauled through this slope in five-ton cars, and a considerable saving in the cost of production has resulted.







Left—Asbestos quarry, Vimy Ridge mine, Bennett Martin Asbestos & Chrome Co., Coleraine, Quebec. Center—British Canadian pit, Asbestos Corporation of Canada, Black Lake, Quebec. Note the number of derricks and cables. Right—British Canadian asbestos mill, Black Lake, Quebec. Note the large dump of waste rock. Photos by Dr. R. Harvie, Department of Mines, Geological Survey, Dominion of Canada.

Methods of Dressing the Rock Vary

As the same method of dressing the rock, as the segregation of the asbestos from the serpentine is called, is not followed at any two mills, it is possible to give only a general outline of the processes that the rock passes through, in order to separate the asbestos in a marketable form.

At the majority of the quarries No. 1 fibre, that is, fibre ¾ in. in length and upwards, is separated by hand-cobbing, while at other quarries, No. 2 fibre, ranging from 5/16 to ¾ in. in length, also is separated by this method.

The rock is sorted by hand in the quarries: that containing the long fibre is broken to a convenient size, and sent to the cobbing sheds, that containing the short fibre is sent to the mill; the barren rock is sent to the waste-dump. Usually there are two cobbing sheds; the men's shed and the girls' shed. The sorted rock is received at the men's shed, where it is broken up by 7-lb. single-handed sledge-hammers. The rock containing long fibre is sent to the girls' shed and the remainder to the mill. Seated at a table with heavy steel plate in front of each girl, and using 3-lb. hammers, the girls break the fibre from the serpentine by pounding the rock on the plate with the hammer; they then sieve it to remove the waste rock, sort the fibre and put it in the proper bins, which are placed conveniently under the table at which they are seated. All the refuse from the girls' shed is sent to the mill.

The large pieces of low-grade rock that are sent directly from the quarry to the mill are broken to convenient size in a rock-breaker, and then, before it undergoes any further form of treatment, the rock is dried. This usually is done in some form of rotary drier, the design of which varies considerably at the different mills. The most common type consists of a cylinder, 30 to 40 ft. long, supported at the ends on rollers. The cylinder is set at a gentle slope (about 7 deg.) and generally has two grates, one at the lower end and one at the middle. With the exception of about 1 ft. at each end, where it is supported by the rollers, the whole of the cylinder is enclosed by brickwork, and the flames from the grates play between the cylinder and the brickwork, the products of combustion finally escaping through a chimney, placed near the upper end of the cylinder. The rock is fed in at the upper end of the cylinder, which is rotated by friction or gear wheels, and made to revolve four to seven times per minute; the rate being so arranged that the passage of rock through the cylinder shall deprive it of its moisture, without heating it unnecessarily. Each furnace will dry from 50 to 80 tons of rock daily, the quantity depending on the size to which the rock has been broken and on the quantity of moisture that it contains. Some drying kilns, instead of having a single tube, have five 15-in. tubes, which are fastened to large cast-iron cylinders at the mouth and discharge, much on the same principal as a tubular boiler, and these kilns, offering a larger surface to the fire, dry the rock more quickly.

The rock is next passed through a series of crushing machines, the nature of which varies at the different mills, and then over screens. These are shallow rectangular boxes, the bottoms of which are made either of wire screening or punched steel plate. The holes are about 1/16 in. in dia., and the crushed rock passes through them, leaving most of the fibre on them. Above the shaking screens is a suction device, closely resembling the nozzle of a vacuum cleaner, and this sucks up and carries away the light fibre that has been freed from most of the rock. This fibre is passed to another screen, where the operation is repeated, to completely free the fibre from loose rock. The material that is neither drawn up by the suction arrangement nor passed through the screen is a mixture of serpentine and fibre, and is sent to a machine known as the cyclone fiberizer. The machine consists of two beaters, shaped like the screw of a steamship, enclosed in a chamber with a heavy chilled-iron lining. The beaters revolve in opposite directions at the rate of 2,000 to 2,500 r.p.m., and beat the particles of rock against each other and against the lining of the machine, quickly reducing the serpentine to an impalpable powder, without greatly injuring the tough asbestos fibre. The liberated fibre and dust are continuously drawn out of the machine by a suction device, and separated on screens.

At some of the mills, the fine rock that passes through the shaking screens, and which contains some asbestos, is ground to a fine powder, a partial separation of the rock from the fibre is made by screening, and the fibre, which still contains a considerable proportion of rock, is sold under the name of *asbestic*. It is used for a large variety of purposes, for which asbestos is too costly.

The Many Uses to Which Product Is Put

Few mineral substances are put to a greater number of uses in the arts than asbestos. To attempt to cover all the uses would require far more space than is available. Most of the No. 1 grade of fibre is made ino yarn, a large proportion of which is woven into cloth, and used for fireproof curtains, wall-covering, and theatrical scenery that is particularly exposed to the danger of fire. It is used, too, in the manufacture of brakes for automobiles, winding engines, elevators and similar purposes. Asbestos cloth saturated with rubber is used for gaskets, while asbestos rope saturated with rubber and often mixed with graphite is used extensively as a packing for steam and internal combustion engines. The greater part of the mill stock, that is the fibre produced in the mills, is made into mill-boards, shingles, siding and similar purposes. Mixed with magnesia, asbestos is used very extensively for covering boilers and steam pipes. Low-grade fibre is used extensively in the manufacture of roofing felt. A corrugated sheeting is made of asbestos mixed with a variety of other substances, and is used for practically the same purposes as corrugated iron. Being a good insulator it is better than corrugated iron for many purposes. The short fibre is used in the manufacture of certain grades of paper.

In concluding this article, it will be well, perhaps, to try to correct a very common and wholly wrong impression that chrysotile asbestos cannot be injured by fire. Chrysotile asbestos contains about 13 per cent of water in a chemically combined form, and when it is heated to redness this water is driven off, with the result that, though the appearance of the mineral has not been greatly altered, the fibre has lost most of its original pliableness, and, consequently, its value. Thus, for example, the chances are that if an attempt were made to roll up an asbestos curtain after it had been subjected to a hot fire, it would be so brittle in places that pieces of it might drop out. It, however, would have served its purpose in preventing the spread of the fire, and it would have some value as scrap, but its original use would have gone for ever. In the same way the great value of asbestos clothes for firemen is that they are incombustible and consequently will not catch fire if the fireman in his duties comes in contact with flames. They are not, however, indestructible, and if placed in a very hot fire would be of no further use for the purpose for which they were originally intended.

In the preparation of this article, though not quoting directly, I freely have used information contained in that excellent book, "Chrysotile Asbestos," by Fritz Cirkle, published by the Mines Branch of the Canadian Department of Mines. Although this book was published in 1910, and, of course, there have been many important advances since then, it still is quite the most authoritative work on the subject. It was published before the discovery of commercial quantities of asbestos in Rhodesia and in northeast Transvaal, and, therefore, makes only scant mention of these now important deposits of the mineral. A number of varieties of asbestos are found in Rhodesia and South Africa, including chrysotile, crocidolite, and amosite. The output of asbestos in Rhodesia has grown from 259 tons in 1913 to 19,529 tons in 1921, while the output in the Union of South Africa has grown from 859 tons in 1913 to 7,122 tons in 1921. The great demand for asbestos during the war had much to do with the development of these important deposits.

The quality of the African asbestos, both in color and in strength of fibre, is inferior to the Canadian mineral, but for many purposes, such as the insulation of boilers and steam pipes, and the manufacture of mill-boards, shingles, corrugated sheeting, and roofing, it serves equally well, and, as the concentration of the asbestos in the rock is markedly higher and cheap black labor is available to operate the quarry, the African deposits are likely to become an ever-increasingly dangerous rival to those in Quebec.

Recently, what promises to be an exceedingly important new discovery has been made at Lionel, in the northwest part of Western Australia, and just on the outskirts of the great desert. According to a report by the Geological Survey of Western Australia, a belt of serpentine outcrops at intervals over a distance of 200 miles, and in parts of this belt, especialy near Lionel, a high-grade chrysotile asbestos is found. At some points the asbestos is said to form 20 to 50 per cent of the rock, and that in color and length and strength of fibre it compares favorably with the Quebec mineral. So far the deposits are believed to be small high-grade ones, but, of course, further development may disclose large high-grade deposits, which would be a very serious menace to Quebec deposits, notwithstanding the far more favorable geographical situation of the latter, with regards to the principal markets of the world.

Baldwin's Electric Locomotive Output

Since 1895 the Baldwin Locomotive Works has been associated with Westinghouse Electric & Manufacturing Co. in the manufacture of electric locomotives. During this period the company has built over 4,600 electric locomotives, which represent the combined experience and facilities of the two concerns. Of these 4,300 have been constructed for mines and industrial establishments and the remaining 300 for light and heavy railway service. Baldwin was a pioneer in introducing the first successful gasoline locomotive in 1910, and over 1,200 have been constructed, the majority for war service.

Drill Steel Advisory Board

Notice of a meeting of the drill steel advisory board to the Bureau of Mines and the Bureau of Standards, to be held at 2 p. m., February 19, 1923, at the Engineering Societies Building, 33 West 39th Street, New York, has been forwarded to members by D. A. Lyon, chief metallurgist, of the Bureau of Mines, who is secretary to the executive committee of the board. At this meeting there will be a discussion of the report, written by Messrs. F. B. Foley, H. S. Burnholz, and C. Y. Clayton, on the present status of drill steel breakage and heat treatment.

Asbestos, An Ideal Insulating Material

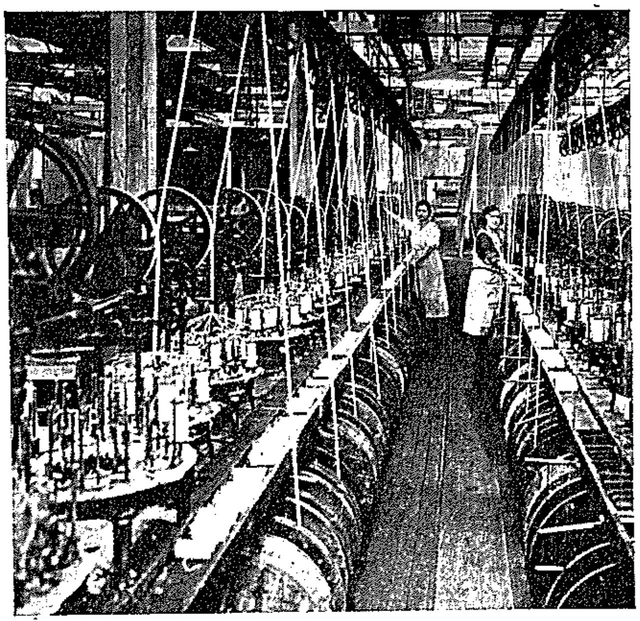
By Robert G. Skerrett

Published by Special Permission of "Asbestos", Philadelphia

The following article was prepared by the author with the assistance of the Rockbestos Products Corporation, New Haven, Conn., so that it is thoroughly authoritative. Unquestionably the field for asbestos as one of the leading raw materials in the electrical industry is broadening.

Asbestos insulated wire, because of its unique properties, is bound to play an increasingly important part in the realm of practically-applied electricity. Indeed, it is dawning more and more both upon electrical manufacturers and users of electrical equipment that asbestos is peculiarly fitted to improve efficiencies, to bring about substantial economies, to insure longer life in service, and withal, to augment the factor of safety.

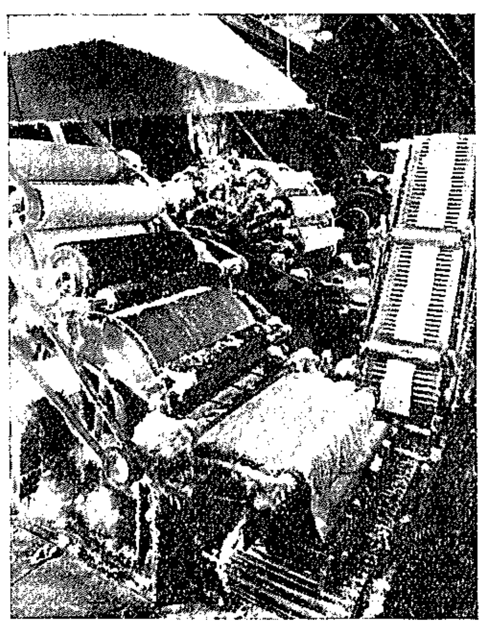
All of us are familiar with the ubiquitous incandescent lamp, and we are similarly acquainted with a wide range of other domestic electrical conveniences, such as coffee percolators, toasters, curling irons, flat irons, etc., which make an especial appeal to womankind. Every one of the foregoing electrical fixtures or appliances functions upon a common basic principle —*i. e.*, the reaction caused by interposing a more or less electrically-resistant metal in the circuit of an energizing current. Agreeably to the character of this interposed metal we have either radiance, as in the case of the light bulb, or we have the red glow of the heating wires or grid of the toaster, iron, etc.



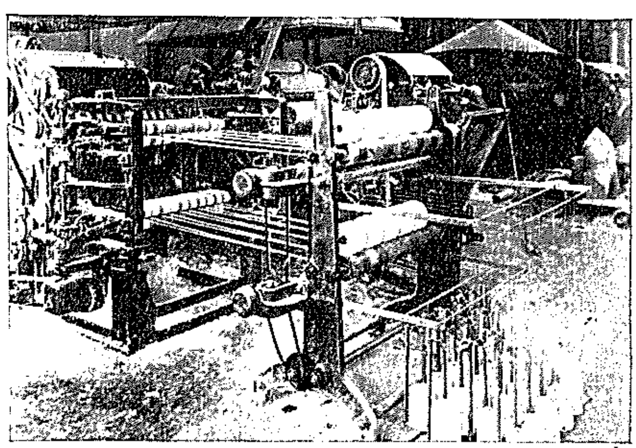
Braiding conductors with asbestos yarn. Photo by courtesy of Rockbestos Products Corporation, New Haven, Conn.

It is likely that only relatively few of us have grasped the fact that the heat produced intentionally in the domestic conveniences cited (for the nonce the lamp is not included in the group) actually menaces the integrity of the attached electrical conductors; and the temperature may climb high enough under some circumstances to break down the enveloping insulation and thus occasion a flaming short circuit. Time and time again this very thing has happened, and people have been badly burned and fires of varying degrees of destructiveness have been started.

Latterly, nitrogen-filled electric lamps have won favor because the inert gas, in contact with an incandescent filament, induces an extremely brilliant light. In fact, the lamp uses considerably less current per candlepower than the usual type, and the nitrogen-charged globe gives a luminance much like that of daylight in quality. But while nitrogen is incombustible, still the gas promotes the transmission of heat from the filament, and when this



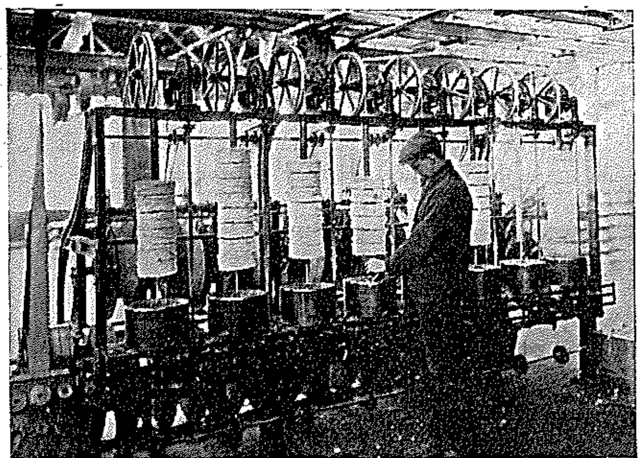
A set of carding machines which comb the asbestos fibres and lay them parallel in a thin sheet or "web" preparatory to working them into roving. Photo by courtesy of Rockbestos Products Corporation, New Haven, Conn.



Asbestos in the process of being formed into roving. It is either wound around the conductors in this state or it is first twisted into yarn to be braided about the conductors. Photo by courtesy of Rockbestos Products Corporation, New Haven, Conn.

heat is radiated through the lamp socket to the connecting wires it is apt sooner or later to impair, if not to destroy, the insulation of cotton or rubber. Therefore, it is essential that some other insulating medium be employed, and for this service none is better than asbestos. Why? Because asbestos is not only fireproof but it is an excellent non-conductor of electricity.

Let us be even more specific. Cotton is a vegetable fibre, and if subjected frequently or continuously to a temperature of 120 deg. F. and upward it is gradually carbonized, and from a non-conductor it is transformed into a very good conductor of electricity — hence loses its insulating properties. Rubber is not fire resistant, and it has an inherent tendency to oxidize in the course of time if in contact with the air. Heating will hasten this oxidation and destroy the rubber's value as an insulator. Asbestos, on the other hand, is a mineral, born when the earth's rocky crust was in a molten state, and it will not melt short of temperature of 2280 deg. F. Further, its dielectric characteristics normally remain substantially unaltered until heated more than 500 deg.



Serving rubber-covered conductors with asbestos in the manufacture of heater cord. These machines can produce 30,000 to 40,000 ft. per day. Photo by courtesy of Rockbestos Products Corporation, New Haven, Conn.

No Metallic Oxides Permissible

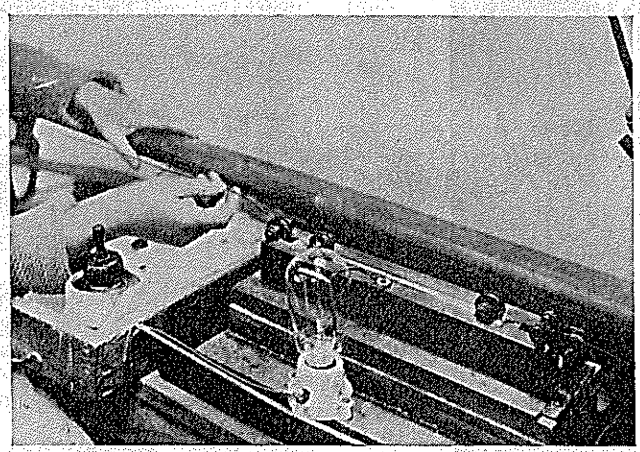
Before describing the various sorts of fixture wire, conductors, cords and cables which are insulated or covered with asbestos for the purpose of adding to their efficiency, let us outline broadly the procedure employed in one big factory which specializes in the production of these commodities. At the very start, it should be emphasized that a paramount desideratum is an asbestos free from metallic oxides. The mineral must not carry any iron, for this metal is a conductor of electricity. Again, the asbestos should be of a long-fibre sort so that the stuff can be worked up into a coating of uniform thickness and ample mechanical strength.

Rock asbestos of this kind is obtainable, and after it is mined it is sent to fiberizing plants where machines of special design grind it, shred it, and free it from adhering fragments of the erstwhile enveloping serpentine. The ultimate product has a fluffy, woolly appearance, and is in a condition to be fed to carding machines. These apparatus comb it out successfully until all of the mineral fibres are arranged parallel to one another. The next step is to make loose strands or *roving*. Inasmuch as the fibres of asbestos lack felting qualities, they cannot be spun, as the term is ordinarily understood, and to give them the needful cohesion they must be mixed or associated with a measure of cotton or silk yarn. The aim is to minimize the amount of cotton, for the reason already explained, and the adoption of the roving process in place of spinning makes this practicable.

With the roving in readiness on spools, the material is transferred to insulating machines, by which it is wound about the conductor. Wires can be covered in this manner at the rate of about 10 ft. a min. If, on the other hand, it is desired, because of service requirements, to braid the asbestos upon the conductor, this work is done by suitable apparatus at a speed of 1 ft. a min. In either case, the asbestos is saturated with a special chemically neutral cement, and subjected to pressure in passing through rolls which compact and smooth the enveloping mass. It is possible in this way to form a wall of insulation about the wire that is no thicker than when a double layer of cotton is employed. If needful, a thicker wall may be obtained by applying successive layers of roving. Asbestos insulation of this character is firm, tough and durable, and will withstand pressure and abrasive action.

Nothing Is Taken For Granted

Nothing is taken for granted in the best of insulated wire fabricated in this fashion. Every foot of it is tested electrically during one stage of production. The practice is to draw the asbestos-coated wire through a shallow trough filled with quicksilver. If this mercury can penetrate the insulation and reach the conductor it closes a circuit, in which is placed an incandescent lamp. Instantly the latter glows and indicates a fault in the insulation. Perfect wire will pass through the trough without causing the little sentinel lamp to shine.



Inspecting asbestos insulated wire electrically. Photo by courtesy of Rockbestos Products Corporation, New Haven, Conn.

A copper conductor may be so insulated with asbestos that the envelope will remain uninjured even when the contained wire is heated to a fusing temperature. Further, the wire may be bent abruptly without causing the insulation to crack or break, and superior asbestos insulation may even be elongated fully 5 per cent without damaging it. It should be noted here that the greater the flexibility of the cord the longer its life in service. These points are interesting, for they show how asbestos may be applied effectively to electrical conductors which are likely to be flexed in use.

And now let us touch briefly upon various kinds of asbestos insulated wire. The term insulation has two meanings: one indicating the power to prevent electrical leakage and the other the capacity to form a barrier against the transmission of heat. Sometimes the purchaser specifies that the wires, of heater cords, for instance, shall first be insulated with cotton and rubber and then reinforced by asbestos. When this is the case, the copper conductor is wound with two strands of cotton yarn; next follows an insulating envelope of high-grade rubber 1-64 in. thick, and this is succeeded by a wrapping of asbestos fibre 1-32 in. thick. According to requirements, two or more such conductors are bound together by cotton or silk braid, which is woven over them. In another style of heater cord the conductors are immediately insulated by asbestos, and held together by a braiding of cotton or silk. An absolutely fireproof cord may be produced by forming the outside braiding of asbestos yarn thoroughly impregnated with a special compound. Heater cord of the latter sort is strongly recommended both because of its dielectric strength and its ability to resist heat or fire. Age, so it is said, does not impair its effectiveness, and the insulation so binds the stranded wires that, should any of them break, the fine filaments cannot pierce the external covering and thus induce a short circuit. Cords of these several types are admirably suited to feed current to electric flat irons, percolators, toasters, vacuum cleaners, fans, soldering irons, welders, etc.

Asbestos Electric and Thermal Insulator

Cords for nitrogen lamps, as well as for other electric incandescent lamps of high candlepower, which are likely to generate a good deal of heat, are now insulated directly by a covering of asbestos, and, for the sake of finish, a braiding of silk or cotton may be employed. Here, the asbestos coating is at one and the same time an electric and a thermal insulator. In some of these cords, however, the silk or cotton textile is omitted and a braiding of asbestos substituted. As a means to greater security against electrical breakdown or fire hazard, cords both insulated and braided with asbestos should be generally adopted for electric desk, table and floor lamps. The asbestos braiding serves not only to check the transmission of heat from the lamps, but it likewise shields the conductor from flame or heat from any other source.

Asbestos insulated and braided conductors are pre-eminently fitted for switchboard wiring. On numerous occasions power plants, factories and shops have been put out of commission by the breakdown of rubber and cotton insulators at switchboards, and owing to this asbestos is gradually supplanting these materials. Asbestos insulated conductors can be made absolutely fireproof and, therefore, are superior to the so-called "slow-burning" wires hitherto common in this department of electrical equipment.

Cables that are insulated as well as braided with asbestos, and thoroughly impregnated with a waterproof compound, are growing in favor for moving picture outfits, but they are given a much heavier primary envelope of asbestos. These conductors are also widely utilized for the wiring of searchlights, electrical car or tram controllers, and for other electrical apparatus to which heavy currents must be carried through places subject to high temperatures, such as steel mills, blacksmith shops, electric furnaces, etc.

Needless to remark, manufacturers of the commodities described in this article have not attained their present proficiency without encountering many difficulties. The physical characteristics of asbestos are, in some respects, quite unlike those of the usual textile fibres, and a vast deal of patient and expensive experimenting has been called for in order to render the mineral filaments amenable to man's needs.

Is Brass Cheap?

The *Chase Diamond* (June, 1922) propounds the question: "Is Brass Cheap?" and proceeds to answer it as follows:

1920

Prices boomed in 1920 and everything went sky high. It is interesting to look back now and see what happened to various metals and commodities at that time.

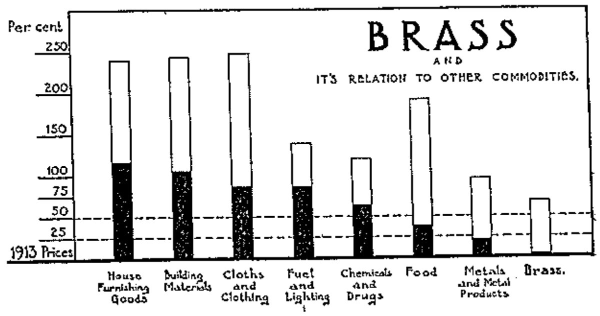
First—How much did the big brass companies charge for their product?

Second—How much of an increase did brass products show?

Third—How did that increase compare with other commodities?

In 1920 coke cost 640 per cent, or 6½ times more than it did in 1913. Paper cost over 4½ times as much as it did before the war, Steel cost about 2½ times its former price.

But brass was only 63 per cent higher, or ½ again as high.



Look and see what has happened to other things. In each case the black line will show the present prices at the point they have sunk from the inflation of 1920. Notice that in 1920 house furnishing goods and building materials went up to nearly 2½ times their former price and are now more than twice as much as they were before the war. Brass is used in both of these items and yet is not influenced by other high prices to keep its own price inflated.

The following table and the accompanying graph show the various increases at that time:

Coke	was 640	per cent higher than in 1913
Paper	" 477	" " " " " "
Lime	" 433	" " " " " "
Worsted yarn	" 373	" " " " " "
Cotton yarn	" 325	" " " " " "
Linseed oil	" 268	" " " " " "
Steel	" 246	" " " " " "
Lumber	" 233	" " " " " "
Pig iron	" 203	" " " " " "
Tin Plate	" 163	" " " " " "
Cement	" 156	" " " " " "
Brass	" 63	" " " " " "

1922

Although brass advanced as little as any metal or any other commodity during the war it has gone down in an even greater proportion than other products.

In 1913 brass cost 15½ cents a lb. At the present time it is quoted at 15¾ cents.

A Munich (Germany) cablegram says discontinuance of copper purchases in America and replacement of copper by aluminum produced in Germany for electrical wiring was urged by Richard Werner, director of the Siemens-Shuckert Company in an address before the Union of German Electro-Technical Industry.