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Asbestos Mining and Manufacturing

(EDITOR'S NOTE: *Messrs. L. H. Corbett and D. Fortune, of Montreal, and W. G. Weber, of Newark, assisted in this issue by making the field investigations.*

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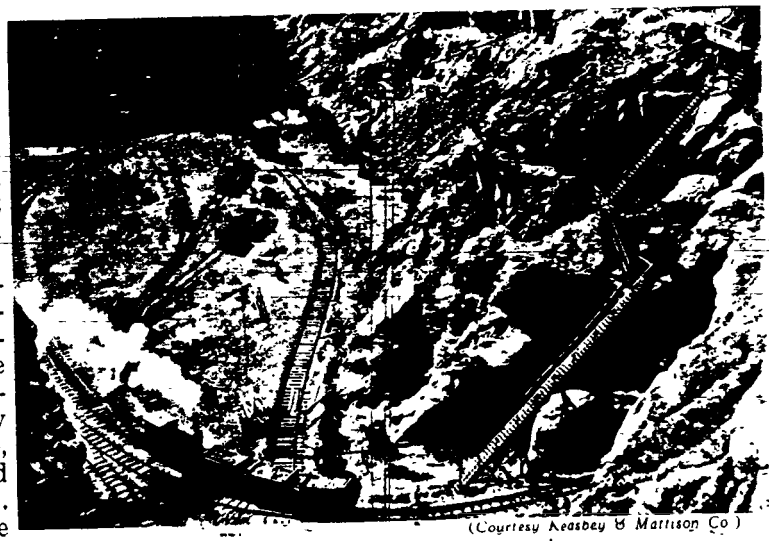
Introduction

The word "asbestos" is derived from the Greek and signifies "unquenchable," "inextinguishable" and "inconsumable." Because of the similarity in appearance to cotton, it is termed by the French "Pierre à Coton" or cotton stone. Under the term "asbestos" is understood generally a group of minerals, the fibrous, crystalline structure of which, combined with special qualities and characteristic appearance, entirely differentiates them from any other minerals. Some varieties possess such fine, silky, elastic fibre that they may be carded, spun, and woven similar to wool, flax or silk. Owing to this property, the mineral has been called a "mineralogical vegetable"; also a physical paradox.

In mineralogy, three minerals are classified under the term "Asbestos," namely anthophyllite, amphibole, and serpentine. Chemically the two first-mentioned minerals much resemble each other, being silicates of lime and magnesia with alumina, compounds of silica with an earthy base; whereas the last, serpentine, is a hydrated silicate of magnesia. The principal asbestos of commerce occurs in the serpentine variety, which is so called because of its green serpent-like cloudings of serpentine marble. In Canada, this type occurs in three varieties, the first named being the most important and outstanding: chrysotile, picrolite, and soapstone (talc). The minerals vary as to color and texture, although in some instances it is difficult to distinguish between them.

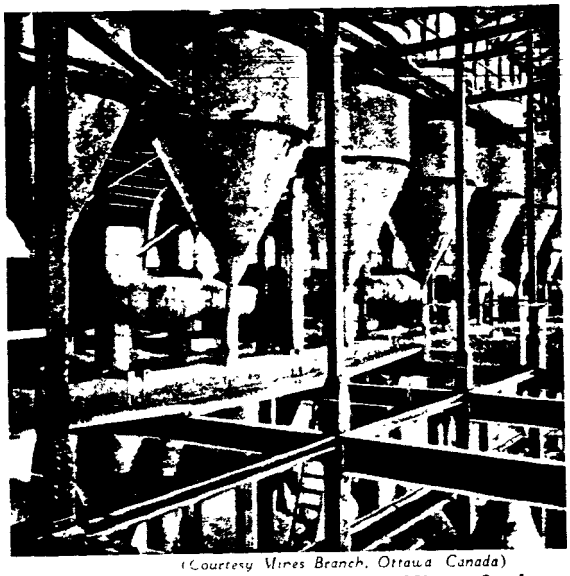


(Courtesy Keasbey & Mattison Co.)

Pit of Bell Asbestos Mine.
Most of asbestos fibre is taken out through the main tunnel, seen on the right, which inclines up through the rock to the mill on the surface.

Asbestos has been known for untold centuries. Its principal uses in ancient times were for cremation cloth in which to wrap human bodies to be consumed by fire, for the wicks of lamps tended by the vestal virgins, and, on the Island of Corsica, for packing tow. It is believed that the supply was drawn from the Italian Alps and from

the Urals. Historians relate that the high cost of making this asbestos cloth retarded its coming into general usage and but brief mention is made of its use during the Middle Ages. Deposits were found in the Ural Mountains in 1720, and about 1760 or 1765, a factory was started for the manufacture of articles made of asbestos. Uses, however, were few and the demand so limited that the industry practically disappeared.



(Courtesy Mines Branch, Ottawa Canada)

Collector floor in a mill at Thetford Mines, Quebec.

About seventy years ago, asbestos was "rediscovered" by modern civilization and since then the search for deposits of the mineral has been incessant. Deposits were found in 1862 in the Des Plantes River region between the villages of St. Joseph and St. Francis in Quebec. Fifteen years later, deposits were located in another district in Quebec, in the now famed Thetford and Coleraine sections. In 1878, mining operations were started on a small scale but difficulty was encountered in finding a market. Shipments of the better grades were made to England, causing a sensation in the market there. As a result, many firms and a great number of people became interested.

The industry prospered and took its place among important commodities of trade.

Extent and Scope

United States: Asbestos, of which chrysotile is the outstanding variety, is one of the few minerals used in the United States in large quantities which is supplied to a great extent from foreign sources. Of late years, the Western States have produced asbestos in increasing amounts but the limited quantity of high-grade material and the excessive transportation costs to eastern manufacturers still favor the imported product. The chief sources of asbestos are Canada, Russia, Southern Rhodesia and the Cape Colony in Africa.

According to the October 19, 1931, issue of "Commerce Reports," preliminary figures for raw asbestos imported in 1930 show a total of 208,681 tons, valued at $7,064,824. Preliminary data for the first seven months of 1931 indicated that 84,146 tons of raw asbestos were imported, having a value of $2,541,206. United States' exports of asbestos products were valued at $3,839 102 in 1930 and at $1,300,546 in the first six months of 1931.

Practically every country in the world imports at least small quantities of manufactured asbestos products. The countries leading in the production field are the United States, the United Kingdom, Canada, Germany, Italy, Austria, and Japan.

Statistics for the last census of manufactures, 1929, compiled by the Bureau of the Census of the Department of Commerce for the asbestos industry embrace establishments engaged primarily in the manufacture of commodities (except steam and other packing and pipe and boiler covering) composed wholly or chiefly of asbestos, comprising asbestos textiles, building materials and miscellaneous products. The "steam and other packing, pipe and boiler covering" industry embraces establishments engaged principally in the manufacturing of packing for steam, water and other pipe joints; insulating materials for covering boilers and pipes; gaskets, etc.

Under the first classification, the following figures apply:

Year	No. of Establishments	Aver. # Wage Earners	Amt. of Wages	Total Value of Products
1929	67	8,092	$10,736,712	$56,164,036
1927	62	6,337	8,375,502	44,156,388

Under the second classification, these figures apply for the same comparative years:

1929	170	7,259	9,649,419	45,393,315
1927	159	5,946	7,904,603	43,044,501

Total for both groups:

Year	No. of Establishments	Aver. # Wage Earners	Amt. of Wages	Total Value of Products
1929	237	15,351	$20,386,131	$101,557,351
1927	221	12,283	16,280,105	87,200,889

(Note: Column three does not include salaried employees.)

Canada: According to the Canada Department of Mines, in a 1931 publication entitled "Chrysotile Asbestos in Canada," a summary of "Output of Crude and Milled Asbestos" shows the following figures for 1929 and 1928:

Year	No. Operating Companies	Aver. No. Men Employed Mine	Mill	Total	Wages Paid (Mine & Mill Employees Only)	No. Fatal Accdts.	Rock Mined (Short Tons)	Rock Milled (Short Tons)
1929	7	1,835	1,359	3,194	$3,990,736	7	6,208,970	4,384,120
1928	7	1,739	1,284	3,023	$3,617,574	8	5,171,060	4,118,044

With reference to the Canadian fabricated asbestos industry, these figures by the Dominion Bureau of Statistics are informative:

Year	No. of Plants	Capital Employed	No. of Employees	Salaries & Wages	Selling Value of Products
1929	12	$2,949,712	351	$359,433	$2,286,638
1928	14	3,064,164	345	421,448	2,050,432

(Column six includes brake lining; pipe and boiler covering; packings; building materials, shingles, millboard, and building lumber; and miscellaneous asbestos products.)

Exports of manufactured asbestos products totaled $137,833 in 1930, $76,043 in 1929, and $48,162 in 1928. In 1930, 286,497 tons of raw (crude) asbestos having a value of $12,074,065 were exported. This product ranked twenty among seventy leading Canadian export commodities, compared with 21st place in 1929 (Canadian Trade Index for 1931).

Asbestos deposits are found in the localities of Thetford Mines, Black Lake, Coleraine, Robertson, Asbestos and East Broughton in the Province of Quebec.

Manufactured Articles: There are many articles manufactured from asbestos fibres of various grades. The long fibres are used chiefly for spinning yarns, cords, and in the production of woven fabrics. Some manufacturers in recent years have used a small quantity of stock shorter than those usually classed as spinning fibres in the mixture prepared for carding. The short and very short fibres and a limited amount of residual sands are used with other constituents chiefly to produce moulded articles and building products. The list of products includes, in addition to the ones mentioned previously, automobile brake-band linings; clutch facings; gaskets; tape, listings and tubular lagging; table mats and protectors; theatre curtains; papers; sheeting; wallboards; blackboards; asbestos-cement shingles; decorative panels; fireproof paints; insulating materials; asbestos clothing, including aprons, gloves, caps, helmets, and leggings, etc.

(Courtesy Keasbey & Mattison Co.)

Shoveling Arizona crude asbestos in warehouse. Bags of Arizona appear in the background.

Conditions at Plants and Mines

Plant A: One of the main factories where asbestos products are manufactured is located in the eastern part of the United States. At the present time, there are approximately 1,300 employees, of whom 30% are female workers. In the office, doing clerical work, there are about 200 employees, and of this number about 60% are female. The personnel in the plant is made up chiefly of workers of foreign birth, particularly those of Polish, Hungarian, Italian and Jewish descent.

The factory buildings, of which there are 12 including one used as an office building, are of fireproof brick construction. In one of the buildings, there is a chemical laboratory for the purpose of making various tests. The company also maintains its own power plant and pumping station. All of the buildings are equipped with modern machinery, and every known safety device and preeau-

tion is used to protect the workers.

On the pay roll of this company, there are two nurses and a physician. They are subject to call at any hour during the night, as well as during the working day. This company has a favorable record for illnesses and injuries, there having been no serious injuries or loss of limbs during the past four and a half years; the injuries sustained are usually minor cuts and bruises. Most of the illnesses of the employees are caused by negligence in not taking ordinary care of themselves.

The organization does some welfare work among its employees, dealing directly with the families and not through any agency or other medium. The living conditions of the employees in the town are slightly below average, and there is some poverty among the employees and former employees who make up the population of the town where the plant is located.

The machines and bins used in the manufacturing processes are covered with hoods and the Pangborn Dust System of blowers is used throughout. Seventy-five or eighty per cent of the raw materials used is worked on when damp with water in order to eliminate the hazard of asbestos dust. The dust hazard here is, therefore, slight.

Plant B: This represents the Canadian branch of Plant A, where the mining as well as some of the milling and manufacturing processes is carried out. The company's production activities are located in the Province of Quebec. Including the office force, there are 908 people employed here, 98% being male workers. Of the productive workers, 644 or 70% are classed as skilled (50 or 6% represents the clerical force). The personnel consists of native-born Canadians or those of Anglo-Saxon descent, with the exception of 8 who are of foreign birth.

Three tennis courts, a baseball and a football field, a skating rink, and a playground for children of the employees are provided by the company. A series of concerts is usually held during the winter months. A clubhouse was built by the company and is used for shows, boxing, wrestling, concerts, dancing, etc.

The factory buildings are of concrete and brick and are equipped with fire-fighting apparatus. Smoking is forbidden in all of the buildings. All belts are guarded and, in some departments, the gears are covered with from 12 to 14 gauge sheet iron. Explosives are stored in a concrete hold away from all of the other buildings, and it is not necessary for men other than those handling explosives to be in the vicinity of this building. Underground mining operations are not carried on, as this organization follows the "open-pit" method of securing the crude asbestos. This has resulted in an evacuation approximately 3,000 feet in diameter by 200 feet deep. The removal of asbestos-bearing rock is done by the bench system, the benches having a vertical interval of 25 feet. This has been found to be the most practical height of working face to avoid rock slides with resultant danger to workmen and to equipment. A special system of rock drilling has been developed to suit the height of working face and to break to shovel size the maximum percentage of rock in the primary blasting.

The pit is kept free of water by means of canals strategically located around the sides of the pit and on the different benches to prevent surface drainage from entering. Some water, during the flood seasons, does find its way to the central sump. This is removed by electrically driven centrifugal pumps.

Crude fibre is picked in the pit and cobbed by hand.

A fully owned subsidiary railroad furnishes transportation for the plant and for the near-by town.

Regular plant inspections are conducted by a safety engineer and an officially appointed medical director who are in charge of a department for safety and industrial health. New employees are required to pass a physical examination, and every employee is given an annual medical examination free. In each department, there is a safety committee to report on accidents and to improve conditions in that department to lessen the possibility of accidents. Each accident is the subject of a report by the safety engineer, and all serious cases are referred directly to the management.

New employees are given instructions in the prevention of accidents by the employment bureau staff prior to starting to work, and thereafter by their foremen. Competition among the departments in accident prevention is fostered and stimulated by the award of a safety flag to be displayed in a prominent place by the department having the best accident record during the preceding month.

Certain employees are trained in first-aid work, and they have charge of the first-aid stations located at different points about the plant. A hospital is maintained and is thoroughly equipped by the company with an

operating room, together with the latest scientific apparatus for X-ray and other treatments. The company doctor and two nurses are in charge of the patients, and twenty-four hour service is maintained. These same facilities are available to families of the employees at moderate prices.

Plant C: The mines of this organization, which is incorporated under the Laws of the Dominion of Canada, are located in the Thetford, Black Lake, Broughton and Coleraine districts in Canada. Approximately 30,000 acres are either owned or under lease. The company is one of the largest producers of raw asbestos in Canada, the output in one year having reached 120,000 tons. The six active mills have a total capacity of 500 tons of rock per hour. There are seven other properties controlled by this company which are now inactive.

About 400 men are employed in the mines and mills. They are either native-born Canadians or of Anglo-Saxon descent. Practically all of them have been working for a period of over five years; some have been employed for a period of forty years.

The mills are constructed of cement, although a number of the older mills are of wood. They are five and six story buildings and are well ventilated and clean. The machines used in the mills are of recent design and construction and are equipped with safety devices, where possible, to protect the worker. Safety work is in charge of a safety engineer who, with the general manager or superintendent, makes daily inspections of the buildings and machinery. The mines are inspected on the average of twice a week by one of the executives and the safety engineer.

Underground mining is the method used by this company to secure the asbestos rock or ore from one of their properties. Two tunnels run into a side hill. No picking of crude fibre and little sorting of barren rock are done at this particular property. On the other properties, the open-pit method is used. For transportation, surface and underground, 12 electric locomotives, 8 steam locomotives and 300 cars are in service.

This company recently formed an association with other asbestos producers for the purpose of putting on a safety campaign to eliminate accidents. The accident record for this company has been favorable.

Plant D: This mine and mill, located in the Thetford area, are owned by a company whose headquarters are in the United States. The average depth of the pit is 220 to 240 feet with a length of 1200 feet and a width of 600 feet. Approximately 300 men are now employed. They are either native-born Canadians or of Anglo-Saxon descent.

The plant is entirely self-contained, even to engine shops for repairing locomotives. A complete machine shop is maintained, and also a sawmill and wood-working shop. As in the other plants, equipment is modern and guarded against accident wherever possible. A safety department is maintained to give instructions against accidents, as well as to remedy any trouble that develops.

The open-pit method is in use here. Drilling is done in vertical holes 40 feet in depth. On the floor of the pit, tracks are laid on which cars are hauled by steam locomotives to the foot of the incline track.

The capacity of the mill is 75 tons per hour. Slow speed, flat shaking screens are used for cleaning out sand and bedding the rock and fibre. Collectors of the pull-through type are used, and grading and cleaning are carried out on flat shaking screens. Eighteen different grades of asbestos are made, the production of 0-0-5-11 fibre being greater than that of any other grade. The maximum production is from 45,000 to 55,000 tons per year.

General: All of the organizations operating in the Thetford, Black Lake, and Broughton areas have formed a tubercular association, headed up by a local doctor and three nurses who daily go about among the families in their district, attending to their needs. For a period of three years, a large life insurance company made a special study of conditions at the mines, paying particular attention to tuberculosis. They were unable to find one case where an employee had contracted this disease through his work. This fact was further substantiated by a prominent doctor of Montreal who was employed by the producing companies to make a special study of conditions. However, in making this study he did not make post mortems, and without this having been done, the effect of asbestos dust on the lungs cannot be definitely established.

During the year of 1929, in all of the asbestos mines that were in operation, there were but six fatal accidents; in 1930, there were five; and according to preliminary statistics for 1931, there were only two.

(Courtesy Mines Branch, Ottawa, Canada)

Blower system whereby fibres are sucked up to storage bins before going into collectors which grade or sort various lengths. Mill located at Thetford Mines, Quebec.

Mining, Milling, and Manufacturing Processes

General: Processes of mining, milling, and manufacturing differ to a certain extent in each one of the plants operating in this industry. In this report, general methods are described, and it is recognized that no two plants operate exactly alike in carrying out the various steps of the general process.

Asbestos, as it is put on the market, is divided into two classifications: "crude" and "fibre," which are sub-divided into various other grades. Crude asbestos consists of veins of asbestos of the cross-fibrous types. Prices vary according to the quality, length, and tensile strength of the fibres. (In 1931, the value of crude #1, crude #2, and other crudes per ton ranged from $132.00 to $431.00. The spinning fibre, shingle fibre, paper fibre, waste stucco or plaster, and refuse or "shorts" ranged in price from $13.00 to $107.00. Waste rock, composed only of sand, gravel, and stone, sold for approximately 83c a ton.)

Mining

At Thetford, asbestos is now being worked to a depth of 400 feet. Specimens have been taken from a depth of 500 feet and from drill cores to a depth of 1,700 feet, and are found to be equal in grade to the material produced nearer the surface. The depth to which quarrying may be carried on is limited by the width of the zone. It is necessary that walls be maintained at a safe angle, and with the known width of zone at Thetford, the walls of a quarry would be too close together at a depth of 500 to 600 feet to leave a floor for working. In order to secure asbestos below this depth, underground mining methods have been adopted in two instances. This method was first started in 1916.

Underground Mining Methods: To secure asbestos from the rock either by hand-cobbing or by milling, the fibre-bearing ground must first be stripped of overburden and mined or quarried. Underground methods are similar to those found where other minerals are mined, as, for example, coal. To date, 8 shrinkage stopes have been completed on the 300-foot level, 200 to 250 feet long, 30 to 43 feet wide, and 120 to 150 feet high. Steel chutes are at 30 feet in centers. A steel line man-way raise is at each end of each stope. (Stopes are 80-foot centers. The haulage drifts are 8 by 9 feet. Sub-level stopes are being tried for comparison with shrinkage stoping. Developments are on a 500-foot level; also 500 feet of cross-cuts to stope locations.) Holes are drilled in the virgin face for blasts, after which the rock is loaded by hand and by shovel into small tram cars. These tram cars operate by hand on narrow tracks, and are pushed along and finally the contents are dumped into chutes. These chutes are of structural steel and plate, as no wood is used underground. (The reason for this is that wood becomes mixed with the asbestos fibres and it is then difficult to remove the wood splinters.) The ore is loaded into five-ton boxes at the chutes, hauled to the pit floor and hoisted by an overhead cableway. (This method costs but little more than the open-pit or quarry method. The steel mine supports which are now being used have proved satisfactory.)

Open-Pit Method: In opening a quarry, the first step is to remove or strip off the overburden of soil or boulder clay which covers the larger part of the asbestos-bearing area. The depth of overburden varies from a few inches to as much as 86 feet. Where the overburden is shallow, it is loaded by pick and shovel into horse-drawn dump carts, or into boxes for hauling by cable derricks. Where the depth exceeds a few feet, steam shovels are employed, by means of which trains of dump cars are loaded and the earth hauled to a dump ground some miles distant. It is necessary to keep a rim of rock around the pit free from overburden, to avoid clay's falling into the pit and discoloring the fibre.

As a rule, the quarries are elongated and somewhat irregular in outline, the length being determined by the property boundary lines and the width conforming to the width of the fibre-bearing zone. At times, the

width of the pit is greater than that of the zone, as low-grade or barren rock must be removed to maintain a safe working slope on the walls to enable the full width of profitable zone to be worked at the bottom of the pit.

All rock within the confines of the quarry is removed. No pillars or barren rocks remain. Worthless rock is also quarried, and discarded in as large pieces as possible to save the cost of drilling and blasting.

Drilling: Two methods of drilling quarry faces are employed; one by short horizontal holes in the face, and the other by long vertical holes or inclined holes from bench floors. The method most prevalent is to drill rows of holes, each to a depth of from 15 to 20 feet or from 30 to 40 feet, along the face of a bench to be blasted, using air-hammer drills. As many as 300 to 500 holes may be connected up and fired in a single shot, bringing down sufficient rock for the loaders or shovels to be kept busy for several months. (Care must be taken in so placing the holes that the rock is shattered into fragments of such size that an excessive amount of "block-holing" is not required.) For vertical drilling, a heavy type of air-hammer drill is mounted on a portable derrick so that the holes may be drilled vertically or at a slight angle. The weight of the drill, together with the weight of a metal block, is sufficient to hold the drill bit against the rock. The drill steel is fed automatically, and the workers are employed in changing steel, blowing out the hole, and moving the derrick.

Blasting: In blasting, the charge is from 12 to 50 pounds of explosive per hole. The bottom third of the hole is filled with gelatine dynamite in 2" x 16" cartridges. The balance of 40% gelatine is placed next in the hole, and the remainder of the hole tamped with mill tailings sand. Electric blasting caps with 30-foot and 20-foot wires are attached to a stick of dynamite in each hole, although they are not connected in the same series. Each cap is tested by means of a galvanometer before being used as a primer. After the holes are loaded and tamped under the supervision of the head blaster and pit foreman, the wires are connected in parallel series. Throughout the pit are lead wires connected to a switch in one of the several blasting houses. The head blaster closes a firing switch and sends a 110-volt current through the circuit. Blocks of rock which are too large to be hoisted conveniently are drilled or "block-holed" by means of plugger drills. For blasting these, 1" x 8", 25% nitroglycerine dynamite cartridges are used. Tailings sand, packed in paper bags, is used for tamping. Block-holes are connected 50 in a series, being joined in parallel, and as many as 200 holes may be fired in one shot.

Pickers: When the rock has been blasted, crude pickers gather into boxes the loose long fibre, with bits of rock adhering. As the removal of the rock pile progresses, the crude is carefully sorted out. Large blocks of rock in which veins of crude asbestos are visible are drilled and blasted to free the fibre. Spinning fibre is obtained from crude which has been passed over by the pickers or carried to the mill in pieces of rock. Where no crude or hand-cobbed fibre is produced, all the rock containing fibre, together with the fines from the blasting, is sent to the mill. In quarries where the different grades of crudes are recovered, the broken material to be sorted comprises:

1. The long asbestos fibre and pieces of rock containing same.
2. The milling material or rock containing the shorter fibre.
3. Fine material resulting from blasting and breaking up the rock by means of sledge hammers.
4. Barren or dead rock.

The material specified in #1 is sent to the cobbing shed. The material indicated in #2 and #3 is sent to the primary crushing unit of the mill. The dead rock is transported to the dump.

Removal Methods: The method of removing material from the pits depends on the pit location in some cases, and on the nature of the rock in the other. Where no sorting is practiced or advisable, loading into cars is done by means of steam or electric shovels. The cars may be hauled to a storage bin below pit level, from which the rock is transported on a conveyor belt to the primary crusher, or it may be hauled direct on level or inclined tracks to the primary crusher.

Where sorting is carried on, ore and rock are shovelled by hand into separate boxes. The boxes are hoisted by means of overhead cable derricks, by which they may be dumped into cars at the surface or into bins, and from there into cars. The ore is hauled to the crusher and the rock to the dump. The loaded boxes may be lifted by boom cranes and dumped into cars, the cars being hauled on a level or inclined track to the crusher, if the boxes contain ore; and if they contain rock, to the dump. The capacity of rock and ore cars varies from 5 to 15 tons.

Milling

The greater part of the rock mined is mill rock containing asbestos fibre, varying from microscopic lengths to three quarters of an inch. The mill rock, coming from the pit, contains much moisture, and before any attempt is made to lift the fibre by means of a suction fan, the rock must be thoroughly dried, as the efficiency of a fan, when lifting, depends on the weight of the material.

Crushing and Drying: Mills are generally composed of two distinct sections: First, the crushing and drying plant, in which coarse crushing and drying of the rock take place; and second, the fiberizing and screening plant, in which the operations consist of fine crushing, fiberizing, collecting of asbestos, and grading.

Two types of dryers are in use: 1, the rotary dryer; 2, the stack dryer. The first consists of a long cylinder made of strong boiler plate and lined with sectional replaceable liners bolted to the shell. The drying is assisted by long blades which lift the material and allow it to fall through a current of hot air circulating through the cylinder. The stack dryer, some 50 feet in height and 7 feet across, is fitted with sets of grid bars of a certain shape. These hinder the speed of fall of the material which meets a rising current of hot air from fire boxes at the bottom. The speed of the hot air is regulated by a suction fan which draws off some of the fibre and dust which are caught in a collector, milled and cleaned.

From the dryer, the rock is conveyed to a storage bin to be drawn upon by the fiberizing and screening departments as needed. The bottom of the bin is fitted with gates through which rock may be fed to the conveyor belt running to the mill. The conveyor belt is equipped with an electric weightometer, so that an accurate record of the rate of feed and the amount of rock going to the mill may be kept.

Milling consists of reducing the rock in size by successive stages of crushing, at the same time opening or fluffing the fibre, screening out the fine sand, and lifting the freed and opened fibre after each crushing operation. The sand screened out goes to the waste dump, and the fibre is lifted by air suction to collectors, and then it passes to grading screens, each grade being separately cleaned and bagged. On first entering the mill, the rock is sized by screening, so that free fibre and fines will not pass to the first coarse crusher which breaks the larger sized rock.

The first mill breaking of rock may be done in one of several types of crushers: hammer mill, roll, jaw crusher, or gyratory. The product of the crushers and the "throughs" from the sizing screens go either to screens or to fiberizers and then to screens.

Four types of fiberizers are in use to reduce the rock so that the fibres may be extracted.

Screening: From each crusher the broken rock falls on, or is conveyed to, a screen where the sand is shaken out, the fibre lifted by suction at the lower end, and the "overs" passed to the next crusher. Shaking screens are used throughout the mills, and the shaking or bumping motion is imparted by means of an eccentric drive. In addition to screening out the sand, the motion moves the mass forward, causing the fibre to rise through the rock fragments to the top layer from which it can be lifted by air suction. The fibre is lifted by air suction through a vertical pipe, and the product is collected in a container made of galvanized iron. Fibre is dropped from the collectors to the graders through lengths of pipes equipped with traps. Both flat and rotary screens are used for grading.

Fibre is fed into one end of the screen, and revolving paddles beat it up and force the short fibre through the screen of the first section, the longer fibre through the screen cloth of the second section, and the longest fibre out at the end. Each grade falls on to a flat cleaning screen where sand, dust, and unmilled splinters of fibre loosened in grading are cleaned out. Extra grades may be made by allowing portions from each screen section to combine. Any grade may be split into a number of grades in a second rotary screen or on a flat screen. From the ends of the cleaning screen, the fibre is lifted by suction; the unopened fibre and rock are allowed to fall from the end of the screen to be returned to a breaker for milling. The fibre, lifted to a collector, is dropped to a store room for bagging. From the bagging room, the asbestos is carried on conveyors to the warehouse where the bags are piled ready for shipment.

Hand Dressing: Hand dressing applies only to the preparation of fibres sold in the crude form, as all other grades are produced mechanically. Long fibre with adhering rock

is brought from the pit to the cobbing shed and dumped on a horizontal coil of steam pipe to dry. After drying, it is parcelled out to the cobbers, who work at benches in rows. (As many as 60 may be employed in one plant. Each cobber works in a separate compartment.) A flat stone or iron plate, 10 to 12 inches square, is fitted into the bench.

(Courtesy Canadian Asbestos Co)

Close-up of a "cobber" with cobbing hammer poised on its way to split the piece of asbestos. Note that operator's thumb of left hand is bandaged due to having hit it with the hammer on morning picture was taken.

The fibre is flattened out and freed from rock particles by being struck with a cobbing hammer, which is from three to seven pounds in weight. Each grade of fibre is placed in a separate box, and the refuse, rock, dust, and short fibre are dropped into a receptacle under the bench. The #1 crude is screened on a flat shaking screen with 3/8" holes, and the #2 crude on one with 3/16" holes. The refuse from the screens and cobbing benches is sold as screenings, or added to the mill feed for the recovery of such fibre as it may contain. The crude fibre ready for the market is put up in bags holding 100 pounds each. It still contains from 3% to 20% of rock, dust, and short fibre, which material, useless to the spinner, is cleaned out when the fibre is opened at the factory in preparation for spinning.

Manufacturing

Asbestos is received from the mines or mills in freight cars. It comes packed in bags into which it has been forced by compression. It is unloaded on hand trucks and taken to the receiving department. The fibre is sent to the picking machines, to be graded and separated into different kinds and sizes.

Carding: In the carding room, it is carded or combed by machines into strands. The purpose of this is to lay all of the small fibres in the same direction for use in a spinning frame. The fibre is then sent to the spinning room where it is put through a spinning machine which converts the carded asbestos fibre into yarns of various types. (For some uses, a certain percentage of cotton or other vegetable fibre may be mixed with the asbestos upon receipt at the factory.) Twisters may insert copper or brass wires into the fibre, in order to increase the tensile strength. This is passed on to the weaving room, where the asbestos fibres are made into sizes and thicknesses varying from an eighth of an inch to 120 inches wide, and from an eighth of an inch thick to an inch and a half. The product is now practically finished, except to go to the different buildings to be used in the manufacture of products, such as shingles, pipe coverings, etc.

Asbestos Paper: Asbestos paper is made much like any other pulp paper, the fibre being put into beaters where the binding material is added and thoroughly incorporated, after which it is placed in the millboard or wet machine. The water is drawn off through a fine-wire gauze on a revolving cylinder on which it leaves a thin coating of the asbestos pulp. This is picked up on a felt belt and run over a series of large revolving cylinders heated with steam to drive off the remaining moisture. The paper is wound into rolls, and sold for linings of buildings, etc.

Asbestos Millboard: Millboard (asbestos cardboard) is made in a similar manner, except that the coating is built up on the cylinder to its proper thickness before being cut across the roll and removed. It is then pressed between plates in hydraulic presses, hung up to dry, and cut into convenient sizes for use as lining for hot air furnaces, gas stoves, etc.

Asbestos Shingles: Shingles may be composed of asbestos fibre and Portland cement.

These are subjected to tremendous hydraulic pressure, so that the resulting product possesses elasticity and great density.

Other Products: Asbestos, when fiberized and properly prepared, is spun into thread and woven into cloth like cotton. The uses to which asbestos is put are innumerable and are increasing annually.

Potential Health Hazards

Mining: If the quarry method is the procedure followed, then the attendant hazards include the danger of falling rock and other objects, exposure to varying kinds of weather, and physical strain, as well as explosion hazards. Dynamite in addition to its dangers of explosion is capable of producing a toxic state characterized by severe headache and tachycardia, particularly. There is also the hazard of noxious gases arising from blasting. In underground work, the latter named is especially dangerous, as the failure of ventilating systems or the entry into drifts not within the ventilating system may lead to asphyxiation. Fortunately, this is a rare occurrence.

Air drills controlled by hand lead to tenosynovitis of the hands and forearms.

In blasting carbon monoxide is produced. It may also be formed by incomplete combustion of mine timber in case of fire.

The depth of the underground mine leads to exposure to temperatures which are not conducive to good health. Also existent is the hazard of wetness. Wetness is not always a guarantee of freedom from dusts.

The International Labour Office comments on this subject in an interesting manner in their Occupation and Health Brochure Number 27. We include extracts from this article:

"The worker engaged in the extraction and manufacture of asbestos is constantly exposed to danger from dust, more especially, however, in the operations of spinning and weaving.

"The baneful influence of the dust in relation to the production of tuberculosis is brought out in the Annual Report of the Chief Inspector of Factories for England and Wales for 1910, which records 5 deaths from tuberculosis amongst 40 workers engaged in an asbestos weaving factory, where the most dangerous process was revealed to be the weaving of asbestos mattresses composed of bags of woven asbestos filled with short asbestos fibre. They were placed on a table and beaten out flat by a man with a wooden flail, which process occasioned the production of much dust. Women sewed the mattresses into sections using asbestos threads, and as they worked beside the heaters they also of necessity inhaled much dust.

"Towards the beginning of 1924, a fatal case of poisoning by asbestos dust was reported at Rochdale (England). The victim was a woman who had been employed in an asbestos factory. A post-mortem examination revealed death as due chiefly to a fibrosis of the lungs due to the inhalation of mineral particles and in part to tuberculosis. A microscopic examination of the lungs and of dust samples taken from three different workshops of the factory revealed the same black particles present in each, alike in form and dimensions.

"A striking example of the noxious property of asbestos dust is instanced by the following case: In an asbestos spinning and weaving factory (Calvados), there were 40 deaths in the five years 1890-1895. The mortality rate decreased considerably with the installation of a good system of local ventilation over the carding machines.

"In an asbestos weaving factory in Saxony, the workers complained of headaches and loss of appetite. These affections were caused by fumes given off by a rubber solution with which the asbestos cloth had been coated to eliminate dust.

"An investigation carried out in Canada in 1911 revealed that hygienic conditions were greatly improved as a result of the adoption of an effective system of ventilation. Nevertheless, a local doctor with long experience stated that respiratory troubles, and in particular tuberculosis, were of very frequent occurrence amongst asbestos workers.

"Rambousek drew attention to the risk of lead poisoning during the weaving of asbestos when a thread of lead is added to the weft, as is sometimes the case.

"Marked frequency of chronic conjunctivitis with hypertrophy of the rims of the pupils has also been noted amongst the asbestos workers of the Island of Cyprus. The workers in question were chiefly engaged in grinding, screening, and packing the asbestos in sacks.

"The weaving of asbestos has only developed importance during the last twenty years. All processes from extraction onwards unquestionably involve a considerable hazard. . . . . .

"The lack of more accurate and detailed

data in medical literature regarding this industry in its various branches, including the utilization of by-products, is to be deplored in view of the self-evident importance of asbestos dust as a predisposing cause of pulmonary tuberculosis, more especially since the rapidly increasing development of industries utilizing asbestos adds greatly to the urgency of studying the conditions with a view to their amelioration."

Messrs. S. G. Hopkins and L. E. Ludwig of the Penn Mutual Life Insurance Company prepared a paper on "Asbestos Mills," covering conditions in the United States. The paper was read at the Fifth Informal Intercompany Occupational Rating Conference held at the Home Office of the John Hancock Mutual Life Insurance Company, Boston, Mass., on May 23 and 24, 1928. Of particular interest, are these excerpts:

"During the carding process, and to a less extent in all the processes, a very considerable amount of dust is generated. In up-to-date factories, all machines are fitted with exhaust systems and the dust removed. This dust is what will be of interest to those of us who have to do with occupational classification and ratings.

"Microscopically, asbestos fibre is seen to consist of two very different elements. The bulk of the fibre is translucent and glistening, with here and there black opaque angular particles. Minute black granules also are present. These black particles are actually part of the fibre, but their appearance suggests a different chemical composition and different physical characters from the translucent portion. The dust generated during manufacture is seen to consist of these sharp angular particles and minute granules, suggesting, of course, that they are more brittle than the translucent part of the fibre. These particles are found in very small numbers in the finished article. Analyses of samples of dust have shown that the dusts containing the greatest number of these black particles contained the largest amount of iron. The iron content of the finished article, raw material, and dust is as follows:

Finished Article:
Iron (As Ferrous Oxide) ..... 0.1 %
Crude Material:
Iron (As Ferrous Oxide) 2.81%
Dust from Carding Room:
Iron (As Ferrous Oxide) ..... 18.4 %

"From these results, it appears conclusive that the blackened brittle parts of the asbestos fibre are the iron-containing portions—the bugbear of the manufacturer, the cause of 'dust,' and a danger to the health of workers in the process of manufacture."

The article comments on three papers dealing with Pulmonary Asbestosis which appeared in the British Medical Journal of December 3, 1927, prepared by Dr. Cook, Dr. McDonald, and Sir Thomas Oliver, as follows:

"The limited evidence of pulmonary asbestosis contained in the above papers does not warrant definite conclusions as to the hazard of those exposed to asbestos dust. The modern conditions in the United States under which the average employee works, along with such protective devices as dust elimination systems, moisture-laden atmosphere, well-lighted, well-ventilated buildings, present a decidedly more favorable picture than in former years. We do, however, feel that until we have the benefit of our experience with this class of workers we should continue to look upon those who may be exposed to large quantities of dust, such as employees engaged in the opening, picking, screening and carding, as risks to be selected with great care and only at an extra premium that will provide for an estimated extra mortality of 50%, disability not to be granted.

"Our personal inspection of the plants at .....convinces us that all those who are engaged in operations prior to the spinning and weaving of asbestos are subjected to extremely large quantities of dust that must, from its natural chemical form, contain a high per cent of injurious material. Our conversation and correspondence with physicians in these towns bear out to some extent the unfavorable findings of our honored investigators abroad."

An investigation was made in June, 1932, in a Pennsylvania State asbestos products manufacturing plant employing about 500 people when working full time. A doctor employed there told of a condition peculiar to asbestos products. It seems that the short fine fibres sometimes become embedded in the skin of workmen. Apparently they do not cause an infected wound, but form a slight lump in the skin which must be cut out, if the foreign material is to be removed. There is no serious effect in connection with this. The doctor stated that when the material gets into the skin it does not fester as other foreign matter would do. The body apparently tries to build up tissue around the foreign substance.

Another feature which might be mentioned as found in this plant is the fact that impregnated coal tar compounds which are used in asbestos products of this kind might form obnoxious or inflammable vapors. However, suitable ventilation methods would eliminate this hazard.

Classification and Index of Jobs

(All employees are male except where otherwise indicated.)

Mining

Blaster (Open Pit and Underground): Fills holes with dynamite and explosive gelatine; prepares wiring for a blast; attaches fuses and final connections and shoots the charge. Works under Head Blaster who supervises the work to see that everything is attended to properly. **Chief Hazards:** Explosions; falling rock; gases subsequent to blasting.

Cager (Surface): Operates a cage or elevator from a small cement building at ground level, using a lever, to hoist and lower men, tools, or steel equipment for timbering purposes. **Chief Hazards:** Mechanical; mental strain of elevator work; slight variations in atmospheric pressure.

Cage Tender: See Cager.

Car Loader (Open Pit and Underground): Loads ore into small cars by hand, using a shovel. (In open pit, these cars are elevated by incline or crane. In underground work, the Loader assists in pushing the car to the chute and in dumping the rock down the chute.) **Chief Hazards:** Open pit—physical strain; dusts; falling objects. Underground—usual underground hazards; physical strain; dusts.

Carman (Open Pit and Underground): Rides on ore cars acting as a brakeman to brake cars at proper time. In some mines, small electric engines are used, operating on 110 volts. **Chief Hazards:** Marked mechanical hazards as in railroading; danger of falls; underground hazards; some electrical hazard.

Driller (Open Pit and Underground): Operates hand air drills as well as those mounted on derricks to do vertical drilling. Drills holes into the rock to be filled later with explosives by the Blaster. **Chief Hazards:** Vibration; dusts; falling rock; all hazards of underground work. Underground—driller works ahead of miners, etc., often without conveniences of adequate lighting, ventilation, propping, etc. This is hazardous work.

Driver (Surface Only): Hauls away the overburden when breaking new ground and also hauls supplies and equipment to the mill and warehouse. Horses are used on surface. **Chief Hazards:** Physical strain; monotony.

Dumper (Surface and Underground): The Dumper underground is really the Car Loader who follows the small car to the chute. The Dumper on the surface works at the point where cars are loaded, at the crusher chute and at the dump. Stands by and, with a large pole which has a hook attachment at the end, dumps the load into larger cars for transportation to the mills. (These loads of rock come from the open pit. A crane may be used in some places and small boxes in others.) At the crusher, cars are dumped so that the rock goes into the crusher feed. Cars of tailings are dumped at the dump. The Dumper works on the side of the car opposite that from which the rock is to be dumped. **Chief Hazards:** Open pit—physical strain; dusts; falling rock. Underground—physical strain; dusts; underground hazards.

Electrician (Surface and Underground): Installs and keeps in order the electric lines. Also does the wiring for light in the main tunnel of the mine. Keeps the motors which carry a voltage of 2200 in running order. When making repairs, works when operations have been suspended and the lines are dead. **Chief Hazards:** Electrical hazard; all underground hazards.

Explorer (Surface and Underground): Studies surface and underground indications of ore, new drifts, and new workings. Necessary for him to go into all of the working places. **Chief Hazards:** Surface—no characteristic hazards. Underground—usual underground hazards.

Helper (Surface and Underground): Assists Driller or Blaster. See occupation in which he helps.

Hoist Operator (Open Pit): The work of the Hoist Operator who is in charge of the hoist in the underground mine is explained under Cager. The Hoist Operator above the ground may be in charge of a derrick with which he raises bottom loads of asbestos rock from the pit by means of a cableway. He stays on the derrick or hoisting machine and operates the lever when he receives the signal from the Signalman at the bottom of the pit. **Chief Hazards:** Mechanical; physical strain.

Loader: See Car Loader.

Miner: In some asbestos mines, a Miner does the work described in this report under Blaster and Driller, the other named workers not being employed. In other companies, he does the work described under Car Loader, working both in the open pit and underground. **Chief Hazards:** Explosions; falling rock; dusts; all underground hazards; physical strain.

Motorman (Open Pit and Underground): Operates a small electric engine which hauls tram cars. (Voltage in the mill is 220 and trolley wires underground carry a voltage of 110 volts. Required to wear rubber-soled shoes and to take other precautions in view of the wires' being so low in the stopes.) **Chief Hazards:** Electrical hazards; mechanical; limited underground hazards.

Mucker (Underground): Usually a beginner; has the hardest work in the mine. Cleans up after a blast has been fired, and has duties similar to Car Loader. (Usually either a Car Loader or a Mucker is employed but not both, as duties are same.) **Chief Hazards:** Physical strain; dusts; all underground hazards.

Powder Man (Surface): Works in the powder house to see that powder is properly guarded; gives out powder by order to men. Has helpers who carry the powder and fuses to the various jobs. **Chief Hazards:** Explosions; danger from nitroglycerine.

Prospector: See Explorer.

Shovel Operator (Open Pit): Operates either an electric, gas, or steam shovel by levers from a cab on the shovel. Makes necessary small repairs on the machine. (Voltage on the electric shovels is usually 2200.) **Chief Hazards:** Mechanical; electrical hazard if operating an electric shovel.

Signal Man (Open Pit): Watches the loads of rock which are to be hoisted to the surface, and from there taken to the mill. When the cable has been attached to the loaded bag, he gives a signal by pressing an electrically controlled button, to inform the Hoist Operator on the surface that the load is ready to hoist. This man remains in one place practically all the time at the bottom of the pit. He is not usually able to see the derrick or hoisting apparatus. **Chief Hazards:** Falling objects; monotony.

Switchman (Open Pit): Inspects all switches on the tracks to see that they operate properly. Also operates switches so that cars may go in the proper direction. **Chief Hazards:** Mechanical as in railroading.

Teamster: See Driver.

Timberman (Underground): In an asbestos mine, duties are similar to work carried on in any other underground work. The only difference is that all wood timbering has been done away with; this work is now being done with steel girders and plates. (With wooden timbering, particles of wood became mixed with the asbestos which lessened its value. The new method does away with this difficulty.) Examines the roof and faces of the mine for weak spots; scales loose rock and wherever necessary puts steel protections in place. (Must be familiar with the joining of steel basis so as to assure proper support for the roof and sides of the mine.) Goes into mine after explosion has taken place and prepares supports so that others who are to work here are protected from slipping ground or falling rock. **Chief Hazards:** All underground hazards, especially falling rock.

Trackman (Open Pit and Underground): Lays tracks for the tram cars, repairs the tracks when necessary, and also sees that the bed of the track is in proper condition. In each level in the underground mine there are tracks on which individual cars, or trains of cars consisting of 5 or 6 cars, are operated. **Chief Hazards:** Usual underground hazards; severe mechanical; wetness.

Milling

Bagger: Fills bags with graded asbestos fibres and places them on an automatically operated conveyor to be taken to the warehouse. This is hand work. Some companies use automatically controlled machines to bag the asbestos. **Chief Hazards:** Asbestos dust; monotony; strain.

Carpenter (General Plant): Does general wood work about the mill, such as making repairs or installing new equipment. Occasionally he might have to work outside the mill, above the ground, but this work would not occur very often. **Chief Hazards:** Accident due to falls; falling objects.

Cleaner: Inspects the asbestos which has been separated from the rock and removes all matter which should not be there. (Work is done on large tables by hand. This process applies only to the better grade of asbestos, as the mill asbestos is put into bags direct from the machines.) **Chief Hazards:** Asbestos dust; sedentary work; postural hazards; monotony.

Cobber (Usually a Young Girl or a Young Boy): Breaks up the rock, using small hammers. Separates the crude asbestos and clas-

sifies it into various trays according to grade. (Works standing up at a long bench.) **Chief Hazards:** Physical strain; dust; fatigue due to standing; mechanical.

Conveyor Man: Checks and regulates operations of the conveyor which takes rock, asbestos, etc., from one department or worker to another department or worker. **Chief Hazards:** Mechanical.

Crusher Man: Stands near the feeder to see that rock is fed in a steady stream to the machine. Occasionally uses a metal pole to guide the rock. Rock from the pit is fed to the crushers by gravity. **Chief Hazards:** Mechanical; monotony; fatigue due to standing.

Fireman (Furnace Room): Usual duties of a fireman; shovels fuel into furnaces for heat. (To operate the dryers, the hot air must pass through the dryers to eliminate moisture from the rock.) **Chief Hazards:** Physical strain; occasional slight burns due to contact with hot furnaces; humidity.

Floater: Inspects and supervises the operation of screens which are vibrated by an eccentric drive. The purpose of this is to screen the sand out of the asbestos fibre and at the same time to cause the fibres to rise through the rock fragments to the top layer from which they can be lifted by air suction. **Chief Hazards:** Mechanical; asbestos dust.

Machinist (Machine Shop): Makes repairs and constructs various parts of machines. **Chief Hazards:** Usual to the trade.

Millwright: Repairs and installs machinery. **Chief Hazards:** Physical strain; mechanical.

Oiler: Oils machinery, such as derricks, engines, etc., so as to keep them in good running order. **Chief Hazards:** Mechanical.

Ore Sorter (Crude Asbestos Worker): Takes out rubbish from regular deposit and separates various grades into trays. All hand work. **Chief Hazards:** Sedentary work; postural hazards; monotony; asbestos dust.

Painter: Duties of a general painter. Keeps buildings (outside and inside) in first class order. **Chief Hazards:** Usual to the trade.

Sheet Metal Worker: Makes pipes and spouts which are used in the crushing mill for conveying fibre to the next process. Besides the making of these pipes, worker installs them on the machines. **Chief Hazards:** Mechanical.

Sorter: See Ore Sorter.

Sweeper: Sweeps the floors of the mill. **Chief Hazards:** Asbestos dust; monotony.

Warehouse Man: Receives and piles bags of asbestos for shipment. (These bags are sent to the warehouses by automatic conveyors and when they are shipped out to their final destination, they also are moved by means of conveyors.) **Chief Hazards:** Physical strain; monotony.

Manufacturing

Beater (Paper Mill): Places asbestos fibres in four-foot vats and sprays them with water before the fibres are put through the beating process. **Chief Hazards:** Monotony; asbestos dust; wetness.

Carder (Textile Department): Operates a carding machine which winds fibres on cylinders preparatory to spinning. **Chief Hazards:** Mechanical; dust.

Feeder (Shingle Department): Feeds asbestos ore into a mixing machine. (This machine is located beneath the floor and has a chute on top with a screen through or across the opening to prevent the operator's putting his hands into the machine. A hood over the opening carries off the dust through a pipe.) **Chief Hazards:** Mechanical; eye injuries; dust.

Foreman (All Departments): Supervises work done in his department. **Chief Hazards:** No characteristic hazards; hazard of department in which employed.

Machine Operator (Shingle Department): Operates a spraying machine which colors and paints shingles. Does no spraying by hand; watches a valve on the machine and keeps it adjusted. May also operate belt and bucket carriers. **Chief Hazards:** Fumes from paints; mechanical.

Mixer (Shingle Department): Supervises and controls operation of mixing machines which are of the type of cement mixers. (Cotton is combined with asbestos in proportion depending upon its ultimate use.) **Chief Hazards:** Dusts; mechanical.

Picker (Textile Department): Operates a machine which grades and separates asbestos fibres. **Chief Hazards:** Dusts; mechanical.

Pressman (Shingle Department): Operates a press which prepares shingles into bundles of definite size and weight. (This is not a hand feed machine; feeding is done by a belt carrier.) **Chief Hazards:** Mechanical.

Puncher (Shingle Department): Uses a punch machine to make holes in shingles. **Chief Hazards:** Mechanical.

Spinner (Textile Department): Works on a spinning machine which spins the fibres

into a definite thickness. **Chief Hazards:** Dusts; mechanical.

Stacker (Shingle Department): Piles shingles in "Fog Room" for 30 days' seasoning treatment. **Chief Hazards:** Physical strain; dampness.

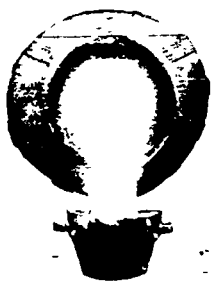
Stripper (Shingle Department): Separates shingles, when finished, from the steel plate used to keep the shingles in shape while they are being run through their various processes. **Chief Hazards:** Cuts.

Twister (Textile Department): Operates a twisting machine which inserts wires into the fibres and twists them together to make the product stronger and tougher. **Chief Hazards:** Mechanical.

Unloader (All Departments): Unloads bags of asbestos fibre and ore from freight cars and transports them to the various departments. **Chief Hazards:** Physical strain; monotony.

Weaver (Textile Department): Male and Female. Operates a weaving machine which makes the desired asbestos product. **Chief Hazards:** Mechanical.

Winder: See Carder.



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