MINES BRANCH
DEPARTMENT OF THE INTERIOR.
HONOURABLE FRANK OLIVER, M.P., MINISTER.
EUGENE HAANEL, PH. D. SUPERINTENDENT OF MINES.

ASBESTOS

ITS

Occurrence, Exploitation and Uses

BY

FRITZ CIRKEL, M.E.

OTTAWA, CANADA
1905.

OTTAWA, 8th June, 1905.

SIR,

I have the honour to transmit herewith a report on the "Occurrence, Exploitation and Uses of Asbestos," the second of a series of publications on the economic minerals of Canada to be issued by the Mines Branch.

I have the honour to be,

Sir,

Your obedient servant,

EUGENE HAANEL,

Superintendent of Mines.

Honourable FRANK OLIVER, M. P.,

Minister of the Interior,

Ottawa.

OTTAWA, August 12th, 1904.

SIR,

You are to proceed at once to the productive asbestos region and make a complete report on the occurrence, mining and milling of the mineral "asbestos" and on the present status of the asbestos industry.

This report shall contain:—

Physical and chemical properties of the mineral.
Geological occurrence and distribution in Canada.
The mining of asbestos: methods in vogue and machinery employed.
Dressing, comprising handsorting and mechanical treatment.
Milling methods and machinery employed.
Cost of production; market and prices.
Status of the industry; statistics.
Descriptions of mines and prospects.
Commercial application.
Occurrence in foreign countries.
Extract of laws governing the prospecting for and mining of the mineral in the Province of Quebec.

This report is to be accompanied by cuts through the formations and deposits, photographs of typical occurrences and of mining and milling plants, drawings of the milling machinery and a map of the asbestos region.

Yours very truly,

(Signed) EUGENE HAANEL.
Superintendent of Mines.

FRITZ CIRKEL, Esq., M.E.,
80 Stanley Street,
Montreal, Que.

MONTREAL, June 5th, 1905.

SIR,

In compliance with your instructions I have visited and examined the Asbestos Region of the Eastern Townships of Quebec and I now beg to submit the annexed report thereon.

I have to acknowledge with sincere thanks the valuable aid you have given me by your suggestions regarding the carrying out of the work entrusted to me and especially the compiling of this report.

I have the honour to be,

Sir,

Your obedient servant,

(Signed) FRITZ CIRKEL.

Dr. EUGENE HAANEL,

Superintendent of Mines.

Ottawa.

TABLE OF CONTENTS.

CHAPTER III.

CHAPTER IV.

CHAPTER V.

CHAPTER VI.

CHAPTER VII.

APPENDIX.

LIST OF PLATES.

INTRODUCTION.

The asbestos industry has assumed such a prominent place among the mining industries of Canada that a general outline of the geological occurrence of the mineral, present status, condition and future prospects of the industry will be of interest, not only to those engaged in the mining of this mineral but also to the public at large. It is with this object in view that the present monograph has been written and in doing so the writer has had in mind the student, the mining engineer and the investor.

Much has been written on asbestos, especially on the geology of the ore deposits, and the results of original research have added materially to our knowledge of the nature of the ore bodies, but the economic side, the most important from an industrial standpoint, that is the mining, separation and modern application of the mineral, has been only briefly or imperfectly treated.

The sources from which the material for this monograph has been obtained are: personal visits to all the mines and mills in the district, correspondence with the manufacturers of machinery employed, personal experience in asbestos mining and the literature bearing on the subject.

The writer wishes especially to express his gratitude to mine and mill owners, managers and mill men and to manufacturers of machinery for their courtesy in furnishing information and for their valuable assistance in the gathering of the material for this report.

The arrangement of this monograph is based on the natural divisions of the subject: (1) the location and geology of Canadian deposits, (2) the mining, (3) the separation, (4) the occurrence of asbestos in foreign countries, and (5) the commercial application

As to the geology, the writer has taken advantage of the valuable data occasionally given in some of the periodical publications, such as the reports of the Geological Survey of Canada and others, especially those articles written by Dr. Ells, who has made a special study of the occurrence of asbestos in the Eastern Townships of the Province of Quebec, since the inception of the industry.

The subjects of mining and milling have been treated in detail from personal investigations on the spot and from information received from competent and reliable mill men, as well as from personal experience in mining the mineral.

The two chapters treating of these subjects comprise also the description of the machinery employed, accompanied, when obtainable, by sections of the apparatus and while this may be of secondary importance to the Canadian engineer the writer has had in mind also the foreigner, who is, as a rule, unacquainted with the kind of apparatus and machinery and with their effects and working principles, as employed in this country, in the separation of this peculiar mineral.

The efficiency of the various mill schemes as applied in the district is imperfectly indicated for lack of reliable data.

The majority of the plates and photographs in this work are representations from nature, taken by the writer, while all the drawings and maps have been constructed partly according to measurements and surveys made by the writer and partly from material furnished by the mining companies and manufacturers of machinery.

FRITZ CIRKEL, M.E.

MONTREAL, June 5th, 1905.

CHAPTER I.

HISTORY. QUALITIES OF ASBESTOS. GEOLOGICAL DISTRIBUTION AND CHARACTERISTICS OF THE DEPOSITS.

HISTORY.

Asbestos is so different from any other mineral that its occurrence, mining and preparation for the market is an entire study in itself.. When the mineral was first mined in the Italian Alps in the beginning of the last century it seems to have been looked upon only as a substance of interest to the mineralogist and geologist, but of little or no practical commercial value, and it was not until the beginning of the seventies that the first attempts were made by London parties to exploit asbestos deposits in the Aosta valley for the purpose of experimenting on a large scale with the Italian product. Concurrently with the exploitation in Italy a discovery of asbestos was made in the Des Plantes River region, between St. Joseph and St. Francis villages in the Province of Quebec, and at the exhibition in London in 1862 a specimen of fine silky-fibred asbestos from the above locality was exhibited. The extension of the belt of serpentine rocks in which the mineral was known to occur had been traced with some care from the Vermont boundary in the township of Potton to and beyond the Chaudiere river, but the deposits of asbestos discovered were comparatively limited. All attempts to work them profitably failed and for the next fifteen years nothing was done in the way of exploration or exploitation.

However, in 1877 asbestos was discovered in another region in Canada, this time in the serpentine hills of Thetford and Coleraine. The credit of this discovery is claimed by Mr. Robert Ward, though by others it is stated that the first find was made by a French Canadian named Fecteau. Following closely upon this discovery several parties secured areas both at Thetford and Black Lake in Coleraine township close to the line of the Quebec Central Railway, which for some miles runs through a belt of serpentine. Large fires having swept over the country and all forests being thereby destroyed, the discovery of veins was facilitated by the weathering of the mineral on the surface.

Mining operations on a small scale commenced in 1878 and in this year fifty tons were taken out, for which, however, it was difficult to find a market. The quality of the fibre mined was excellent and the width of the veins was everything that could be desired, from one-half inch up to two, three and sometimes four inches. This justified the expectation that large deposits of the mineral might exist in that locality, though their true importance and value were not ascertained for several years following. Shipments of the better grades made to London created quite a sensation in the market; extensive tests and investigations were made and the result was that the high value on account of the exceptional qualities for spinning purposes was soon established and the race for the acquisition of additional areas likely to contain the valuable mineral began. The land was considered practically of very little value, either for agricultural or any other purpose, and mining operations were rapidly extended. The principal areas in which the asbestos bearing serpentine was found to occur were on lots 26, 27 and 28, near the line between the ranges 5 and 6 of Thetford, and in the township of Coleraine near Black Lake station, four miles south-west of Thetford station, in an area previously unsurveyed but adjoining, on the south-west range B, also on lots 27 and 28 range B and on lot 32 range C. All these areas were speedily secured as well as most of the serpentine bearing ground extending southeastward from the Quebec Central Railway towards Caribou lake, and for several miles along the Poudrier road.

For the next ten years we witness a rapid development of the industry. The mines were worked on a large scale, while the prospector was still busy exploring for the mineral in the mountains of the surrounding country. Villages sprang up like mushrooms in a country physically speaking one of the roughest. The population, comprising before the beginning of mining operations only a few scattered families, increased to several thousands and the whole country showed all the evidences of industrial activity and prosperity.

But it was soon discovered that the primitive methods of hand extraction were faulty, inadequate and expensive, especially as far as the lower grades were concerned, as a matter of fact, under prevailing price conditions only those mines which were working on richer ground and had a large percentage of crude asbestos had a chance to live and carry on operations with a profit. The natural outcome of this condition was obvious; many mines producing only a very small percentage of the higher grades were forced to shut down and this together with serious difficulties accentuated by overproduction and a consequent fall in prices caused the industry to receive a severe set back in the middle of the nineties. For some years the industry languished, which was dispiriting to all save those who would not be discouraged, no matter what should happen.

However, mechanical ingenuity of those engaged in the mines and of those having the development of the industry at heart came to the rescue; handcobbing of the lower classes of asbestos gave way gradually to mechanical treatment and this method in the course of years was so successfully and effectively worked out that we find to-day every mine in the district with a complete milling and fiberizing plant. By this process all the smaller fibre which in the earlier years was left in the rock and thrown into the dump is saved and as new applications for this short material sprang up the life of a mine was prolonged and attended with less difficulties.

As a result of these new innovations 16 mills with a capacity of 3,500 tons of asbestos rock per day are operating at present in the district and if reports materialize the capacity of the mines and mills will be largely increased in the course of the present year.

The asbestos industry is a striking example of what human ingenuity, if applied in the right direction, may accomplish. It demonstrates that in order to attain success it is necessary "to strive to seek, to find and not to yield."

The asbestos mines in the Eastern Townships constitute one of the most prosperous industries in the Dominion of Canada and they are of special interest to the mining and industrial world from the fact that in so far as now known they practically represent the only deposits where this mineral of a quality adapted for spinning and for the finer purposes of manufacture can be mined with a profit. So great are the advantages which these mines possess, particularly as regards the accessibility and the ease with which the extraction of the fibre is now accomplished in the mills that, unless fields as yet unknown and as easy of access can be discovered, the Province of Quebec will long enjoy the privilege of being the principal source of supply for this particular mineral, not only in the North American continent but in the world.

DIFFERENCE OF QUALITIES.

The name asbestos,* as commercially used at present, covers at least two distinct minerals, having in common only a fibrous structure and more or less fire and acid proof properties. These minerals are: (1)amphibole or hornblende asbestos (tremolite and actinolite), (2) serpentine asbestos, (amianthus and Canadian chrysotile asbestos). In external appearance and in chemical composition they are much alike, so much so that when the crystals occur in long slender prisms or in radiating masses the mineral is called actinolite, but when found in long, slender, flexible fibres easily separable it is named asbestos. The difference between the two minerals, between good and bad asbestos, will be at once perceived when the fibres or long slender crystals are subjected to tearing, twisting and bending between the fingers. The good asbestos applicable to the finer purposes of manufacture will give up fine silky threads of great elasticity, amenable to the various spinning processes, while bad asbestos will split up into harsh and sometimes brittle fibres, occasionally breaking up when rubbed between the fingers.

The heat resisting property of both of these varieties of asbestos is approximately the same, so that when this characteristic of the asbestos is the only quality desired, the amphibole variety would give as good satisfaction as the chrysotile, but whenever strength of fibre as well as nonconductivity of heat is desired, the chrysotile variety is the only one that can be used satisfactorily. Chemically the two species are much alike. Chrysotile asbestos is a hydrous silicate of magnesia, while the amphibole varieties are all silicates of lime and magnesia or compounds of silica with an earthy base, part of them hydrated. A special feature to be noted is that none of the anhydrous varieties have much of the unctuous feel which is so common a characteristic of the chrysotile species.

Actinolite.

Actinolite deposits occur in the township of Elzevir in Hastings county and are closely associated with a blackish green horn-

*The term "asbestos" is derived from the Greek and signifies "unquenchable," "inextinguishable," inconsumable." It is described in a French work as "mineral filamenteux et incombustible." The Germans call it "steinflachs" (stone flax) and the Italians "amiantho," from the Greek "amiantos," signifying "undefiled, pure, incorruptible." The French-Canadian calls it "pierre à cotton" (cotton stone) in allusion to its similarity in appearance to cotton.

blende rock, which runs in ridges in a northeasterly direction, bounded on both sides by granites. The width of these hornblende belts is from 250 to 500 feet. The whole area is affected by faults. Zones, patches and veinlike occurrences of an asbestiform mineral, a fibrous hornblende, are frequent. An analysis of this mineral made by Professor Coleman, of Toronto, gave the following results:*

Silica	61.82
Magnesia	23.98
Ferrous oxide	6.55
Lime	1.63
Alumina	1.12
Water	5.45

This mineral has been mined since 1884 near the village of Actinolite and the output hauled to the village of Bridgewater, a distance of about eight miles, where a mill, run by water-power, grinds all material and divides it into four grades, Nos. 1 and 2 being employed for boiler coverings and No. 3, which is finely ground, for plaster.

There are two companies operating in the district, one is the International Asbestos Company, with head offices in New York, the other is the Joseph James Company, of Actinolite. It is claimed that from thirty to forty per cent. of all the rock mined goes through the mill and of this about ten per cent. is extracted as fibre.

Actinolite is also found in some of the hornblende rocks of the Sudbury district, where the writer found fibre measuring from six to ten inches in length.

It appears, however, that the market for this mineral is very limited, the prices, are as a rule, not satisfactory and for this reason mining is conducted on a very limited scale.

Chrysotile.

The writer will, therefore, proceed to deal in the following only, with the mineral known as chrysotile, which is the standard article of its kind and which is found in payable quantities only in Canada in the Province of Quebec.

PHYSICAL PROPERTIES OF CHRYSOTILE.

Chrysotile asbestos is a fibrous form of serpentine and occurs in this rock in small veins, laces or stringers. The main essentials of asbestos, to render it of economic value, are length, fineness and

*Report Bureau of Mines of Ontario, 1893, page 98.

elasticity of fibre, tensile strength, flexibility and power of fire resistance. The Canadian chrysotile possesses all these qualities, the length of the fibre being one of the principal factors which determine the different grades. The main difference between asbestos and any other material or substance is its finely fibrous structure and at the same time its property of fire resistance. It may be said that upon these two qualities the great value of asbestos is generally based. Temperatures of 2,000° F. to 3,000° F. are easily withstood, while with some varieties a temperature of 5,000° F. has apparently produced no visible effect. Its property also of successfully resisting the action of acids is one of great value and these combined properties render asbestos of great importance in certain chemical operations, so much so that its use in laboratories and chemical factories is largely increasing.

Chrysotile has a great adaptibility for spinning. For a long time, however, the fibre produced from asbestos, unlike any other, resisted all attempts in this direction, the difficulty arising from the peculiar formation of the fibres, which, possessing perfectly smooth surfaces and being much less elastic than fibres of organic origin, slipped past each other when subjected to the spinning process. But all these difficulties have been overcome; a single thread of fair tensile strength can now be made, weighing not more than an ounce per hundred yards.

The hardness of the Canadian chrysotile is from 3 to 3.5 Mohs' scale, its specific gravity 2.2 to 2.3.

Asbestos has a lustre subresinous to greasy, pearly, wavy and silky. The colour is generally dark green to blackish-green. The asbestos in East Broughton is grass green, while that from Templeton is yellow, sometimes with a pale green tint. Blue asbestos has been found in Canada only in one place in a shaft 60 feet deep in Templeton, but this is an exceptional occurrence. In most cases, however, the fibre, when drawn out in threads, is white with a silky lustre. Brown and discoloured asbestos is also found, but this colour is not original and must be attributed to the weathering process or to infiltration of other substances mostly of iron.

The fibre in chrysotile is arranged in parallel layers and vertically to the bordering planes, is easily separable and has a length of from a small fraction of an inch to several inches, the fibre of the great bulk of the mineral, however, is half an inch and less in length.

CHEMICAL COMPOSITION OF CHRYSOTILE.

As already stated the chrysotile of Quebec is a hydrous silicate of magnesia, water entering into the composition of the same to a very appreciable extent. The following table contains the analyses of various classes of asbestos by Professor J. T. Donald:*

	Italian fibre	Canadian Fibre		
		Cambrian, Thetford	Chrysotile, Broughton	Laurentian, Templeton
Silica	40.30	39.05	40.87	40.52
Magnesia	43.37	40.07	41.50	42.05
Ferrous Oxide	0.87	2.41	2.81	1.97
Alumina	2.27	3.67	0.90	2.10
Water	13.72	14.48	13.55	13.47
	100.53	99.68	99.63	100.10

Professor Donald points out that chemical analysis throws light upon the cause of harshness of the fibre of some asbestos. The water present in the asbestos is in the combined form, which may be driven off by a sufficiently high temperature.

When harsh fibre is analysed, we find it to contain less water than the soft and silky fibre. In fibre of very fine quality from Black Lake, analysis showed 14.38 per cent. of water, while a harsh fibered sample gave only 11.70 per cent.

It is well known that if soft fibre be heated to a temperature that will drive off a portion of the combined water there results a substance so brittle that it may be crumbled between the thumb and finger. There is evidently some connection between the consistency of the fibre and the amount of water in its composition. It is probable that the harsh fibre was, as originally deposited, soft and flexible and has been rendered harsh by having a portion of its water driven off by heat, either produced by the movement of the associated rocks or resulting from the injection of molten matter through volcanic action.

GEOLOGICAL DISTRIBUTION.

In a geological sense there are two kinds of asbestos:

First—The species belonging to the Laurentian formation in the Templeton area north of Ottawa, in connection with the serpentinous limestone.

*Transactions General Mining Association of Quebec, 1891, page 27.

Second—The asbestos of the Eastern Townships, more particlarly confined to the serpentine areas of the mountain belt, which extends from the boundary of Vermont to the extremity of Gaspe peninsula.

Asbestos in the Laurentian.

The presence of asbestos in the crystalline rocks of the Laurentian formation has been known for over twenty years and mining was attemped from time to time but was found unprofitable, owing to the limited character of the deposits. But as there appears to be still some difference of opinion regarding the character of these deposits the writer, who has spent several years in their investigation, will give here a brief resume of the operations conducted in that locality and the results obtained.

CHARACTERISTICS OF THE LAURENTIAN DEPOSITS.

The serpentine in which asbestos occurs in this formation is closely associated with crystalline limestone which traverses the gneiss formation in form of bands in a generally northeast, southwesterly direction. These crystalline limestone belts occur at intervals and constitute one of the main parts of the so called Grenville series, extending from Ottawa eastward for several hundred miles. The occurrence of serpentine and asbestos, however, is so far only restricted to the country north of Ottawa and in the following a description is given of the occurrences and operations carried on in the township of Templeton.

DESCRIPTION OF TYPICAL OCCURRENCES AND OPERATIONS ON LOT 11, RANGE VII. TOWNSHIP OF TEMPLETON.

The rock in which the asbestos serpentine deposits occur forms a large stratum of massive crystalline limestone of about 700 feet in width, striking in a northeast, southwesterly direction, bordered on both sides by red, gray and white orthoclase gneiss. The crystalline limestone contains a number of accessory minerals, such as small crystals of mica, iron pyrites, small veins of graphite, pockets of hematite, while grains of serpentine are disseminated through the whole rock. The asbestos deposits assume frequently the form of concretionary masses, sometimes like rounded boulders, but also disconnected patches or pockets of small extent, from one foot up to three feet in diameter; irregular masses of limited extent and deposits with ring-like or elliptical sections, with a diameter from three to fifty feet, and with serpentine walls varying from half a foot up to three feet in thickness. (Fig. 1).

They sometimes present masses of yellowish green, spotted with crimson or blood red patches from disseminated peroxide of iron.

The outlines of these deposits on the surface form generally an ellipse, though in different places straight veins of small extent have been observed. In the elliptical deposits a sharp, defined line can be recognized between the deposits and the associated limestone and the veins generally follow the contours of the deposits.

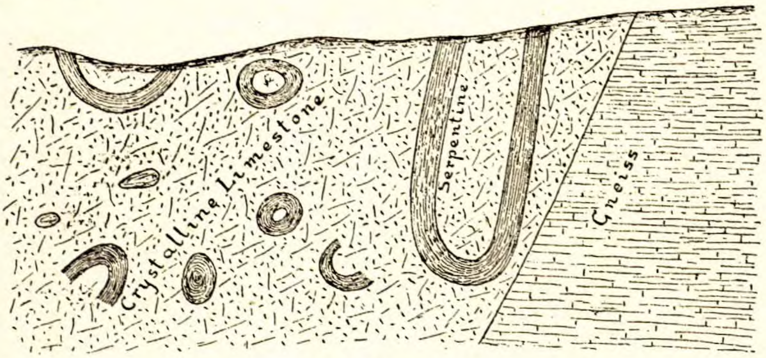

FIG. 1—Laurentian Asbestos deposits.

The serpentine has a light green, yellow green and dark green colour and it is difficult to say which colour is characteristic for the occurrence of asbestos. A grayish green colour is very often seen in the larger deposits. Small fissures through the serpentine, caused by the mechanical action of the water, are very numerous and for this reason the material splits up and is not obtainable in dimensions useful for ornamental purposes. The fresh serpentine contains much water and is easily separable from the asbestos. Some light green varieties are soft and have a peculiar unctuous aspect*.

*As the serpentine has been used from time to time and sometimes in large quantities for a number of purposes, especially as a plaster and roofing material, it may be of interest to give here some additional information regarding its physical and chemical properties. The Laurentian serpentines have a lower specific gravity and contain less oxide of iron and more combined water than ordinary serpentines. The analyses of some of them are subjoined, (Geological Survey, 1863, page 472). No. I is from Grenville, taken from a white crystalline limestone. Its colour varies from honey yellow to oil green and its density is 2.47–2.52. No. II is a similar serpentine of a pale wax yellow, from Calumet Island, its density is 2.36–2.38. No. III consists of grains of honey yellow serpentine, separated by dilute nitric acid from a white lamellar dolomite from Grenville. No. IV is the reddish brown serpentine rock or ophiolite of Burgess.

	I	II	III	IV
Silica	39.34	41.20	44.10	39.80
Magnesia	43.02	43.52	40.05	38.40
Peroxide of iron	1.80	0.80	1.15	7.92
Water	15.09	15.40	14.70	13.80
	99.25	100.92	100.00	99.92

Asbestos is found in small veins or layers, usually following the contours of the outer coat of the serpentine deposit and ranging in thickness from a fraction of an inch to half an inch and sometimes even more. They run in parallel layers, which may split up and form a larger number of veins or coalesce. The veins are sometimes displaced out of their natural positions and cut off by faults, as observed in several places, but such a displacement is seldom larger than six feet. In many cases, instead of fibrous veins, asbestiform matter of a white colour and of the same structure is met with. It has an unctuous aspect and shows occasionally the gradual change to the fibrous variety. The asbestos itself has a very fine silky fibre and is splendidly adapted for spinning. It has a marked wavy lustre, a light yellow, light green, seldom a dark green colour, and is very transparent, an indication of the absence of impurities. The chemical analysis shows that the Laurentian asbestos contains very little iron, much less than any other asbestos found in Canada. Black blue varieties with a very silky fibre of from one and a half to two inches in length have been observed only in one place at a depth of sixty feet. This is, however, an exception to the general rule.

As to the number of these asbestos serpentine deposits, they are irregularly distributed through the whole limestone strata and on account of the lack of leading indications it is difficult to say which part of the limestone probably contains workable deposits, even if the asbestos outcrops on the surface. As an illustration of this fact it may be mentioned that in one place five deposits were outcropping on the surface, containing fibre measuring from one quarter to one and a quarter inches in length, and the opinion prevailed that this spot, according to these indications, might contain workable deposits. However, in exploiting the latter, it was found that all the veins were of very limited extent, and on account of the concretionary form of the deposits they terminated at a depth of ten feet. Sinking further to a depth of forty feet revealed nothing of value save some beautifully colored masses of serpentine.

Amongst all the other deposits found on this property there was one specially remarkable. This deposit, which outcropped on the surface in elliptical form with a larger diameter of fifty feet and serpentine walls of a width of two and a half and three feet and containing splendid fibre of from one half to one and a half inches in length, continued to a depth of sixty feet in great regularity. At this depth a drift was run along one of the walls and it was found that the character and the horizontal extension of the deposit were exactly the same as on the surface. In sinking, however, the asbestos veins gradually disappeared, the serpentine being broken up into smaller pockets and bunches, containing here and there a few small stringers of the mineral. Most of the other deposits found on this property did not show a larger diameter than twenty feet. It was very often observed that asbestos of one and two inches in length on the surface disappeared by following the vein towards depth.

The percentage of fibre in the serpentine as determined by the writer in the mills at Buckingham was very satisfactory, sometimes more than fifteen per cent. of the milling material, but the latter was not plentiful and the bulk of fibre extracted was small.

The deposit in Denholm near the Gatineau, is similar to that in Templeton in the mode of occurence, but it appears that on one place the accumulation of asbestos deposits was large and warranted for some time the expenditure for mining. It is reported that from one shaft which was sunk to a depth of over 160 feet in one year twenty-five tons of fibre and crude and 850 tons of asbestos cement of very fine quality was mined and that a profit of $6,000 was made after paying all expenses.

LOCALITIES OF LAURENTIAN ASBESTOS.

Among the many localities where the Laurentian asbestos has been found to occur may be mentioned:

Township of Portland West, county of Ottawa, lot 16, range V*. The chrysotile occurs in two principal bands, one of which is near the brow of a ridge of limestone with a band of serpentine near the contact with the gneiss and with a dike of white granite or pegmatite along the contact. The elevation of this ridge is about sixty feet above the road at its base and in the serpentine band there are from twenty-five to thirty small veins in a space of two to three feet. Most of these are mere threads,

*Geological Survey Report, 1899, page 105 J.

but some reach a thickness of half an inch or even more. The band of limestone is here exposed for a breadth of about one hundred and fifty yards and a second narrow band of asbestos bearing rock occurs near the eastern edge of the area, which terminates against a mass of red granite-gneiss. In this area the concretionary looking masses of serpentine are not observed.

Several areas of serpentine with small quantities of chrysotile have been found at various points. Thus, about three miles north of St. André Avelin, côte St. Pierre, a band of limestone occurs between two dikes of greenstone. The contact between the limestone and the greenstone (diorite) is marked by a zone of serpentine, in which small veins of chrysotile are seen. The lower portion of the limestone has small grains of serpentine distributed through it.

Of other deposits may be mentioned:—Lot 14, range VII; lot 2, range VIII, and lot 16, range V, all in the township of Templeton.

In the township of Wentworth* on lot 20, range IX, south of Silver lake, the belt of crystalline limestones which extends eastward from Lost river to Sixteen Island lake contains in its lowest part near an intrusive pyroxene a narrow band of serpentine with several small veins of crysotile, on which an attempt at mining was made some fifteen years ago. Some of these veins have a thickness of half an inch. White granite dikes occur also in the vicinity.

On Blanche lake in the township of Mulgrave similar serpentine deposits occur with small quantities of this mineral, as also on the east side of Grill lake, but it may be said that of all those yet examined in this district the quantity is too small to render its extraction profitable.

Serpentine occurs similarly at several points along the Ottawa river, in the rear of "Pointe au Chêne" and a mill was erected at this place several years ago to separate the fibre. The amount of fibre, however, was too small for successful treatment and the works have been closed.

The Asbestos Deposits of the Eastern Townships, Province of Quebec.

The distribution of serpentine in the Province of Quebec may be grouped into three areas: (1) The area covering the Gaspe peninsula; (2) the Thetford, Black Lake area; (3) the Danville, Orford and Potton area. (Fig. 2).

*Geological Survey Report, 1899, page 107 J.

In the Gaspe peninsula* the serpentine presents a very large development, especially in the Shickshock mountain range, Mount Albert and Smith mountain. It is found in bands sometimes a few yards in breadth, interstratified with the slates and sandstones and sometimes with diorites, in conjunction with which it forms knoll-like hills or elongated ridges of considerable extent.

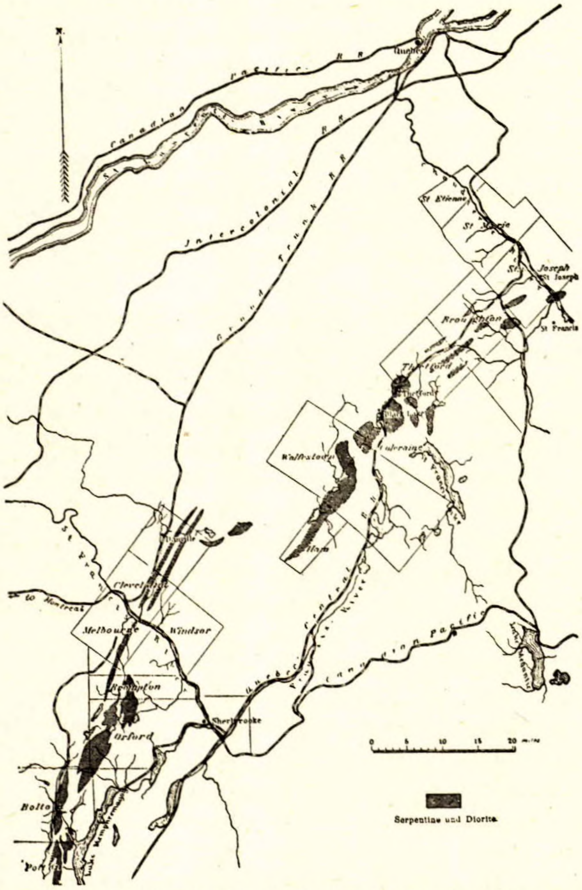

Fig. 2—Map Showing the distribution of Serpentine in the Eastern Townships of Quebec. By Fritz Cirkel, M.E.

The western portion is too hard and silicious to give much promise of asbestos, but some portions of Mount Albert have shown small veins along with deposits of chromic iron ore.

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*Geological Survey Report, 1888-89, page 143 K.

In the eastern portion of the peninsula at Mount Serpentine on the Dartmouth river, a few miles from its mouth, Mr. Obalski has discovered some veins of asbestos in a band of serpentine associated with hornblende rock. This mountain rises to a height of 1,600 feet above the sea and is surrounded by the sandy and calcareous beds of the Siluro-Devonian system of that region. The area under question has never been carefully explored with a view to ascertain the presence of the mineral in quantity, owing largely to the present difficulty of access.

The second and most important field from an economic point of view is that generally termed the Black Lake-Thetford area. It commences with several small knolls of serpentine north of the Chaudiere river and in the vicinity of that river between the villages of St. Joseph and St. Francis. Small veins of asbestos can be seen in some of them, but apparently not in quantity sufficient to render them commercially important. Further to the southwest in Broughton, Thetford, Coleraine, Wolfestown and Ham a very great development of these rocks is observed, forming at times mountain masses from 600 to 900 feet above the surrounding country and contributing largely to the generally rugged character of the latter by their sharp outlines and weathered surfaces. In Black Lake and Thetford a great part of the serpentine is asbestos bearing in commercial quantities and it is here where most of the mineral is found and mined on an extensive scale. This large or central area terminates southward in Ham mountain, which in its southern extremity constitutes a prominent knoll of diorite.

The third area, which may be termed the southwestern area, commences with the village of Danville and extends through Brompton, Orford, Bolton, and Potton in a chain of hills to the American boundary, beyond which the continuation of the serpentine can be traced into Vermont. With the exception of the Danville area asbestos has as yet been discovered only in small quantities. Several attempts have been made at mining, but in every case the mineral was found to exist in too small a quantity to be of commercial value. However, it must be mentioned that the area under question is largely covered with heavy humus and forest growth, so that, on this account, prospecting is very difficult and almost impossible and the true value of this area can only be surmised. It is evident that unless the heavy forests were destroyed by fire and the soil removed, as in Black Lake and Thetford, there is very little chance that the presence of the mineral in paying quantities will ever be established.

THE THETFORD—BLACK LAKE AREA.

Geology and General Features of the Serpentine.

The workable asbestos deposits of this area are confined to the serpentine belt near Black Lake and Thetford and to a small detached area near East Broughton station.

The serpentines of the townships form disconnected masses, generally of small extent in the great series of slates, schists and diorites designated as a part of the Cambrian formation (Fig. 3).

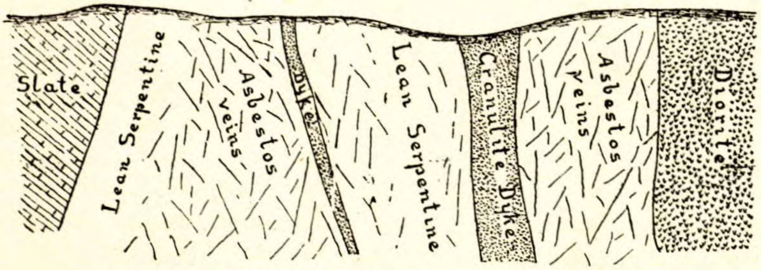

FIG. 3—Profile of Asbestos-bearing formation at Black Lake and Thetford.

Occasionally they assume such proportions as to form mountain ridges, as may be noticed in Black Lake, where most of the productive mines are located on the great serpentine ridge which attains a height of 900 teet over the track of the Quebec Central Railway and strikes in a northerly direction through the country The serpentine masses are unquestionably an alteration product from an olivine diabase or gabbro, which forms also prominent hill features in this area.

All the rocks in the district from Vermont north to the St. Lawrence river have been subjected to a great series of folding and disturbances* and evidences of this effect may be seen all through the asbestos region in the decidedly slaty and schistose structure of parts of the serpentine masses. The rocks in Thetford and Black Lake, however, although exhibiting to some extent faults and slickensides have withstood the strain of pressure and are of a more massive character.

Slickensides and faults as a result of these movements are very frequent throughout the serpentine region and in some places

*Geological Survey Report, 1890-91, page 20 S.

have cut off entirely working faces, presenting a barren wall for a time. Sometimes, however, veins of good asbestos are concealed by the soft, slippery serpentine with which they are covered and it is necessary, therefore, that the miner should examine these walls very closely before he is fully certain that they are barren.

The serpentine exposed in different sections of this area varies considerably in character. Some of the rock is hard and silicious and dry looking, as in some portions of Black Lake, Ireland and Wolfestown and contains no asbestos. Sometimes it exhibits a tarnished yellow colour and in most cases imperfect, stiff or harsh fibre is found. Frequently seamy partings can be observed (Fig. 4d and Plate III), crossing the rock in every direction and while

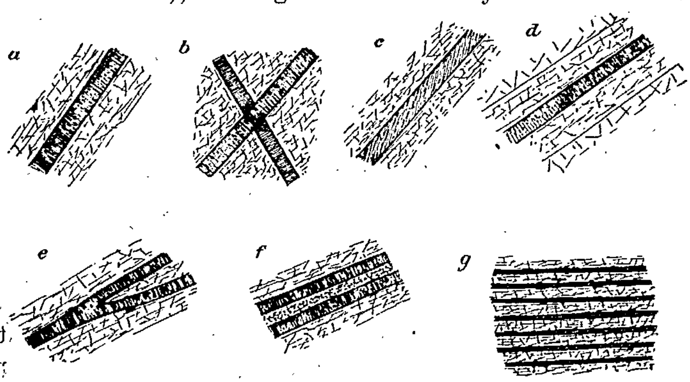

FIG. 4—Typical Asbestos Beds.

(a) Regular vein.
(b) Crossing of veins.
(c) Drawn out vein in fault or slickenside.
(d) Seamy parting containing vein in middle.
(e) Forking of vein.
(f) Two veins divided by small seam of chronic iron and serpentine.
(g) Ribbon like arrangement of small veins.

it is true that in a great many of them no asbestos can be found, still it appears that these indications form characteristic features of the presence of the mineral in some of the mines. In certain portions of the belt these seamy partings are quite numerous and by some prospectors are supposed to indicate the presence of asbestos veins. Even in the mining district of Black Lake and Thetford there are large portions of the serpentine belt which do not contain asbestos in payable quantities. The rock carrying good asbestos veins is generally of a gray weathered, dark green or gray green colour. It contains to some extent numerous particles of iron ore, both magnetic and chromic and as a rule serpentine rock of a black, hard, chippy aspect does not promise well for the presence of asbestos.

The serpentine is often cut by dikes of granite, which can be noticed in most of the mines in Black Lake and in Thetford. They range in size from small bands of one and two feet up to large intrusions of 50 and 100 feet in width and some of the gray and reddish varieties form conspicuous hills between the villages of Thetford and Black Lake.

In many cases these dikes have shattered and altered the rock in contact; the latter appears to be highly fissured and at places large accumulations of asbestos veins can be noticed, apparently indicating that the intrusion of these dikes has exercised some influence in this direction. Sometimes these dikes cut off the work entirely and very often a face of good asbestos veins, but good ground is generally found by driving through the dike mass.

Early attempts to use serpentine for decorative purposes.

The serpentine of the Eastern Townships presents several interesting features as a material of indoor decoration. Unfortunately it is easily affected by atmospheric agencies and is not, therefore, adapted for outside work, since the polished surface speedily becomes tarnished by weathering. In earlier years attempts were made to obtain good sized blocks from some mines in Thetford, but while these can be extracted in large masses the stone appears in many cases to be affected by joints and seams, which, in the dressing, interfere very seriously with the efforts to secure good, solid pieces for polished work. Slabs can, however, be readily sawn which when well polished have a very rich and pleasing effect for interior decoration and present a considerable variety not only in colour but in the markings.

In Vermont these serpentines have for some years been quarried and sold under the head of "verde antique marble."

Accessory minerals in serpentine.

In some places the serpentine is intimately associated with steatite or soapstone. In such cases, where occasionally small veins may be seen to occur, the mining of asbestos has never been profitable. Chromic iron ore is also found in connection with asbestos, in small pockets, seams and irregular masses from a few feet up to ten and fifteen feet in width, but it appears that wherever these two minerals occur together the mining of asbestos has not been profitable.

Characteristics of asbestos veins.

The veins in the asbestos bearing rock occur without any special arrangement, intersecting each other and the mass generally in every direction, but generally forming straight lines. (Fig. 4). Sometimes they split up in several smaller veins or coalesce and form a larger vein. Certain peculiar arrangements, however, are noted in some of the areas, as at the King Bros. mine in Ireland* where the serpentine appears to be regularly stratified almost in the manner of sandstone or quartz in layers dipping to the northwest and the veins of asbestos apparently follow what in sedimentary rocks would be regarded as bedding planes. In several other places the veins cut the rock in an almost horizontal direction and when found in a knoll can be traced across from one side of the hill to the other, nearly on the same plane, but as a rule the veins are irregularly placed.

The thickness of the veins varies from mere threads up to several inches, but it may be said that the largest bulk of the asbestos mined is between one quarter and one half inch in length. The longer fibre is very often divided in the middle by a seam of serpentine carrying magnetic or chromic iron ore. As a rule, in most of the mines the asbestos can be easily separated from the rock, but in some veins the fibre appears to be frozen to the rock, its complete separation being very difficult.

The veins are sometimes displaced by the action of faults and slickensides in the serpentine, giving the impression that the fibre is of considerable length, whereas when closely examined it is found that the veins carry fibre of the usual length, but drawn out along the fissures. (Fig. 4 c). Sometimes a long, woody fibre is observed deposited in a fissure between two rock portions. This woody material usually termed hornblende by the miner is in reality a picrolite and can be noticed principally in the mines at Thetford and East Broughton.

A peculiar occurrence of asbestos is noticed in the Megantic mine at Coleraine. Here the serpentine for several feet is laced with small, minute veins of asbestos one-sixteenth and one-quarter of an inch in thickness, giving the rock a ribbon-like structure. This same mode of occurrence can also be noticed in some mines of Black Lake.

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*Dr. Ells, paper read before the Asbestos Club, Black Lake, February 19th, 1891.

Discolouration and alteration of the fibre.

Discolouration of the asbestos and also alteration of the fibre itself can be observed everywhere throughout the region. This is due to three causes:—(1) to the influence of the weather and action of water; (2) to large forest fires which swept over the region; (3) to the presence of intrusive dikes.

A change of colour is very often observed on the surface, especially where the rock is shattered by intrusive dikes or some other causes, permitting water, generally charged with iron, to filtrate through the rock along lines of fracture and discolour the fibre. This condition, however, disappears in depth and the fibre assumes its normal condition. A discoloration and to some extent a harshness of the fibre is observed on the outcroppings of deposits which have been swept by large bush fires. But we find sometimes also harsh and brittle fibres in depth and this condition may in a large measure be attributed to the presence of intrusive dikes. We have already learned that dissipation of water in the fibre causes brittleness and harshness and it appears that the heated intrusive magma of the dike has had the same influence upon the asbestos veins as the forest fires have had on the surface outcroppings, in dissipating some of the water contained in the fibre, destroying its silkiness and fine texture and rendering it brittle and harsh. However, this condition is not observed in every case where there is a granulite dike; in many instances no such alteration has taken place and the fibre occurs in its normal condition.

THE EAST BROUGHTON AND DANVILLE AREAS.

A small detached area of serpentine occurs in East Broughton. The serpentine is enclosed between a highly quartzose slate, probably of Cambrian age. Its largest width is about 700 feet and its general trend about 20° east of north. (Fig. 5). Most of the serpentine is completely shattered, is much softer than the serpentine of Black Lake and Thetford and is easily mined. The asbestos forms small, gashy veins along the cleavage planes, is sometimes crushed and seems at places to be disseminated through the whole mass of serpentine. Much of the fibre is short, but it is of an excellent quality, being of a grass-green colour when freshly broken. Occasionally fibre measuring two inches in length is found. Large sheets of ligniform serpentine of white and green colour are found along fracture lines in the serpentine, resembling picrolite, which is sometimes so soft that it can be cut with a knife.

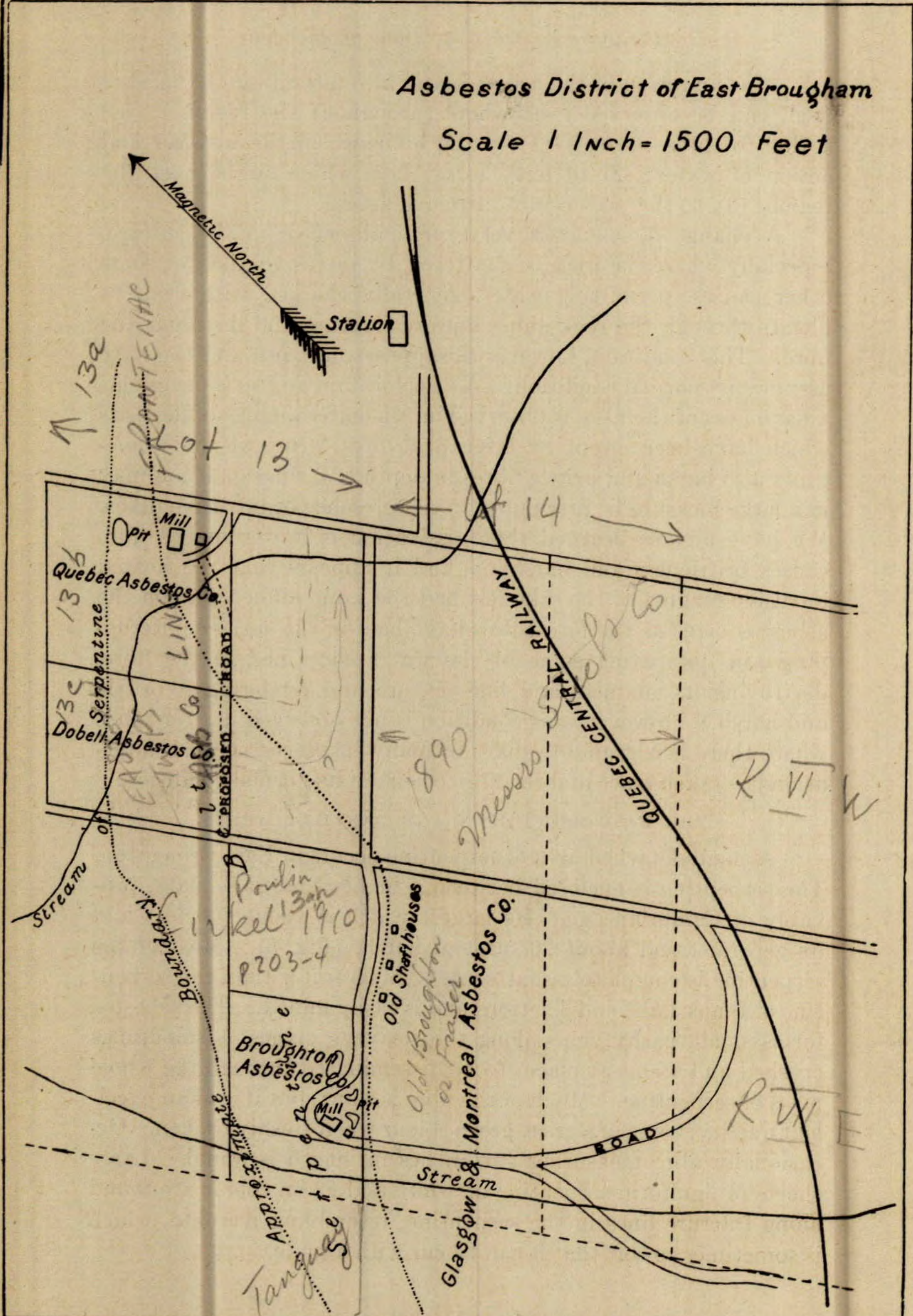

Asbestos District of East Broughам
Scale 1 Inch = 1500 Feet
Magnetic North
Station
Mill
Pit
Quebec Asbestos Co.
Serpentine
Dobell Asbestos Co.
PROPOSED ROAD
QUEBEC CENTRAL RAILWAY
Stream
Boundary
Old Shafthouses
Glasgow & Montreal Asbestos Co.
Broughton Asbestos Co.
Mill
Pit
ROAD
Stream
APPROXIMATE

Fig. 5.

Another detached mass of good serpentine occurs near Danville. This whole area is much affected by faults and some of the larger veins are cut off by intrusive dikes. However, the quantity of fibre appears to be large and the general conditions for mining excellent. Asbestos up to one-half inch and longer occurs plentifully, while the whole of the serpentine is impregnated with very fine, short fibre, representing a first class milling material. It is stated on good authority that between seventy and eighty per cent. of the total rock mined goes through the mill.

COMPARATIVE ANALYSES OF ORES.

The following comparative analyses of some of the ores of the district have been furnished me by Professor Donald, of Montreal:—

	I	II	III	IV	V	VI
	Asbestos	Asbestos	Asbestos	Asbestos	Serpentine	Picrolite
Silicia	39.22	41.90	41.84	42.64	40.34	43.70
Magnesia	40.27	42.50	41.99	39.54	43.32	40.68
Alumina	3.64	0.89	——	——	1.32	——
Ferrous oxide	2.26	0.69	2.23	3.66	1.23	3.51
Water	14.37	14.05	14.28	14.31	14.17	12.45

No. 1 is from the Southwark mine at Coleraine, the sample being classed as fair. Analysed by Professor Donald, Montreal.

No. II. Very fair quality of ore from the Glasgow and Montreal Company's mine at Broughton. Analysed by Professor Donald, Montreal.

Nos. III and IV. Asbestos from Danville. Analysed by Professor Smith of Beloit College.

No. V. Serpentine from Brompton Lake.

No. VI. Picrolite from Bolton. Analysis by Dr. T. Sterry Hunt. The special point to be noted here is the variation in alumina, ranging from 3.64 per cent. at Coleraine to none at all in Danville.

ORIGIN OF ASBESTOS.

Several theories regarding the origin of asbestos have been advanced. Mr. Hyde Pratt* of the United States Geological Survey summarizes his ideas on this subject as follows:—

*United States Geological Survey, 1904. Bulletin on Asbestos.

"There is but little information to be had regarding the origin of chrysotile, the fibrous variety of serpentine. Its occurence as a fibrous, silkv product lying in narrow seams in the main mass of serpentine and having almost identically the same chemical composition as the enclosing rock which is known to be an alteration product and not the primary rock raises some puzzling questions regarding its formation. There are a number of points to be taken into consideration—the relation of the chrysotile to the serpentine in which it occurs; the relation of the main body of serpentine to the enclosing country rocks; the mineralogical and chemical relation of the chrysotile to the mass of serpentine; and the origin of the rocks from which the main mass of serpentine has been derived.

"It can be conclusively shown in nearly all cases that the serpentine in which the chrysotile asbestos is found is of igneous origin. Some of the main points leading up to this conclusion are the presence in the serpentine of the mineral chromite, either as small grains or as segregated masses; the almost entire absence of any carbonates, except those which are of undoubted secondary origin; the occurrence of small masses of gneiss, granite, or other rocks entirely surrounded by the serpentine, which have undoubtedly been broken off from the main masses of these rocks during the intrusion of the rock of which the serpentine is an altered facies; the blunt, lenticular form which so many of these masses of serpentine are observed to have; and the sharp line of separation of the masess of serpentine from the surrounding country rock.

"The original rock in cooling would solidify first along its contact with the rocks through which it had penetrated and where it was in contact with any included masses of the country rock that had been broken off during the intrusion of the molten magma. The outer portions of the molten rock would thus cool much more suddenly than the interior portions and there would be a tendency for them to develop cracks and parting planes. In the alteration of these primary rocks to serpentine, through the agency of aqueous solutions, vapors, etc., there would be perhaps, to some extent at least, a widening of these cracks, but in the end they would be filled with serpentine deposited from aqueous solutions from their walls and the resulting fibrous structure of the serpentine filling these seams represents the nearest approach to a true crystallization that the mineral serpentine assumes, except when it is found as pseudomorph after another mineral. It is probable that this chrysotile asbestos may have been formed some time before the complete alteration of the primary rock into serpentine. This is emphasized by the fact that in the southern part of the United States where these basic magnesian rocks have been but partly altered to serpentine, seams of chrysotile asbestos are occasionally found, and that in other cases seams of serpentine are found almost entirely inclosed by a peridotite rock which is altered but little into serpentine. Then again, it may be that in the first alteration of the basic magnesian rocks the seams and crevices are filled with serpentine which has been derived from the main mass of the basic magnesian rock and that later, during the process of complete alteration of the rock into serpentine, these seams have become asbestiform, due to the action of aqueous solutions.

"As one studies these basic magnesian rocks in their primary or nearly primary condition, as found in the various peridotites of North Carolina, South Carolina and Georgia, it becomes almost immediately evident that these rocks are badly cracked and seamed in proximity to their contact with the country rock through which they have intruded, this being especially true of those containing but little chromite or corundum. During the process of alteration, these seams and crevices have become filled in some instances with a clay-like material; in others, with a compact serpentine; and in still others, with the fibrous variety of serpentine These seams and crevices have no regularity, they are apt to run in nearly all directions and are not of any considerable length.

"With very few exceptions, all the fibres of the asbestos are standing at nearly right angles to the sides of the seam, which would conclusively show that they were not formed by any shearing movement of the rocks. In a few exceptional instances, chrysotile asbestos has been reported where the fibres were lying lengthwise with the seams, and in these cases there may have been shearing movements of the rocks, which have resulted in the formation of a fibrous serpentine.

"Another point of interest to be noted is that in those bodies of serpentine containing a large quantity of chromite, corundum, genthite, or garnerite there is little or no chrysotile serpentine. This would seem to indicate that the chromite and corundum had in their separation from the molten magma interfered with the extensive formation of the cracks which are necessary to the formation of the chrysotile serpentine."

Dr. Ells* of the Geological Survey of Canada gives his opinion as follows:—

"The asbestos veins which traverse the serpentine in all directions in the asbestos-bearing portion probably owe their origin to fissures which have been formed in the rock-mass as a result of some one of the several periods of movement. That some of them were formed prior to the final crushing is probable, since occasional veins are found in the crushed condition; the greater part of these veins, however, are but little disturbed and the fibres are still at right angles to the sides of the fissure.

"The intrusion of the white granite dikes has probably exercised some influence in this direction, since often in the mining as the dikes are approached the veins increase in number, as if the rock had been opened up by their action. Sometimes masses of granite invade the serpentine and cut off the asbestos-bearing rock entirely, so that the workings have to be abandoned. When a face of good asbestos-rock has been cut off by the action of faults, good ground is generally found again by driving for a short distance through the barren wall.

"In whatever way the fissures were caused, and it is very probable that they have been formed by the great processes of metamorphism to which the rocks were exposed in the change from dioritic matter to serpentine, the vein asbestos appears more naturally to have been produced by a process of segregation of serpentinous matter from the sides of the fissure very much as ordinary quartz in many mineral veins is known to have been produced, the segregated or infiltrated matter gradually filling the original fissure and meeting at or near the centre, in proof of which the presence of a comb of particles of iron is very often found occupying the centre of the vein and quite frequently these iron grains assume sufficient size as to form a regular parting of iron ore in the fibre. In this respect asbestos veins resemble very closely mineral veins with quartz or calcite which frequently contain alternate layers of ore on either side of a central comb of crystals. The arrangement also of the fibre at right angles to the sides of the containing fissure, except where the rock has been disturbed, is confirmatory evidence in the same direction."

George Merrill† holds that the crevices in the serpentine are due to shrinkage such as is incidental to the change of a highly

*Bulletin on Asbestos, 1903, page 12.
†"Mining World," April 1905, page 398.

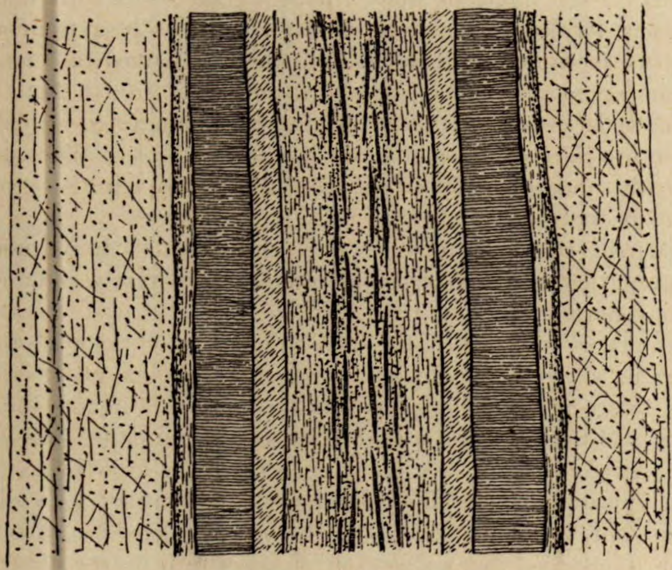
hydrated colloidal substance into a less hydrated and more solid form and perhaps also to a loss of silica, as suggested by Professor Kemp. He compares them with the shrinkage cracks which appear in clay on drying or those which result from the shrinkage of a gelatinous mass of iron carbonate, as in the so called septarian nodules of clay-ironstone. The masses of serpentine are supposed to have undergone a process of hydration and swelling with a subsequent shrinkage sufficient to produce cracks.

As to the filling of these cracks Merrill refers to a fibrous structure formed under quite similar conditions in gypsum and also, but more rarely, in calcite. In the first named the crystallization apparently takes place by a process of growth from one of the walls, considerable force having been manifested, sufficient to rupture the rock mass in which it is taking place. Whether or not such conditions exist in the case of asbestos veins is perhaps yet to be proved.

Merrill then continues in his argument: "It is noted however, that veins of any considerable width rarely show continuous fibres extending from side to side. In most cases the continuity is interrupted by small fragments of the wall rock; or again, where this is lacking, there exists at some intermediate point between the walls a break or line of separation, as though the crystal fibres had been pushed outward from either wall until their extremities met. In many such cases the growth has continued until the fibres are pushed past one another to a slight extent, the line of contact thus becoming jagged or saw-like. Again, there are other indications of pressure from the direction of the walls, manifesting itself most frequently in a crimpling of the fibres."

The writer's own opinion is that it is quite probable that the process of dehydration which forms fissures or cracks in clay-ironstone, as illustrated by Merrill, may have gone on with serpentinous masses on a large scale, and this process may have been facilitated by the loss of silica during serpentinization, as suggested by Professor Kemp. But it is also very probable that the intrusion of those granitic dikes so frequently met with in the serpentine masses has caused or facilitated to a great extent the formation of numerous fissures in the immediate proximity of these intrusions, by rapid dehydration through the agency of heat. The fact that, as outlined in a preceding paragraph, very frequently an accumulation of asbestos veins can be noticed in approaching these intrusive dikes seems to substantiate this theory.

The assumption of Pratt, however, that the fissures in their entirety are the result of a cooling off of the rock mass, where the latter was in contact with the country rock through which it had penetrated, cannot be very well upheld in view of the fact that we find in many portions of the serpentine, even in contact with the country rock, no asbestos veins whatsoever, while in the same serpentine mass sometimes far from the contact a large number of veins may occur.



A B C D F E F D C B A

FIG. 6—Section of seamy parting (natural size) illustrating the successive deposition of mineral matter through segregation. Lot 13, Range V, Thetford.

(a) Dark green serpentine, containing specks of chromic iron.
(b) Dark blue serpentinewith grains of chromic iron on contact line with A.
(c) Whitish asbestiform matter, with fibrous structure vertical to walls.
(d) Layers of pale green serpentine.
(e) Dark blue serpentine with grains of chromic iron.
(f) Fine asbestos laces 1-16 and 1-32 of an inch thick.

As to the vein filling, the writer believes that the asbestos has been formed through segregation of serpentinous matter from the sides of the fissure. In support of this theory it may be mentioned that a great number of veins, especially those of larger size, have in the middle, between the two walls, a parting of serpentinous matter and chromic iron ore; that the arrangement of the fibre is at right angles to the sides of the fissure, excepting, of course, those veins which have been disturbed; and that further—and this is the most important proof—some of the veins, in which the process of formation of the asbestos has not been completed, exhibit an arrangement of alternate layers of mineral matter from the sides of the walls, similar to metalliferous veins, which frequently contain alternate layers of ore on either side of a central comb of mineral.

In support of the segregation theory the writer may mention that he has recently found a seamy parting with a small asbestos vein on one of the outcrops on lot 13, Range V, Thetford, near Robertson station (Dr. Reed's property), which shows very clearly (Fig. 6) the successive depositions of the mineral matter deposited from aqueous solutions from the walls of serpentine.

The latter, when freshly broken, is of a grass-green colour, seems to be softer than the general run of serpentine and appears to have undergone considerable crushing movements. Seamy partings running in all directions occur frequently, sometimes containing fine, silky asbestos fibre and at other times holding asbestos, which has not completed its process of development and formation.

CHAPTER II.

MINING OF ASBESTOS.

The work of extracting the asbestos from the rock in which it occurs and converting it into a saleable article will be described under the following heads:—

First.—The mining proper, that is, the blasting, separating the dead from the useful material, hoisting the same from the pits and transporting it to the cobbing sheds or mills.

Second.—The cobbing or dressing of the better qualities, that is, the separation of the fibre by hand from the adhering rock particles, together with the mechanical treatment of all rock or fine material containing fibre in mills, grading of all products, followed by marketing, transport to the railroads and shipping.

It is of importance to treat all these different stages through which asbestos has to pass until it is a finished product separately, as these involve the entire expenditure from the winning of the product in the rock up to the delivery to the consumer. The success of a mine depends to a very large extent upon the careful, economic and intelligent direction of the different operations just enumerated as the peculiar qualities of the mineral and the mode of its occurrence differ so widely from those of any other known mineral.

ADVANTAGES AND DISADVANTAGES OF OPEN CAST WORK.

Experience shows that open cast work is the best suited and most economical method for the extraction of asbestos.

Attempts have been made by several companies to overcome the difficulties incident to severe winter seasons, but it must be said that with the exception of one case where the conditions for underground work, on account of the singular nature of the occurence, were exceptional the results have not been satisfactory. At the Union mine some ten years ago a somewhat extensive tunnel was run during the winter from the foot of a hill and a shaft sunk of large dimensions in connection therewith. A wide shaft was sunk and large roomy drifts were recently run in the western part of the property of the Bell Asbestos Company, but all these attempts have illustrated beyond doubt that underground work, on account of the general erratic occurrence of the veins in the rock and especially of the dikes and barren zones of serpentine met with is neither suitable nor profitable. In the old Broughton mine a shaft to a depth of 100 feet has been sunk in an accumulation of parallel veins near the contact with the slate formation and it is reported that the results were satisfactory for the first seventy-five feet, but owing to the irregular course of the veins in depth work had to be abandoned.

The advantages of open cast work, compared with underground work, may be summarized in the following:—

1.—Easier supervision.

2.—No trouble as regards ventilation; the men are always working in good air.

3.—Easier lay out of works in larger steps and stopes than is usually possible in underground works.

4.—No timbering is necessary.

5.—Complete extraction of all the asbestos encountered in the rock, no loss in the form of pillars.

The principal disadvantages of open cast work are:—

1.—The removal of all the waste rock resulting from dikes and barren zones of serpentine.

2.—Exposure of men to the inclemency of the weather; work is interfered with; its effect reduced considerably, or it may be stopped by bad weather, such as heavy rain, snow or extreme cold, etc.

3.—Curtailment of dumping ground on properites of limited extent.

A great deal of difficulty arising out of open quarry work is the selection of a suitable dumping ground and many mines which have little ground at their disposal find the solution of this difficulty a great problem. In early days of asbestos mining, when very little engineering skill was displayed and little thought was given to the future of the mine, most of the dumps were placed quite close to the quarry, as was the case in most mines. This accumulated waste rock had to be removed, when it was found that the ground so covered contained large asbestos-bearing zones. To-day, long, horizontal and gravity tramways are built to remove the dumps as far away as possible in some of the mines on ground specially bought for that purpose.

REMOVAL OF SOIL.

The first process in opening a quarry is the removal of the soil which covers most of the asbestos bearing areas in a thickness varying from a few feet up to twenty-five feet. In Black Lake the crest and the slope of the large serpentine ridge is for a great part covered with a thin layer of humus, thus rendering prospecting work comparatively easy, while in the lower ground of this locality the territory between Black Lake and Thetford is covered to considerable depth with soil and at Thetford the thickness of the overlying soil is in some places fifteen to twenty feet. The removal of this soil for open quarry work is performed only in the summer time, the winter being too severe on account of frost and snow for this class of work.

The soil is cleared off generally with pick and shovel and loaded into large dumping cars on trucks which are laid for this special purpose close to the work and shifted when required. A new departure in this direction has been made by the Bell Asbestos Company of Thetford; a steam shovel has been put in commission and is working during the summer months on the heavy ground which covers the property between the large open pit of Bell's and that of King Bros.

It is claimed for this new innovation that as an average from

90 to 100 cubic yards are removed in one shift, three men only being required, one for the engine, one helper on the dumping car, and one for transport.

QUARRY WORK.

As a rule, the quarries in the smaller mines have a very irregular shape, most of them following the trend of the asbestos-bearing zones, while the lean serpentine or intrusive dikes are left as pillars. In the larger mines, however, where the locations of the asbestos-bearing and lean rock and the location and extent of intrusive dikes have for years been more fully studied, the quarries have in general a more regular outline as at the King Bros'. and Bell's pits at Thetford (Fig. 7) and the large quarry of Danville.

Here no discrimination has been made between dikes, lean or rich portions of the serpentine; no pillars of any rock have been left, for the reason that these only would prevent mining with advantage towards depth. The shape of the quarries is rectangular and while the outlines of the walls are not strictly in conformity with that shape still the execution and the progress of the work in the pits indicate a certain system which has been followed in later years. The main advantage of the system employed in these mines lies in the fact that as generally a number of different zones, both lean and asbestos-bearing, are thus laid open, the work and also the supply of the ore can be regulated to better advantage and to requirements.

As a general rule, in all the larger pits the rock is taken down in a series of benches, stopes and terraces which vary in dimensions according to the sizes of the pit. A good illustration of the systematic progress of quarry work is the long pit of King Bros. (Fig. 8). This pit has a length of 700 feet and an approximate average

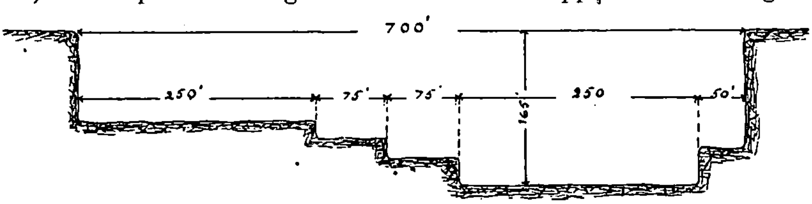
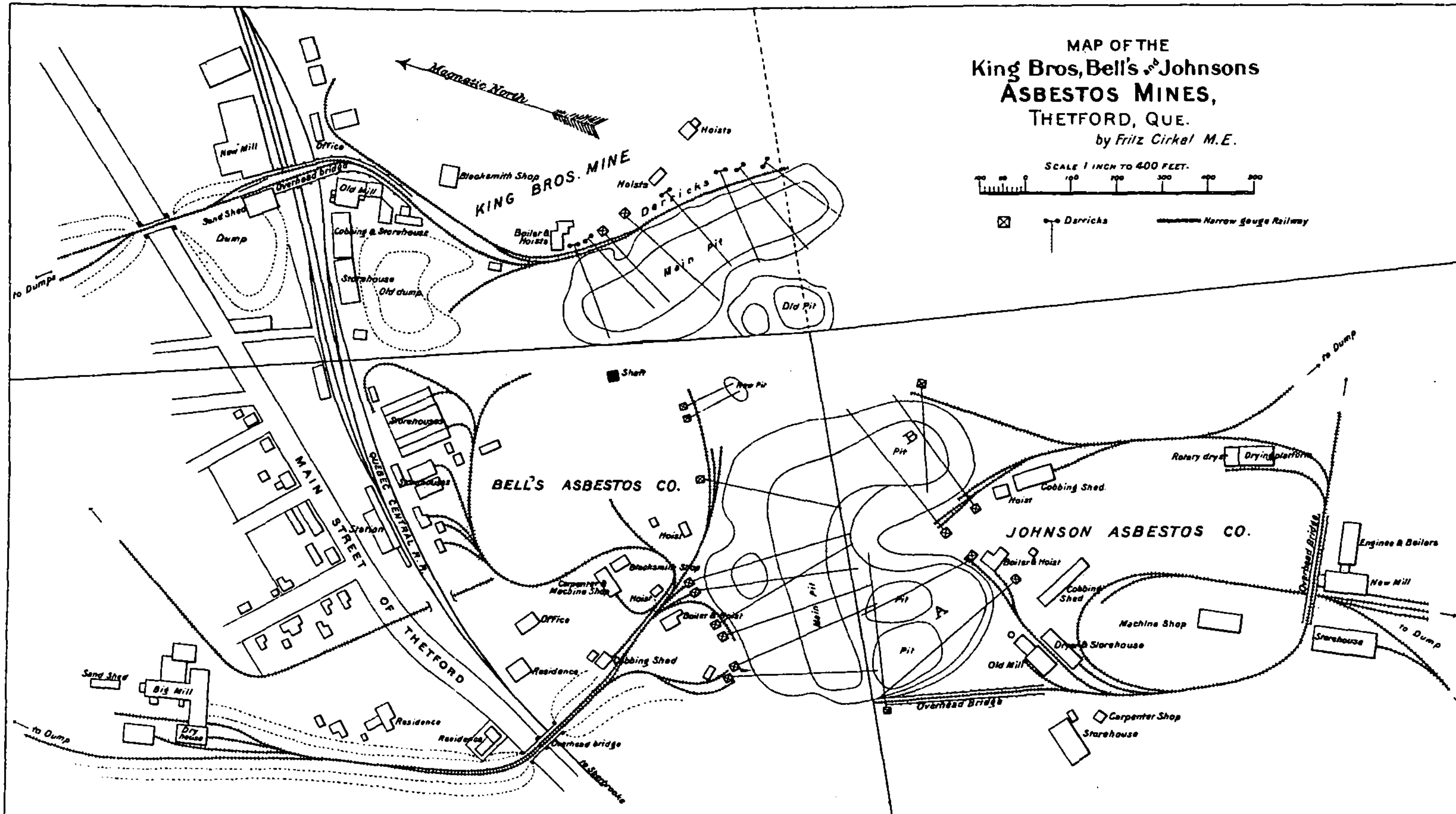


FIG. 8—Section of King Bros' big quarry of Thetford.

width of 200 feet. The height of the benches and stopes varies from five feet in the highest level of the pit to thirty and forty feet in the deepest part, while the length of the terraces varies between 50 and 250 feet.

Fig. 7


MAP OF THE
King Bros, Bell's and Johnsons
ASBESTOS MINES,
THETFORD, QUE.
by Fritz Cirkel M.E.
SCALE 1 INCH TO 400 FEET.
Derricks
Narrow Gauge Railway
Magnetic North
KING BROS. MINE
BELL'S ASBESTOS CO.
JOHNSON ASBESTOS CO.
MAIN STREET OF THETFORD
QUEBEC CENTRAL R.R.
Main Pit
Old Pit
Pit
New Mill
Old Mill
Big Mill
Office
Station
Storehouse
Cobbing Shed
Machine Shop
Carpenter Shop
Overhead Bridge
Residence
to Dump
to Sherbrooke

EXPLOSIVES.

The great bulk of the dynamite used in the asbestos mines contains 40 per cent. nitroglycerine; the cartridges, as a rule, are eight inches long by one and a quarter inches in diameter and are packed in boxes of fifty pounds, containing from eighty-five to ninety-five cartridges. The price is fourteen to fifteen cents per pound.

EFFECT AND COST OF HAND-DRILLING

Hand-drilling is still in use in the smaller mines and prospects, and also for block-holing.

As a rule, three men are employed with one inch octagon steel and six and seven lb. hammers. The average capacity in hard serpentine or granite is from fifteen to eighteen feet per shift and the cost per foot, including explosives, from twenty-four to twenty eight cents. In some of the mines block-holing is done by one man only, using three-quarters inch steel and a three to four lb. short handled hammer. The capacity is from seven to nine feet per day and the cost, including explosives, about twenty cents per foot.

EFFECT AND COST OF MACHINE-DRILLING.

In nearly all the mines machine-drilling is in vogue for the breaking of the rock in situ. The proper placing of the bore holes is a very important factor in obtaining the best results from blasting in asbestos rock. To do this it is necessary that the operator has a thorough knowledge of the position of the strata and the position and trend of cracks and fissures. To obtain this knowledge the intelligent miner examines the rock attentively and carefully ascertains for each blast the position of any joints and fissures in the rock to enable him to form a judgment as to the proper direction to be given to the borehole and the free sides available for the best results, but it happens too often that two miners will have different opinions as to the proper charge of a certain shot. The result frequently is a waste of explosives which sometimes assumes considerable proportions. Where the rock is massive and the walls of the benches to be taken down vertical, the direction of the holes is vertical or nearly so, and when the rock is much fissured, the holes have generally an inclined position according to the largest fissures and the bulk of the rock to be taken down.

When blasting benches with several free sides, the bore-holes are arranged in rows and they are as nearly as possible parallel with the longest free side, so as to obtain the deepest bore hole and thus be able to use the relatively smallest quantity of explosives. In order that the charge may be as fully utilised as possible, due regard is given to the contour of the free sides and the longest line of resistance. The bore boles in this case are generally made vertical, so that the explosion will not have to lift the rock it breaks down, but will allow it to fall by itself and give less work afterwards in removing.

The depth of the holes ranges between eight to ten feet and in the case of exceptionally large faces twelve and fifteen feet. The charges of the drill holes vary of course, according to the position of the latter, quality and quantity of rock, as above outlined, but as a general rule in the course of ordinary work, where the faces are free on one side, from 0.45 to 0.5 pounds of dynamite are used for every foot drilled.

The rock drills in use are mostly of the Ingersoll and Rand types with $3\frac{1}{8}''$ cylinder and a stroke of $6\frac{3}{4}''$.

For block-holing little giant drills are used, the diameter of piston is only $1\frac{7}{8}''$ and the length of the stroke $3\frac{5}{8}''$ and the depth of the holes drilled is from one to two feet.

The steel usually employed is octagonal in shape, $1\frac{1}{8}''$ in diameter for the larger and $\frac{5}{8}''$ for the smaller drills. In drilling, a short steel called the starter is first used and when this has drilled as deep as it will reach a longer piece is substituted for it, this is followed by a still longer piece and this process continued until the desired depth of the hole is reached.

The diameter of the hole at the beginning made by the starter is for the larger machine $2\frac{3}{8}''$ which is gradually reduced by using successively steel of smaller diameter to $1\frac{1}{8}''$ at a depth of ten feet. As a rule two sets of steel are provided for each machine, so that one set may be sharpened while the other is being used. The price per pound of steel is at present from seven to nine cents.

The motive power for actuating rock drills is usually compressed air or steam, but in the employment of the latter there is a large loss from condensation in transmitting steam from boilers to the drills and especially in the usually severe winter seasons all the main pipes require to be covered with insulating material, which entails extra cost.

Compressed air has a great advantage over steam; the loss in transmission is small and consequently the effect in drilling is comparatively high. The effect with steam drills is from forty to forty-five feet per shift of ten hours. The total cost per foot, including power, labour and explosives at present prices of fuel, is from fifteen to eighteen cents, not including, however, wear and tear of machinery and interest on capital involved.

In nearly all the mines the firing of shots is performed by means of electric batteries. There are a few instances where one hole blasts are still in vogue. In support of this practice it is urged that by this system not alone a saving of explosives is effected, but that, also, because the asbestos veins are less liable to be smashed to small fragments and widely scattered, the expense of picking them up is less.

The expense for explosives per ton of rock broken in mines, where the same is of a solid massive character, is about three cents per ton; in mines where the rock is much fissured and shattered, as in the East Broughton mines, the cost is a little less.

As an average each pound of dynamite brings down from 4.25 to 5 tons of rock.

SEPARATION AND REMOVAL OF ROCK AND ORE.

After the firing of shots, the broken material undergoes a hand-sorting process, which is different in every mine, according to the grades to be produced and the ground worked. Where no crude or hand-cobbed fibre is produced all the rock containing fibre, together with the fines scattered all over the pit, is sent to the mill, but in mines where the different qualities of crude are produced the material to be treated comprises:—

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

The material under No. 1 is sent to the cobbing sheds and the material under Nos. 2 and 3 is sent to the mill, the fines first, however, to the dryer.

If the bottom of the quarry is on the same level with the top of the dump, the removal of the debris is simple; the latter is loaded directly into dumping cars or on platforms subsequently placed by means of a small derrick on trucks and then delivered to its destination, but in most cases where deep mining is going on heavy boom and cable derricks are employed.

CONSTRUCTION OF BOOM DERRICKS.

Boom derricks are employed in only a few of the smaller mines or where dumps have to be worked over again. Quarries

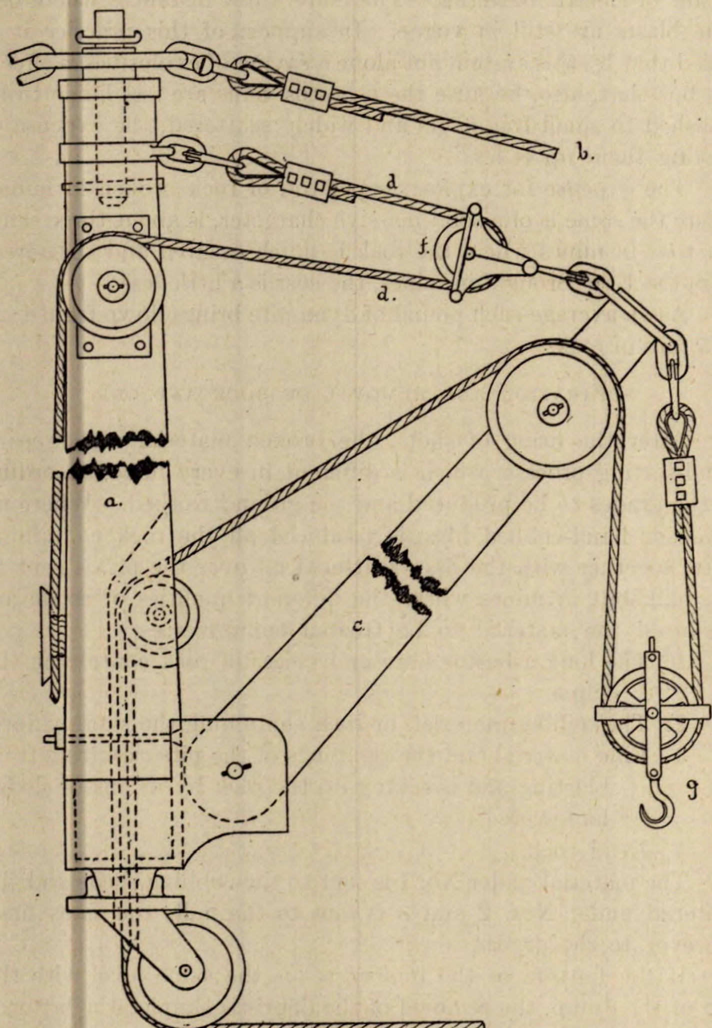


Fig. 9—Boom derrick.

of large dimensions do not admit of the successful general application of boom derricks, on account of their very limited working radius.

A boom derrick (Fig. 9) consists of a mast held in a vertical position by means of guy ropes or legs. To provide for the rotation of the mast about its vertical axis the lower end of it is pivoted into a socket of the fixed bed-plate. A boom or arm is hinged to the foot of the mast immediately above the pivot. The farther end of the boom, which carries the load, is suspended from the top of the mast by ropes, which pass over pulleys to permit the variation of the inclination of the boom to the mast. The length of the boom is from thirty to fifty feet; its working radius is naturally limited and can hardly be extended more than fifty feet.

CONSTRUCTION OF CABLE DERRICKS.

A cable stretched from the top of a well guyed frame or mast to some point across the working pit along which the load is to be transferred constitutes the main feature upon which the cable-

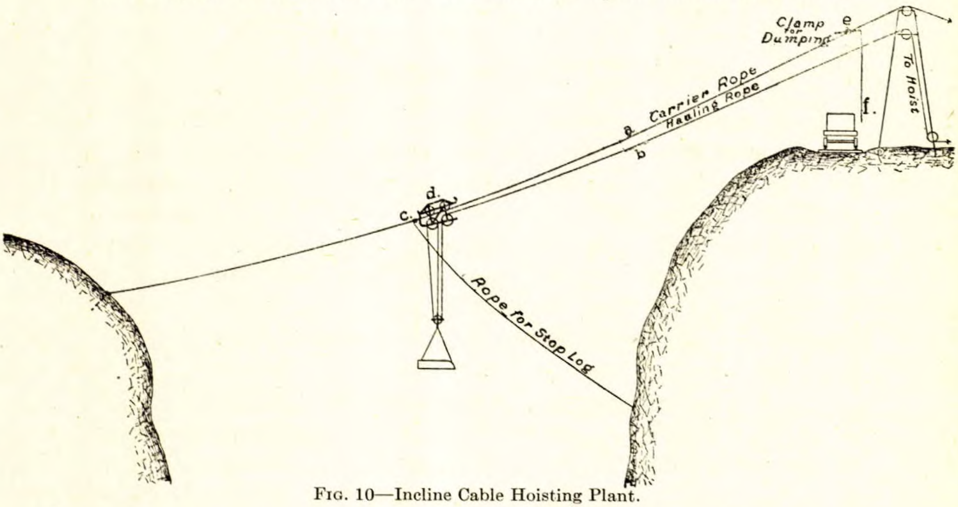


FIG. 10—Incline Cable Hoisting Plant.

derrick is constructed. A carrier suspended from the cable by a system of pulleys travels along the cable and may be arrested, lowered to pick up the load and rehoisted at any point between the limits of the cable. In this manner the load is transported along the cable.

The cables may span a distance of 400 feet, and are made of crucible steel and have a diameter of from one and a half to two inches, depending on the length of the span and load to be carried. The ropes used for hoisting are from $\frac{5}{8}$ to $\frac{3}{4}$ of an inch in diameter.

The cable ways may be either inclined (Fig. 10) or horizontal. (Fig. 11). In the case of the inclined cable ways the carrier is provided usually with one rope: the fall rope, which, however, also serves as a hauling rope. To prevent the carrier moving along the cable when the load is raised it is necessary that the angle of inclination of the cable be at least 30° to render the component of the force of gravity on the load acting down the cable of sufficient intensity to retain the carriage in position until the load arrives at the stop on the cable.

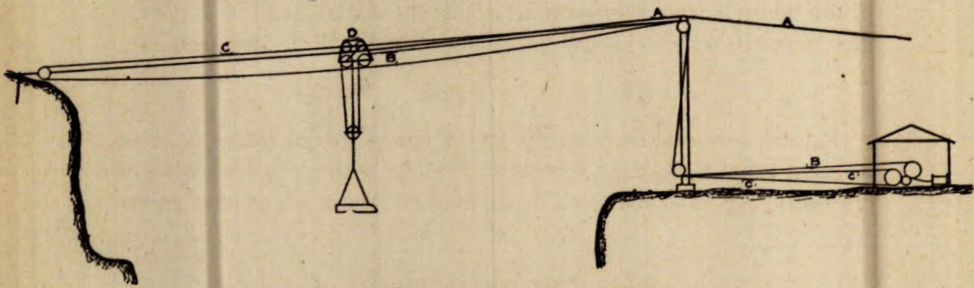


FIG. 11—Horizontal Cable Hoisting Plant.

(a) Carrier rope. (c) Hauling rope.
(b) Lifting rope. (d) Carrier.

On stopping the carriage at any point on its upward journey, the load may be lowered and dumped, after which the carriage returns down the incline to the stop. It is generally necessary however, to provide a bridle or link, (e), pivoted to a wooden clamp on the carrier rope over the dumping point, which link is raised by a cord, (f), and dropped over the hook on the end of the carriage before dumping and afterwards released to allow the carriage to return.

To obtain control of the carriage so that a load may be picked up or lowered at any point on the line, without shifting the stops on the carrier rope, a third rope or extra hauling or tail rope, $\frac{3}{8}$ of an inch in diameter, is required, which is attached to the carriage and is wound in at the same speed as the fall rope after the load has been lifted and by means of which the carriage may be restrained in its movement down the incline on the return trip, or made to stop over any point in its range of travel for loading or unloading purposes.

By making the hauling rope endless, that is, by passing it from the carriage around a separate winding drum on the hoist and around a sheave on the farthest end of the cable way, the latter may be used in a horizontal instead of inclined position. In some mines the inclined and in others the horizontal cable-ways with tail rope are employed. Miners claim in general an advantage for the horizontal over the inclined cable-ways, on account of the ease with which the carriage may be stopped at any desired point from the hoist, while with the inclined cable-way a shifting of the stopping log on the cable rope is necessary.

The support for the cable consists either of a pyramid made of four legs, fitted and bolted securely, or of two legs held in vertical

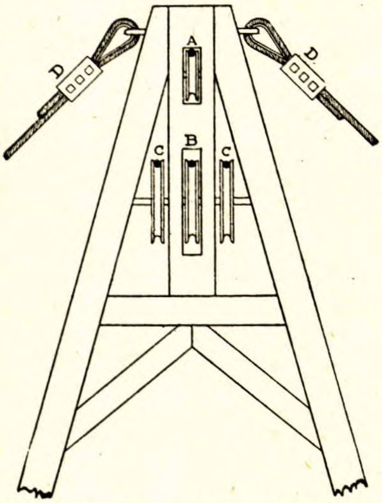


Fig. 12—Two-leg support for Cable Derrick.
(a) Carrier rope. (c) Hauling ropes.
(b) Lifting rope. (d) Guy ropes.

position by $\frac{7}{8}''$ guy ropes constructed in the manner illustrated in (Fig. 12). On the top of these supports are placed also the sheaves for the carrier and haul rope. It is claimed for the pyramid shaped supports that they are more solid and stronger and do not require any guy ropes, while the two leg supports are of simpler construction and can be more easily removed.

Single mast supports have also been noticed in one mine, but they are exceptions to the general rule.

The cable carriage (Fig, 13) is substantially made of wrought iron and is yet comparatively light. The running wheels are of cast iron, have flanges and are provided, as a rule, with anti-friction bearings. The hoisting wheels are also of cast iron and have a diameter of from eighteen to twenty-four inches, in order to reduce the wear on the hoisting rope and to enable the gin block to lower as freely as possible.

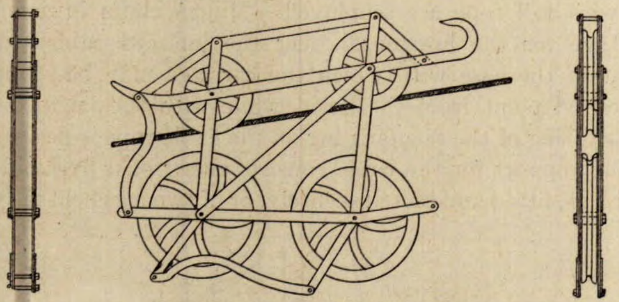


Fig. 13—Carrier for Cable Hoisting.

The boxes for hoisting are made of two inch birch wood and hold between sixteen to twenty cubic feet of rock weighing from 2,200 to 2,500 pounds. The bottom is covered with one-quarter inch steel plate, while in some mines the outside corners are covered

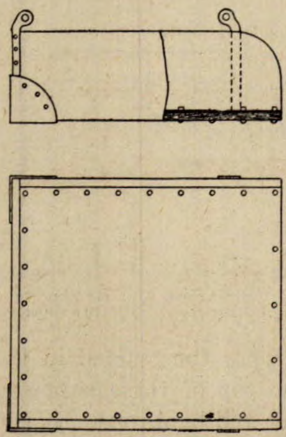


Fig. 14—Construction of Transport Boxes.

and protected by heavy flanges (Fig. 14). It is claimed that a box of above construction in ordinary work does not last longer than from six to eights months. One mine has attempted to use boxes made of iron, but it appears that the experiment was not successful.

The heavy cable is fastened at both ends either to a system of heavy wooden legs loaded with stones (Fig. 15) or to a large iron bar securely fastened in a drill hole in the solid rock.

For the purpose of stretching the cable from time to time a turnbuckle is inserted at one end of the cable in the manner illustrated in Fig. 15.

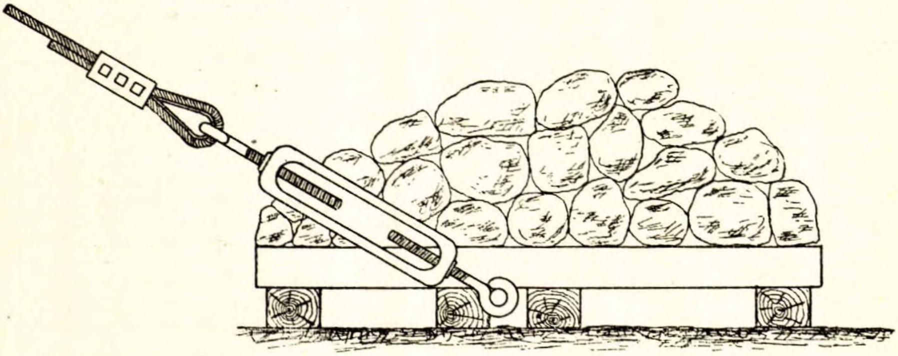


Fig. 15—Anchorage of Carrier Rope.

HOISTING ENGINES.

All hoists used in the district are of the double cylinder type with reversible friction drums.

For boom and inclined cable derricks one drum hoist is sufficient, while cable derricks with tail-ropes require two drums. The newest type of a cable way engine is shown in Fig. 16. This

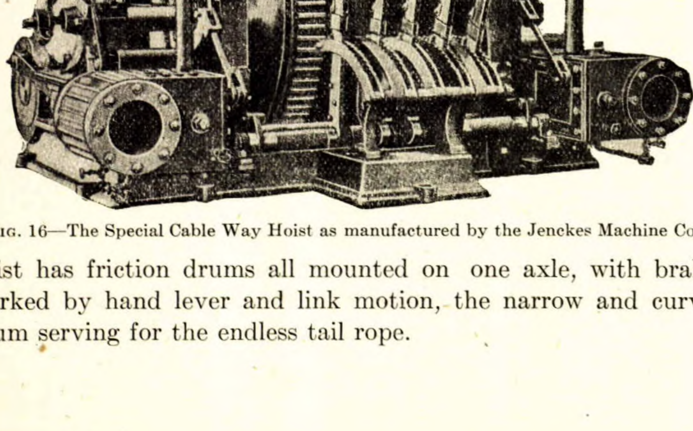


Fig. 16—The Special Cable Way Hoist as manufactured by the Jenckes Machine Co.

hoist has friction drums all mounted on one axle, with brakes worked by hand lever and link motion, the narrow and curved drum serving for the endless tail rope.

This hoist is called the special cable way engine and on account of its simple construction is lower in price than the engines with separate drums and is replacing everywhere the latter. The dimensions and capacities of the different hoists in use as manufactured by the Jenckes Machine Co., Sherbrooke, P.Q., may be seen from the following table:—

Dimensions of cylinders		Horse power	Dimensions of drums		Load which can be raised.
Diam.	Stroke	Diam.	Length		
7	10	20	32	24	2,500 lbs.
8	12	30	36	30	3,500 "
9	12	40	42	30	4,500 "

EFFICIENCY OF HOISTING PLANTS.

The number of tons of rock which can be raised from a quarry by means of a cable derrick depends upon the depth of the pit, the distance to be hauled and the capacity of the machinery. As a rule, however, the distance in nearly all the quarries does not exceed 300 feet, while the greatest depth so far attained is 165 feet. Taking these figures as a basis and assuming the load to be one ton and the capacity of the hoist 40 horse-power, as an average from 250 to 300 tons can be raised in a ten hour shift. It must be understood, however, that a cable derrick is used also for other purposes, as for lifting and shifting heavy pieces of rock in the quarry in order to clear the working face after blasting, and that, as a rule, on account of the work entailed through the separation of the useful from the dead material in the bottom of the pit, a cable derrick is very seldom used to its full capacity. In order, therefore, to provide for a steady supply of ore in all the mines a larger number of cable derricks than the capacities indicate is employed and stationed along the quarries. In illustration of this it may be cited that one mine treating about 300 tons of asbestos rock in the mill and raising for this purpose as an average 500 tons has employed eight cable derricks.

HAULAGE AND DUMPING.

The dumping cars in use are of two classes: those which are hauled by men or by horses and those hauled by power. Dumping cars of the first class consist of a truck and a moveable box, constructed for a guage of twenty-six inches, holding from one-half to one ton.

The box cars for power haulage hold from three to six tons of rock. They are furnished with brakes and such mechanism as will permit the tilting of the box to both sides of the track.

The guage of the latter is forty-two inches. In all the larger mines haulage is being done by small ten and twelve ton locomotives and it is claimed that not only the cost of transport per ton is considerably reduced, but that accidents are very few. The first introduction of these small locomotives was made by Mr. George Smith, in 1895, who used in its construction two cylinders from an old hoisting engine in connection with gearing motion. The experiment was successful from the start and since that time most of the larger mines have been using this class of locomotives. The main advantage of these gearing locomotives is the great ease with which very sharp curves are taken, while their general construction is such as to reduce all repairs to a minimum. It is claimed that in some of the mines each locomotive makes from fifty to sixty miles a day. The diameter of the cylinders is eight inches and stroke ten inches. The engine is fitted with steel frame, saddle tank and steam brake. The price is in the neighborhood of $2,000.

The steel rails employed are of either nineteen pounds (to the yard) for light dumping cars, or forty-five pounds for mechanical haulage.

GENERAL HOISTING AND HAULING ARRANGEMENT AND POSITION OF CABLE DERRICKS.

The position of the cable derricks is determined by the location and number of working points in the pit and changes with the shifting of operations. Where the quarry is of a rectangular shape, all the supports and hoisting engines are, as a rule, placed on one side of the pit, the former usually all in one row near the border of the pit, leaving, however, enough space for the passage of dumping cars. A good illustration of this arrangement is the large quarry of King Bros. at Thetford. (Fig. 7). The derricks employed here are all of the tail rope-type, the cables being stretched nearly parallel at fixed intervals over the pit, while all the hoists, some of them grouped together in one building, are stationed back of the supports.

A similar arrangement is observed at the works of the Asbestos and Asbestic Co., at Danville, where a quarry with a general northeast trend and a length of over 1,000 feet is operated by ten cable derricks, the supports of which are all placed in one line.

In cases where the pits have an irregular shape and curved outline, an effort is generally made to place the hoists and supports on one central spot, from whence all the cable ways are operated.

At the mines of the American Asbestos Co., at Black Lake, for the operation of one large quarry of irregular shape with several working pits a heavy gallow-frame is placed on a central spot, from whence all the pits can be handled simultaneously. The base of the working tower is taken up by an engine house containing three hoists driven by electricity for the operation of the cable derricks.

The tracks for the haulage of dumping cars are generally laid along and close to the borders of the quarries. There are, as a rule, two tracks close to each other, one for the loaded and the other for the empty cars. In some of the mines the tracks are of an ascending grade towards the pit, allowing the loaded cars to descend by gravity for some distance to a shunting yard, where they are sorted and delivered to their destination.

The signalling from the pits to the hoists in shallow workings is effected by shouting. But where the pits are deep and where the operations in them cannot be noticed by the engineer, boys are stationed at points of vantage on the border of the pit, who convey the signals either by electric bells or by means of a galvanized wire to a hammer which strikes a bell, the number of strokes indicating what is required,

Each engineer stationed at a hoisting engine marks the number of box loads he has hoisted during the shift and the summary report of all the hoisting engineers must tally with the number of cars delivered at the different stations, that is, at the cobbing shed, the dryer, the mill and the dumping ground.

COMPRESSED AIR.

In most of the larger mines the motive power for actuating rock drills and hoists is compressed air, generally supplied by straight-line air compressors.

In order to secure uniformity of pressure and to get rid of the water and impurities, the air is led from the compressor into a receiver which is generally supplied with a safety valve, pressure guage and also with a cock for letting off the water which collects gradually.

Where the distance of the pit from the air compressor is very long, over 500 feet, a second receiver is installed about half way for the purpose above indicated. The capacity of an air compressor is generally given in the number of rock drills it can supply; there are 3, 7, 14, and 20 drill air compressors, all of which are employed in the asbestos region, The pressure usually produced for air drills is 80 pounds.

The straight line air compressors mostly in use in the district have the great disadvantage of consuming too much steam. They are superseded now by the duplex steam compound air compressor, manufactured by the Rand Drill Co. and constructed on more economical lines.

DRAINAGE.

Siphons are used for drainage only in one or two cases, where the quarries are shallow and located on the slope of a hill. As a rule, the serpentine rock does not carry much water. Most of the latter comes from the surface and is collected at the deepest point in a sump. A duplex pump of small size is generally stationed at some point of the quarry, well protected against shots, and suffices to keep the water in the sump at bay by being operated only a few hours a day.

CHAPTER III.

THE DRESSING OF ASBESTOS FOR THE MARKET.

Under the term dressing is generally understood the process by which the miner converts his mineral into a saleable article, or by which he extracts a marketable product from it. This process in the case of asbestos is divided into, first, hand-dressing; second, mechanical dressing.

Hand Dressing.

Since mechanical dressing is practised in all the mines, hand dressing is confined to the cobbing of No. I and No. II grades only.

Some mines make only No. I crude, measuring over three-quarters of an inch in length, while in others, besides the above, a No. II grade is made measuring from five-sixteenths to three-quarters of an inch in length.

As already mentioned above, the separation of the useful from the dead material is made in the pits after blasting, the larger pieces of rock being broken up and the fibre gathered up in boxes and sent to the dressing sheds, while the so called fines and stones containing small fibre are sent to the mill for mechanical treatment.

In some of the larger mines the process of handcobbing, as a result of many years' experience, is worked out to great perfection and in the following a description is given of the hand-cobbing process pursued for over fifteen years in one of the principal mines.

There are two cobbing-sheds at this mine: one in which only men and another in which only girls are employed. The men's cobbing-shed receives all rock containing the longer fibre. Small one hand sledge hammers weighing from six to seven pounds are used in breaking up the rock, the longer fibre being screened by a sieve with 3-16″ holes and sent to the girls' cobbing-shed, while the screenings and the rock containing small fibre are delivered to the mill.

In the girls' finishing-shed, which receives besides the products of the men's cobbing-shed also the loose pieces of fibre from the pits, the girls are seated at long tables having underneath a series of compartments for the reception of the Nos. I and II fibre. The hammers used in breaking up the rock and freeing the fibre from the same weigh from 1½ to 2 pounds and the steel plates upon which this work is done are ten to twelve inches square and three-quarters of an inch thick.

In order to get rid of all adhering rock particles, the No. I fibre is cleaned by a sieve with 9-16 inch holes and the No. II fibre by a sieve with ⅜ inch holes. All refuse from the cobbing table and screenings are sent to the mill for mechanical treatment. The crude fibre ready for the market is put up in bags holding 100 lbs.

The cost of cobbing will vary considerably, according to the character of the rock in which the asbestos is found. Some fibre will break off from the rock quite easily, while others will require some labour. Most of the cobbing is done by contract; from 30 to 35 cents per hundred-weight is usually paid. As an average, the cost of cobbing per ton of 2,000 lbs. crude may be put down at from $6.00 to $8.00.

It is not claimed that the process above outlined effects a complete separation of the fibre from the rock, the crude still containing some five and even ten per cent. of rock, but it is the outcome of some fifteen years' experience and has given better results as to extraction and cost than any other known method.

Most of the mines which are working on ground containing little crude do very little handcobbing and extract only No. I, the balance being subjected to mechanical treatment, which accomplishes the extraction of the fibre with a saving of time and labour.

Mechanical Treatment.

HISTORY.

The first company which made any attempt to solve the difficult problem of extracting the mineral from the rock by means of machinery was the Scottish Canadian Asbestos Co. in the year 1889, now owned by the Glasgow and Montreal Asbestos Co., Black Lake. This plant consisted of a 50 h.p. engine, Blake crusher, travelling picking tables, a set of Cornish rolls, revolving screens, elevators, shakers and two large blowers. In 1890, Mr. R. T. Hopper, managing director of the Anglo-Canadian Asbestos Co. of Black Lake,—experimented with the ore in as mall mill, consisting of a Blake crusher, rolls, shaking screens and a fan and succeeded in producing a fibre of marketable quality. In 1890 and 1891 the American Asbestos Co.—now the Union Asbestos Co. of Black Lake, started to experiment with the ore. The main object of this company was to do away with the somewhat indistinguishable No. III grade. This was, however, difficult to realise, unless the fibre could be thoroughly loosened and freed from the rock. The method adopted was as follows: The rock went first through a Blake crusher and fell on an inclined shaking screen, which separated all the loose fibre and dust from the larger pieces of the asbestos rock, the fibre going directly to a cleaning and grading machine, while the asbestos rock dropped on a revolving picking table. Here the barren rock was separated from the asbestos rock by hand. The latter was then dried in dry kilns and sent to the fine roll crushers.

The crushed material went over cleaning and grading machines which consisted of a set of inclined sieves in rapid shaking motion in connection with blowers, fans, etc., the remaining unbroken stone and fibre going again through a set of still finer rolls.

The results obtained in this mill were not satisfactory, as the fibre so produced still contained a very large amount of rock particles and dust.

King Bros., at Thetford, were the next to introduce machinery for the purpose of extracting small fibre from large pieces of rock in the dumps, which in the beginning of the industry did not warrant the expenditure for block holing and further handling.

The plant consisted of a Blake crusher, from which the material was conveyed to a set of Cornish rolls; a revolving screen then cleaned the fibre from dust; but this object was not fully accomplished owing to the failure of the rolls to crush up the rock sufficiently. An additional blowing and screening apparatus was installed, which gave better satisfaction.

In 1893 the writer treated about ten carloads of asbestos rock, containing small fibre, from the Templeton Asbestos Mining Co., which was operating at that time the asbestos mines in Perkins Mills to the north of Ottawa. The mill used for that purpose was located at Buckingham and had been employed before for grinding and screening phosphate rock. It consisted of a system of Blake crushers, Cornish rolls, a pulverizer and screens, and after many changes, especially in the screening devices, the method worked satisfactorily in so far as the liberation of the ore from the rock was concerned, but a complete extraction of the fibre was not effected, owing to the lack of the necessary suction apparatus. When the latter was about to be installed, the mines shut down and the experiments, necessarily, were discontinued.

All the experiments carried on in the above mills conclusively demonstrated the great difficulty in freeing the fibre entirely from the dust and adhering rock particles. Owing, therefore, to the imperfect quality of the fibre so produced, the unwillingness of the manufacturers to buy prepared fibre at that time and also owing to the trouble with the customs authorities of the foreign countries, who considered the fibred asbestos as a manufactured article and levied a duty of 25% ad valorem, the mechanical preparation appeared to come to a standstill.

In 1892, 1893 and 1894 several large shipments of prepared asbestos were made and although the quality was not up to the expectations of the manufacturers, still some of the latter realized the immense importance of the new innovation, having for its object the saving of the freight charges by the elimination of the rock in the different qualities of crude, which, in some cases, amounted to from about 15% to 20% of the total weight. On the other hand, it was of the utmost importance for the mine owners to succeed in the mechanical separation, since the large dumps resulting from the earlier operations contained a very large amount of short fibre and did not warrant the expenditure for extracting by handcobbing and would represent a valuable asset when the mechanical process of separation of the fibre became a success.

The Bell Asbestos Co., under the management of Mr. George Smith, commenced to experiment with the mineral in 1893 and the result was that a mill was built in the following year, treating small quantites of asbestos rock with success. Other mines followed and shipments of fiberized material commenced in earnest in 1895 and 1896 and from that year on the process of extraction has been steadily improved. Mills of large capacity were built; the percentage of crude became insignificant compared with the large output of the fiberized article and to-day every mine of importance is equipped with a complete milling and fiberizing plant.

On account of the success of the mechanical treatment of the ore in extracting all the fibre in the rock, the life of an asbestos mine compared with that of some ten or fifteen years ago, is much prolonged; its operation is attended with less difficulties and mines working on poorer ground, which had been obliged to shut down, were enabled to resume operations.

APPARATUS USED IN THE SEPARATION OF ASBESTOS.

Before entering into a description of the different milling plants and methods in use, it is necessary, in order to fully understand, the working principles of the same, to describe the different classes of apparatus which, according to experience have given the best results in the mechanical separation.

DRYING OF THE FINES.

The fines coming from the pits and cobbing sheds contain a great deal of moisture and before this material can be subjected to further treatment, it must be thoroughly dried. Drying is performed in the district in the following ways:—

1. By exposure to the air.
2. By means of steam pipes.
3. By rotary dryers.

1st.—Drying by exposure to the air: The material is spread over a large wooden platform in a layer two to three inches in thickness, as at the Johnson mine in Thetford. If the weather is favourable a sufficient amount of moisture evaporates naturally to render the mineral fit for treatment by the different processes of crushing and blowing, but a wet season interferes with the work, while drying by this process during the winter is impossible. This method is unstable and unreliable and, for this reason, its application is very limited.

2nd.—Drying by steam pipes: A number of one and a half or two inch steam pipes are arranged parallel to each other and close together on the floor of a shed, joined at ends to form a continuous length, one end terminating in a pipe of larger dimensions, connected with the exhaust of some steam engine, the other end leading into the open. The Bell Asbestos Co. have thus covered nearly the entire floor of a large shed 40 by 60 feet with one and a half inch steam pipes. A track runs through the middle of the shed, allowing the fines to be unloaded at any point desired. All dried material is shovelled into an elevator placed at a convenient point in the centre of the shed, which delivers the same through a shute to the crusher of the mill. The whole effective drying space is approximately 2,000 square feet and it is claimed that from forty to sixty tons can be dried in twenty-four hours; the labour required is two men. The advantages of this simple method may be summarized as follows:

1. No power is required.
2. No extra fuel for drying.
3. There are hardly any repairs.
4. Danger from fire is eliminated.

3rd.—Rotary Dryer: The rotary dryer as illustrated in Fig. 26 and Plate VII, consists of a long cylinder made of strong boiler plate, resting and turning on its ends on friction rollers; in order to allow the shell to expand and at the same time to prevent it from sliding, these friction rollers are flat at the upper end and grooved at the lower end of the cylinder. The length of the shell is from thirty to forty feet, the diameter from two and a half to four feet and its inclination 7°. The whole is bricked in, leaving only the ends of the cylinder with the friction rollers outside. The space between the arch and the cylinder is six inches.

The drying is assisted by longitudinal blades, which lift the material and allow the same to fall through the current of hot air which circulates through the cylinder. The fire is either placed directly under the shell or, in an extra brick case, at the side, on the lower end of the cylinder, allowing the heated air to play round the shell and escape through a chimney placed at the other end of the dryer.

Sometimes fires are made at both ends, the chimney in this case being placed in the middle of the apparatus. The cylinder is made to revolve from six to eight revolutions per minute. The ore, which is charged by hand or by automatic arrangement, travels along slowly, is stirred up by the inside blades and, as a rule, discharges into the elevator for the ore bin. The capacity of this rotary dryer ranges from fifty to seventy-five tons per shift, according to size and the contents of moisture in the material. The cylinder is kept in motion either by an endless chain round the lower end or by gearing transmission, as illustrated in Plate VII.

The main advantage of a rotary dryer over all other drying methods is its continuous operation and the handling of a large quantity of ore in a comparatively short time. However, it has its faults also, the principal one being the necessity of frequent repairs caused by the bulging and twisting of the boiler plates.

Where the charging is done automatically, one man is sufficient to attend to the whole apparatus, otherwise, two men are needed. The expense for fuel per shift for a dryer of the dimensions represented in Fig. 26 is about $3.50 on a basis of $2.00 per cord of soft wood and $3.00 per cord of hard wood.

ROCK BREAKERS.

The rock breakers employed in the district are of two classes:

1. The jaw breakers which are intermittent machines.
2. The rotary and the spindle or gyrating breakers, which are continuous machines.

Jaw Breakers.

The first crusher through which the rock has to pass is invariably a jaw crusher of large size. This is a machine for reducing rock preparatory to fine crushing by rolls. It is durable and simple to operate. The rock is crushed between jaws, one stationary, the other swinging and driven by a powerful toggle movement.

The adjustment of the jaws and the size of the rock leaving the crusher is determined by the character of the apparatus used in subsequent treatment. One rock crusher alone may be used to prepare the rock for the rolls, gyratory or rotary crushers, but for a larger capacity it is preferable to use two sizes with a screen between, the second crusher relieving the subsequent apparatus of a great deal of work.

Since the large size and the irregularity of the feed-rock generally does not admit of automatic feeding, the jaw-breakers are fed by hand and shovel; in many cases by a shute, sloping from the bottom of a bin, the attendant pulling forward the ore in the chute with a rake or pick.

The jaw breakers may be divided into two different types, according to the movement of the jaws:—

1st.—Those which are pivoted above, giving the lower part of the jaw the greatest movement.

2nd.—Those which are pivoted below, giving the upper part of the jaw the greatest movement.

To the former class belong the Blake crushers, to the latter the Dodge crusher.

The movement of the lower part of the jaw is greater in the Blake crusher and the result is that a product of various sizes must drop from the machine, whereas in the Dodge crusher the movement is greater at the top of the jaw, the lower part remaining nearly stationary and the product leaving the machine must be of nearly uniform size, determined by the distance the jaws are set apart. This explains the higher capacity of the Blake, while the Dodge crusher delivers more fines and a more uniform product.

The jaw crushers are manufactured in many sizes; those most in use in the district have openings varying from 16x10 inches to 30x15 inches. The capacity for each size varies according to the product desired.

Rotary Crusher.

The rotary crusher has found its way recently into all new mills and is usually fed with the product from the jaw breakers. The manufacturers, the Sturtevant Co., of Boston, Mass., claim that its capacity is higher than other similar machines, but this statement must be taken with reserve, as no comparative tests under equal conditions have so far been made in the asbestos district.

A section of the machine, as manufactured by this Company, is shown in Fig. 17.

Description.—The vertical shaft (1) carrying the driving gear

(3) runs in a large oil pot bearing (10) thoroughly protected from dust. The crushing cone (21) is supported from the top by large ball bearings which promote easy running and durability. This cone is raised or lowered by a screw (26) from the top and the range of adjustment for wear or to size output is large.

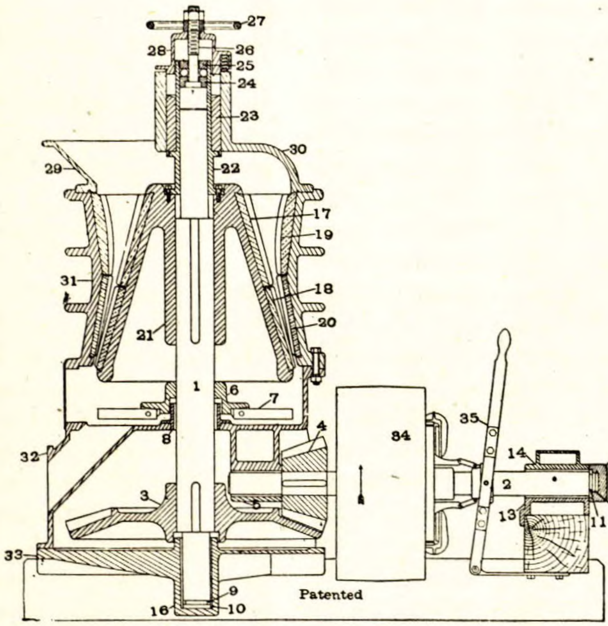


FIG. 17—Rotary Crusher as manufactured by the Sturtevant Co. of Boston.

The scrapers (17, 18, 19 and 20) require no change except replacement for wear and are conveniently reached without dismantling the machine. Having no fly-wheel, this crusher is not subjected to fly-wheel shocks in case of sudden stoppage. The machine is made in three sizes, of which size No. 2 with a hopper opening of 20 x 30 inches is the one mostly in use. The capacity of this size is from eight to twelve tons per hour; the horse power required is from fifteen to twenty and the revolutions per minute 250.

The rotary crusher manufactured by Butterworth and Lowe, Grand Rapids, Mich., is a heavy machine of the coffee mill type and consists of two parts (Fig. 18), an upper part, *A*, for coarse crushing and a lower part, *B*, for fine crushing. All the crushing surfaces are of hard chilled iron. This apparatus will receive rock up to ten inches in diameter and reduce it to an average size of kernels of corn. Its capacity is from seven to thirteen tons per hour and the horse power required from eight to eleven. Mill men

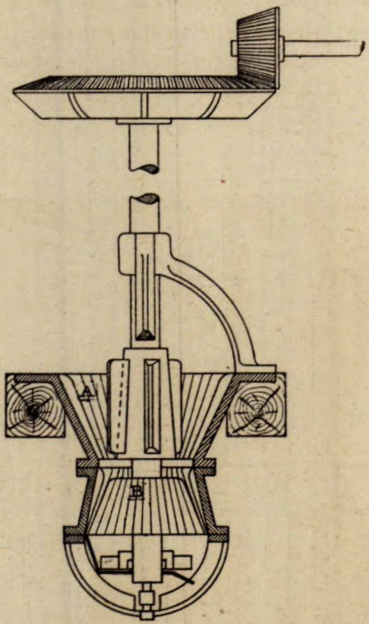


FIG. 18—Rotary Crusher as manufactured by Butterworth & Lowe, Grand Rapids, Mich.

claim that this apparatus, on account of its compact and heavy construction—its weight being 5,300 pounds—gives little trouble; is very efficient and is specially adapted for asbestos rock.

The Spindle or Gyrating Breakers.

Among these are several types, but the most common form, which is used in the district, is the Gates type (Fig. 19). It consists of a bottom plate; (1) a bottom shell, (2) including a chute (32) for the crushed ore; a top shell; (3) a two armed spider, (6) furnishing the bearing for spindle (25). This spindle can be raised or lowered by a screw (24) in the bottom plate. The lower end of this spindle is a journal and finds a bearing in the eccentric hub, firmly attached to bevel gear (9). While the interior surface of the hub is an eccentric bearing for the spindle journal, the exterior surface is a journal, which is concentric with the gear and finds its bearing in the bottom plate. When the bevel wheel revolves, the spindle is free to gyrate or rotate in the eccentric (8). Practically it rotates until ore is fed between the crushing surface (18 and 19), it then gyrates.

The gyrating motion causes the head (18) to approach and recede from the concaves (19) and owing to the fact that the spindle acts as a lever with one end in the spider, it will cause a greater movement at the lower end than at its upper end, and produces a crushing action by pressure upon the lumps of rock.

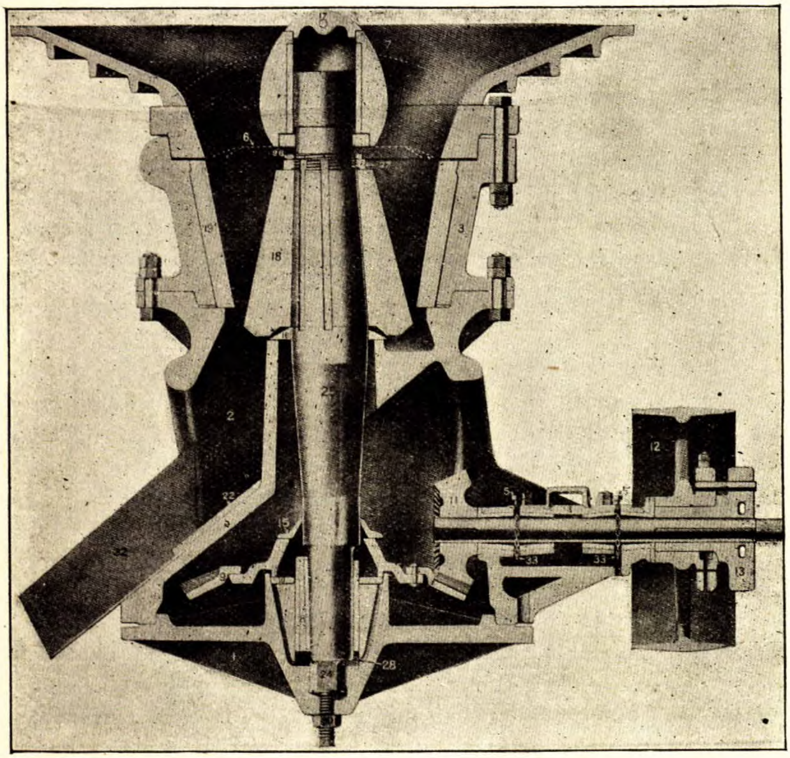


FIG. 19—Gates Crusher as Manufactured by the Allis-Chambers Co., Chicago, Ill.

The angle of gyration varies a little, requiring a small amount of play in the upper and lower journals. The total vertical movement of the spindle is $3\frac{1}{2}$ inches in the larger breakers and 2 inches in the smaller ones.

The larger lumps as broken fall a short distance to a fresh bearing, to be broken again by the next act of compression, and this is repeated until they are broken fine enough to pass between the concaves and the head at the narrowest point. The ore then passes out over the chute.

The Gates crusher is made in five sizes, the smallest one having a receiving opening of 8 x 30 inches, the largest one 21 x 76 inches. However, the two sizes chiefly in use in the district have openings of 8 x 30 inches and 10 x 38 inches, with respective capacities of 15 to 40 tons of rock per hour, according to the product desired. The number of revolutions of the driving pulleys is from 350 to 400 per minute and the power required from 15 to 25 horse power.

FINAL CRUSHING.

The machines for final crushing receive the ore from the rock breakers and the rotary and gyrating crushers and are suitable for separating the fibre from the waste preparatory to the separation by exhaust fans. They act on the principle of crushing by direct pressure, as in the rolls, or by centrifugal force as in the fiberizers and cyclones.

Rolls.

The chief parts which enter into the construction of a pair of rolls, are a pair of shafts upon which are usually mounted permanent cores of soft cast-iron, carrying shells of rolled steel or chilled iron, which constitute the crushing surfaces; one shaft revolves in fixed, the other in moveable boxes.

In some rolls the shells are made of manganese steel, which has an extraordinary hardness and toughness and which lasts much longer than those made of ordinary steel or chilled iron.

The shaft in the moveable boxes is held towards the fixed boxes by powerful springs, the degree of approach being regulated generally by compression bolts. The space between the rolls varies from practically nothing up to three-quarters of an inch. The relation between the diameter of the ore fed and the space between the rolls, that is to say, the amount of reduction, is most important, if the rolls are to do their work. In some mills the ore is fed in nut size, in others in much smaller lumps and the spaces between the rolls are adjusted accordingly.

Some rolls receive the ore from the breakers, others from a rotary or gyrating crusher and others again from a first pair of rolls. They are, however, rarely fed with lumps larger than one and three-quarters of an inch in diameter, generally with an admixture of fine grains. In taking the rock for the rolls from a breaker or other apparatus, the supply of ore is regulated and the output is limited, but it often happens that a sudden rush of ore will choke the rolls and, unless they are supplied with an extraordinary amount of power and strength—which is generally not the case—they will break, especially those which are driven by gearing motion and pulleys.

To avoid this trouble, in some mills, feeders are used, kept constantly full of material, which is fed to the rolls by an oscillating gate. Small scrapers are also used in several cases to remove the adhering fines from the face of the rolls at the lowest point in their revolution.

There are two designs for the driving mechanism of rolls: one is the gearing motion, the other the belt motion. In the gearing mechanism one roll is connected by finger gears on one side, while the other is being driven by pinion gears on the other side; where the rolls are driven by belts each roll is driven by a large pulley. These pulleys are driven, either by one open and one crossed belt from the same shaft, or by two open belts from separate shafts running in opposite directions. Where a crossed belt is used, it always drives the moveable roll.

Some mill men prefer corrugated rolls. It is claimed that the corrugated surfaces produce a sort of grinding action, thus crushing the rock finer and liberating more fibre. However, opinion amongst mill men differs on this point. In some mills corrugated rolls have been installed and worked for some time, but they were subsequently replaced for some reason or another by those with flat surfaces.

Crushing rolls are made in five sizes, from 12 x 10 inch to 36 x 18 inch rolls. The minimum and maximum capacities are one and eight tons, respectively, per hour, according to the desired product, and the horse power required, from five to twenty. All rolls make from 125 to 150 revolutions per minute.

FIBERIZERS.

The machinery so far described has for its main object the liberation of the asbestos fibre from the rock by repeated crushing but in order to make the mineral more amenable to the exhaust and pneumatic process—which will be dealt with presently—it is necessary that the coarse fibre or stone asbestos, which for the most part leaves all the previous apparatus in the form of small lumps, be divided and split into fine fibre of feather-like weight and appearance.

This operation and the work of crushing still finer the small lumps coming from the crushing apparatus, is performed in so called fiberizers, of which there are two kinds in use, the cylindrical beaters and the cyclones.

Beaters.

The chief parts which enter into the construction of a beater (Fig. 20) are a shaft, (a), on which are fastened the beaters or arms, (b), in the manner illustrated, and a trommel or shell, (c), made of strong boiler plate and usually covered with 1½ inch wood screwed to the shell. The arms carry teeth or knives, which, when revolving very fast, cause not only the lumps to be crushed and the liberated asbestos fiberized, but also alternately cause the mineral to travel outwards and inwards. Thus the mineral

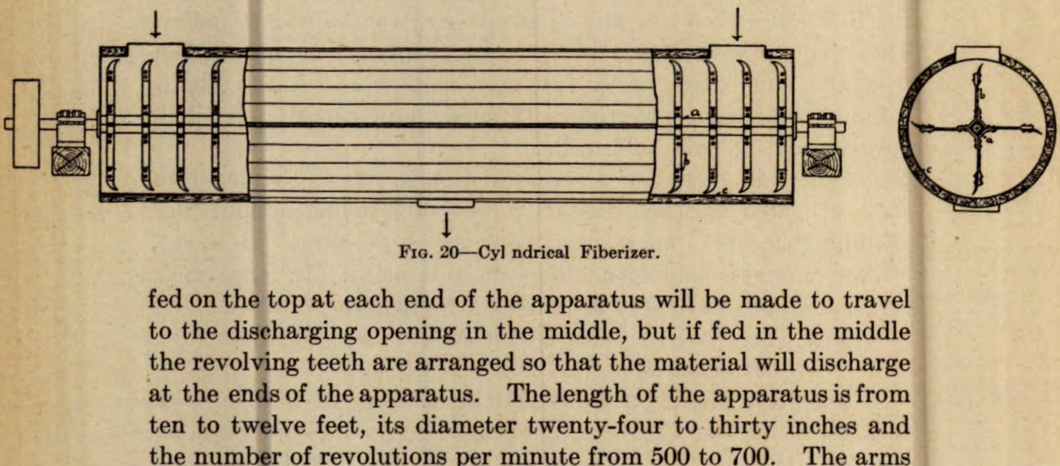


Fig. 20—Cyl ndrical Fiberizer.

fed on the top at each end of the apparatus will be made to travel to the discharging opening in the middle, but if fed in the middle the revolving teeth are arranged so that the material will discharge at the ends of the apparatus. The length of the apparatus is from ten to twelve feet, its diameter twenty-four to thirty inches and the number of revolutions per minute from 500 to 700. The arms on the shaft are, as a rule, six inches apart.

In some mills there are double fiberizers in operation; instead of one, there are two parallel shafts in the shell, the arms being arranged in the same fashion as in the single fiberizer, but revolving in opposite direction.

Cyclones.

The cyclone machine is used now in almost every mill and forms one of the integral parts of asbestos separation. When this apparatus was first introduced, its working principle was not well understood and appreciated. It had also faults in the construction, but experience soon brought forward essential improvements and the result is, that we have to-day a fiberizer without which the efficiency of the mills would be considerably reduced. It is known that the cyclone by its violent action tears up a part of the fibre, but as long as there is no other apparatus which will do the work better, the cyclone will stay and will be one of the chief appliances in asbestos separation.

This apparatus is simple in construction: It consists of two beaters, A, (Fig. 21) of the screw propeller type, driven at a speed

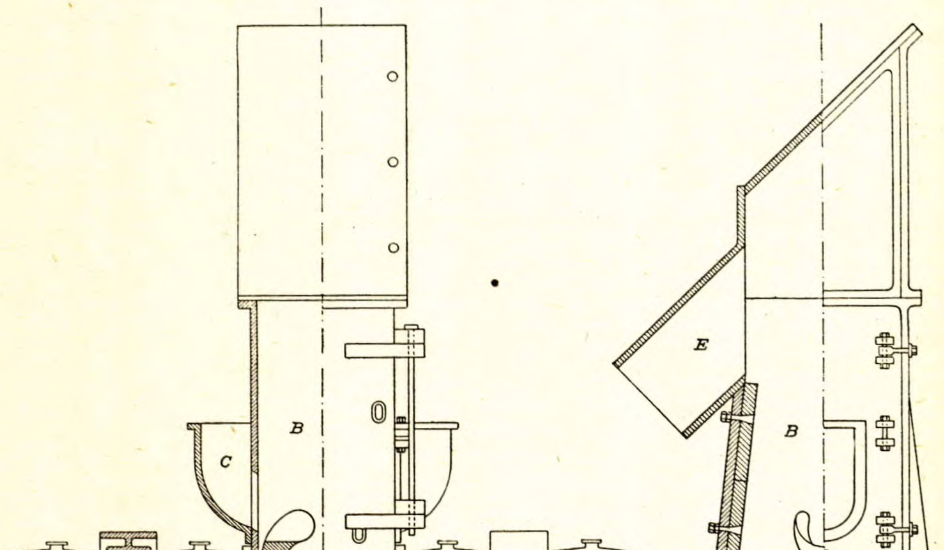


FIG. 21—Cyclone Fiberizer as manufactured by the Laurie Engine Co., Montreal.

of 2,000 to 2,500 revolutions per minute in opposite directions in a cast iron chamber or case, B. The material is regularly fed through the feed holes, C, and the whirlwind created by the beaters hurls the particles against each other with such violence that they are almost instantly reduced to fine grains, or even to impalpable powder

A fan connected with the apparatus causes a suction in the interior, air being supplied through the little vent holes, D, and all material reduced to about peanut size and smaller, is thrown out through the discharge p'pe, E. As a rule, the discharged material falls on a shaking screen, and the latter is placed together with the discharge pipe in an air-tight box, connected with an exhaust fan.

The blades are made generally of chilled iron; they wear out very rapidly and have to be replaced every ten or fourteen days, according to usage and quality.

The capacity of a cyclone depends upon the condition of the rock, the average size of rock charged and the product desired. In mills, where the rock is hard and tough, only from twenty-five to thirty tons can be put through in a ten hour shift. In others

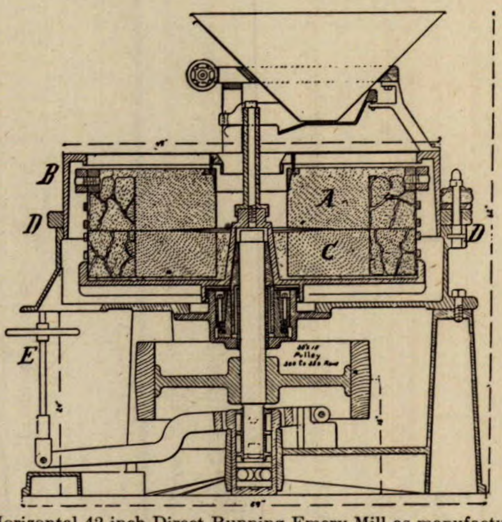


Fig. 22—Horizontal 42 inch Direct Running Emery Mill as manufactured by the Sturtevant Co., Boston, Mass.

from forty to fifty and even sixty tons can be treated. As a rule the size of the rock charged is not larger than a walnut, while the bulk of the discharge is about peanut size.

PULVERIZERS.

In some mills the tailings are ground to a very fine powder, used for plastering, in so-called Emery mills, manufactured by the Sturtevant Milling Co., of Boston, Mass. These mills, as illustrated in Fig. 22, are made either with horizontal or with vertical stones. In the horizontal Emery mill the bedstone *A* is bolted strongly to the top case *B* and is lowered with it directly upon the runner stone *C*, with which it is then in perfect adjustment. The clamp-ring *D* is then tightened and grasps the bedstone case, firmly holding it and its stone immovably in position. The runner can now be lowered away from the bedstone by the hand wheel *E* to such a distance as gives the fineness of grinding required. This simple and accurate adjustment of the mill stones is of special value, since it insures good results with ordinary help. The stone makes from 300 to 350 revolutions per minute; the capacity of a 42 inch mill is from one to three tons per hour and the approximate horse power required is eighteen.

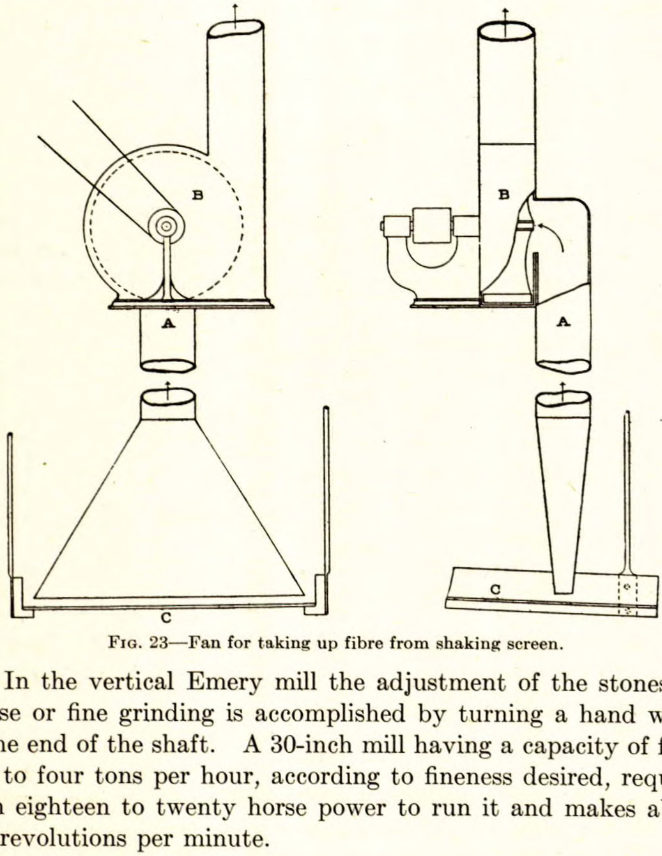


FIG. 23—Fan for taking up fibre from shaking screen.

In the vertical Emery mill the adjustment of the stones for coarse or fine grinding is accomplished by turning a hand wheel at the end of the shaft. A 30-inch mill having a capacity of from two to four tons per hour, according to fineness desired, requires from eighteen to twenty horse power to run it and makes about 650 revolutions per minute.

FANS.

All fibreized asbestos is taken up from the screens by suction fans and is blown into collectors or settling chambers.

For this purpose the suction pipe *A* (Fig. 23) of fan *B* ends in a flattened attachment which tapers in one direction from a diameter of twelve inches of the pipe *A* to six inches and widening in a direction perpendicular to the former to the width of the shaking screen *C*. The fans are made of heavy galvanized iron, are thirty, thirty-five and forty inches in diameter and make from 1,800 to 2,200 revolutions per minute. In all the mills there is so much floating dust that extra fans are needed to remove the same.

ACCESSORIES FOR MILLS.

Screens.—There are two kinds of screens in use: flat and cylindrical. Both are made of wire or perforated galvanized iron. The oscillating movement of the shaking screens is generally caused by eccentrics, the wooden frames being supported from suspending rods. The screens are used in all sizes, from 3 x 6 feet up to 6 x 12 feet. The number of pulsations varies in the mills from 200 up to 300 per minute. Apart from the sizing of the rock and the elimination of the sand, the principal purpose of the shakers is the complete separation of the fiberized asbestos from the rock after it has passed the crushing machines and beaters, the oscillating movement causes the fiberized material in its downward course to come on top of the rock, thus allowing the fans to suck up the fibre and place the same in collectors or depositing chambers.

The revolving screens are nearly everywhere used for the grading of the fibre only. They have arms moving in opposite directions, mounted on a double shaft, for the purpose of loosening up the fibre in order to effect a better separation through the different meshes, of which the wire cloth is composed.

Conveyors.—The conveyors used in the mills are all of the endless belt or chain type, which move the product to be conveyed forward. The belt conveyor consist of an endless belt, generally a rubber belt, running on two pulleys or drums, with intermediate supporting rollers. They are extensively in use now for the transport of the tailings from the mills and as continuous picking tables. Bucket elevators, consisting of a series of steel buckets hung on trunnions between two parallel link belts, are mostly used between dryer and crushers and fiberizing machines to deliver the product from one apparatus to the other.

Collectors and Settling Chambers.—The asbestos fibre is blown by fans into collectors or settling chambers. The construction of a collector is shown in Fig. 24. The fibre enters the upper part of the collector through A, the dust escaping through an inverted chimney B and the fibre falling through discharge tube C on a conveyor or into a grading revolving screen. The collectors are generally made of galvanized iron in sizes ranging from three and a half feet to six feet in diameter. As a rule every collector receives the product of one screen, the larger collectors sometimes from two screens. The settling chamber consists of a room with a longitudinal hopper, at the bottom of which is installed a conveyor (Fig. 25). The fibre enters through the pipes A on the sides of the chamber and falls on the conveyor B, the dust escaping through the vent holes C.

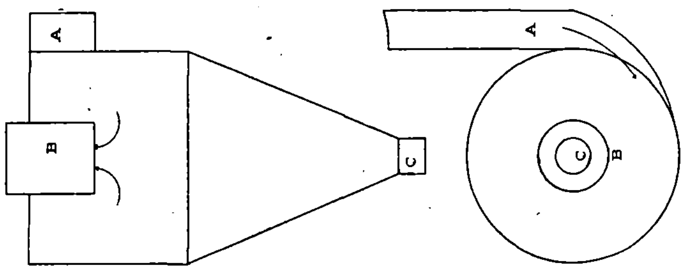


FIG. 24—Collector.

All collectors and settling chambers are generally placed near the roof. In some mills the dust emanating from the collectors, on account of its contents of very fine short fibre, is collected in large receptacles placed under the roof of the mill building and is used in connection with the manufacture of finishing plaster.

Ore Bins.—The varying production of ore in the mines calls for receiving bins large enough to serve for storage when the mine is producing more than the mill can treat and thus provide ore for the mill when none is received. At most of the mines mining is done only for one shift while milling is going on for two shifts. A common rule for the size of bins is that they shall hold at least the output of the mining operations for two shifts, although they are often of much larger capacity. Intermediate bins are used in some mills to act as reservoirs, so that a temporary stoppage of one part of the mill shall not necessitate the stoppage of the parts preceding and following.

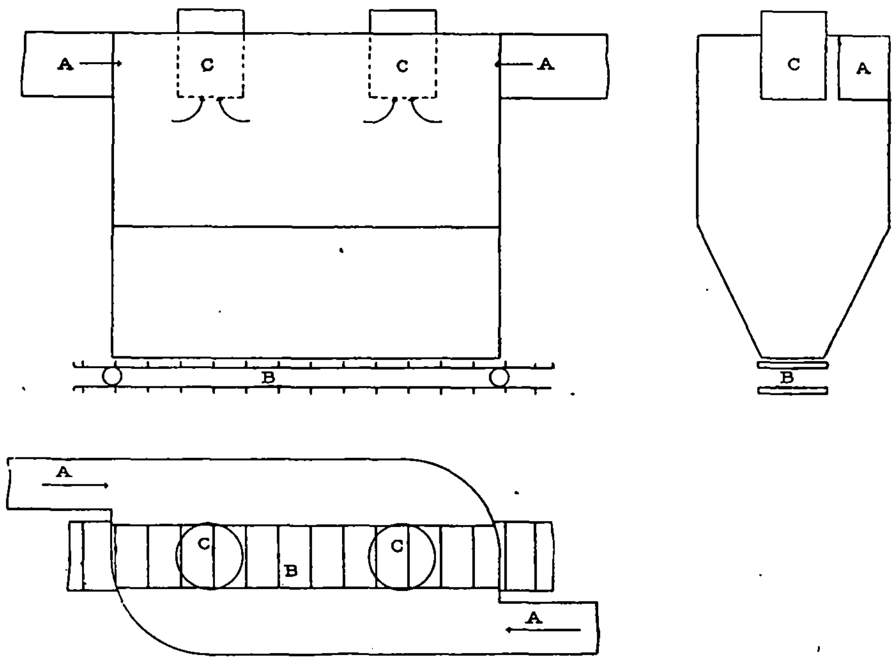


FIG. 25—Collecting and settling chamber.

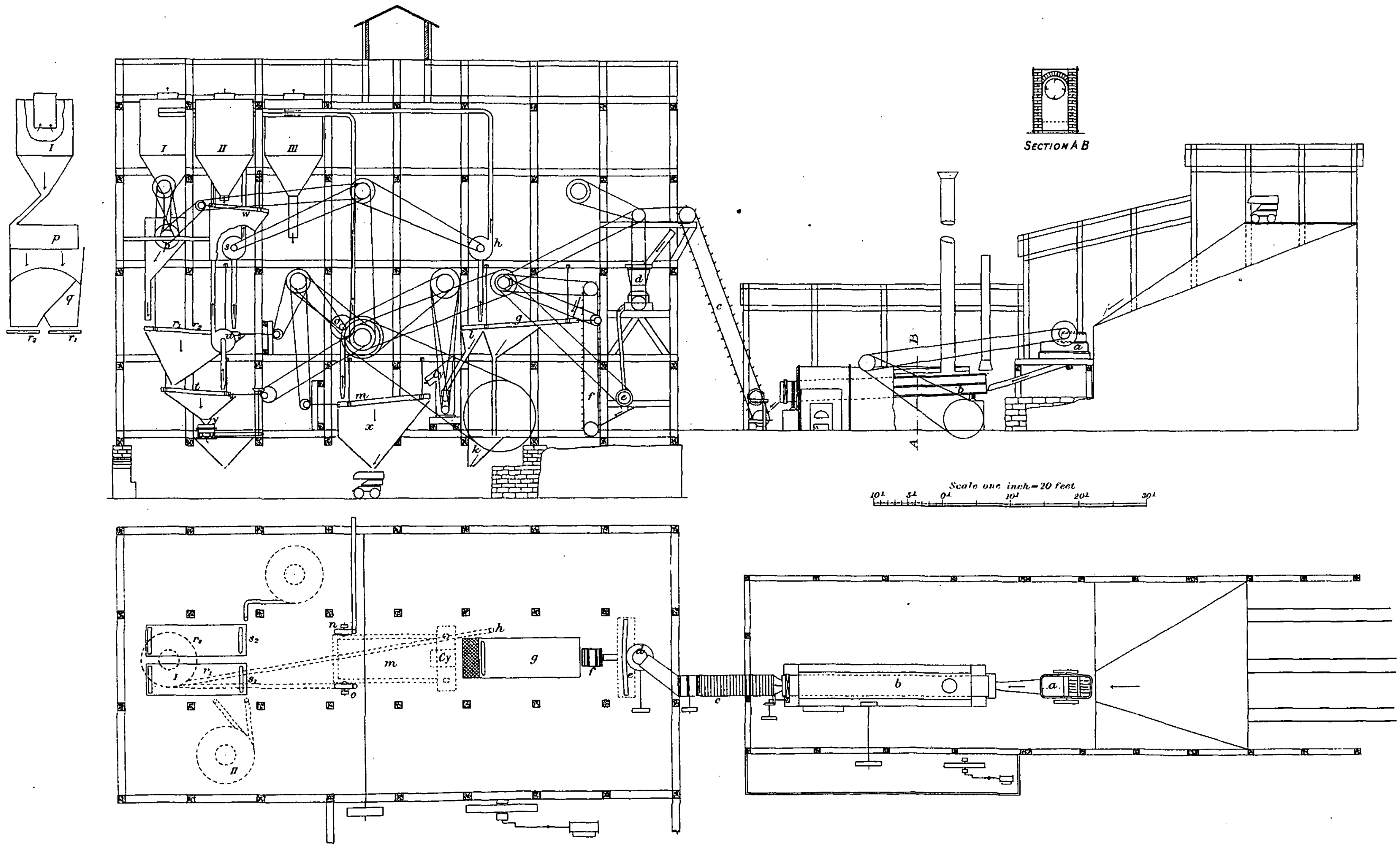
Summary of Principles in the Separation of Asbestos.

Having described individually the various kinds of apparatus which find application in the asbestos mills, there remains now the consideration of the mill as a whole, including the various combinations of principles, the different arrangement of apparatus, general items, such as power, costs, etc., and mill testing.

While the method applied in the asbestos separation is practically the same in every mill, no two mills are built alike. The serpentine in the different localities varies in hardness and toughness, one mine extracts No. I and No. II grade by hand, another only No. I grade, and others again abolish hand cobbing and send the whole mine output through the mill. In some mills two qualities are made, in others four and sometimes five. These factors combined with other minor considerations dictate to a certain extent the course of the treatment which has to be followed and the kind of apparatus to be employed.

In order to illustrate the working of the separation method generally adopted, a description of a mill is given, which, by

Fig.26



reason of its simple construction, facilitates the study of the principles involved.

A section of this mill is given in Fig. 26. No. I and No. II crude are handcobbed and the balance of the asbestos material is sent to the mill for treatment; the serpentine is massive and of the usual hardness as found in the Black Lake and Thetford district. Two qualities are made in the mill with an additional grade out of the tailings of the shaking screens.

FIRST PART OF SEPARATION.

All the asbestos rock and fines produced at the mine goes first through a Blake crusher, (a), then through the rotary dryer, (b), and is raised by means of a bucket elevator, (c), to the third story of the mill building. It passes then through a rotary crusher, (d), into a big cylindrical fiberizing machine, (e). The material is then raised by bucket elevator (f), and falls on a shaking screen, (g), with 1-16 inch holes. All the loose fibre is here taken up by fan, (h), and is deposited in collector, I. The sand from shaking screens, (g), falls into hopper, (k), where it is loaded into cars and sent to the dump. All the remaining rock and fibre from the shaking screen falls through chute, (l), into the cyclone apparatus, (Cy), the discharge of which is placed with the shaking screen, (m), in an air-tight chamber. An exhaust fan, (n), connected with the latter and leading to the open, creates a suction in the cyclone, thereby facilitates its discharge and at the same time takes up all the dust emanating from the shaking screen. All the fibre separated in the cyclone and going over shaking screen, (m), is taken up by fan (o), and deposited in collector I, while the residue from the shaking screen falls into a hopper (x), and is loaded into dumping cars.

SECOND PART OF SEPARATION.

All the fibre extracted from the rock is now placed in collector, I, from here it passes through revolving and grading screen, (p), with arms moving in opposite direction.

In this screen two grades are made, the quality of which is regulated by means of a grading board (q), turning on hinges. In order to eliminate the sand, No. I grade passes then over screen, (r_1), and No. II grade over screen (r_2).

Two suction fans, (s_1), and (s_2), take up the fibre and place the same in the collectors, the first quality in No. II and the second quality in No. III collector. The tailings of shaking screens (r_1) and (r_2) pass again over another screen, (t), where all the longer fibre still in the sand residue is taken up by fan (u), and deposited in collector III, which now contains the marketable article known as paper stock. No. I fibre deposited in collector II is further cleaned on shaking screen, (w), and is then ready for the market.

All the tailings resulting from screens (t) and (w) fall into a hopper and are ground in a horizontal Emery mill, (y), for the manufacture of asbestos finishing plaster.

The following chart II. will illustrate the treatment above described:—

There are various other combinations in use, as will be seen from the mill schemes laid out in charts III, IV and V, and furthermore new combinations may suggest themselves. Theoretically the principles introduced would allow a perfect separation of all the asbestos from the rock and of the different grades, but practically such is very difficult to accomplish and is rarely obtained.

In looking over the charts mentioned above, we find that the principal object in the first stages of the process is to eliminate the sand through the shaking screens and to have as much fibre taken up by the fans as is practically possible, We learn also that many combinations of the crushing machinery are used, but that always the jaw crusher forms the initial step followed by a rotary or Gates crusher, while the last stages of the process are practically the same in all the mills with but few deviations.

In mill IV a picking table is inserted between two jaw crushers, while in mill No. V we find the same between the Gates crusher and the belt rolls. These picking tables consist of an endless rubber belt of a width varying between eighteen and twenty-four inches, turning on a wide cone or pulley, and have a length of from twelve to eighteen feet. Boys are stationed along the belt picking up the dead rock, long asbestos fibre and pieces of iron or rubbish, which may have fallen accidently into the ore. In mines which produce much crude this arrangement is very important as the long fibre which was hidden in the rock, before breaking, can be removed and saved as crude. It is also of equal importance that all the rock which contains no fibre be taken out to relieve the subsequent operations from unnecessary work.

For the extraction of iron in some mills very strong electromagnets are used. In the mill of the Manhattan Asbestos Company a strong electro-magnet (Fig. 27) is placed over the discharge

In the following chart I, a summary of all the different stages, as above outlined is given through which the longer fibre has to pass until it is ready for the market.

CHART I.

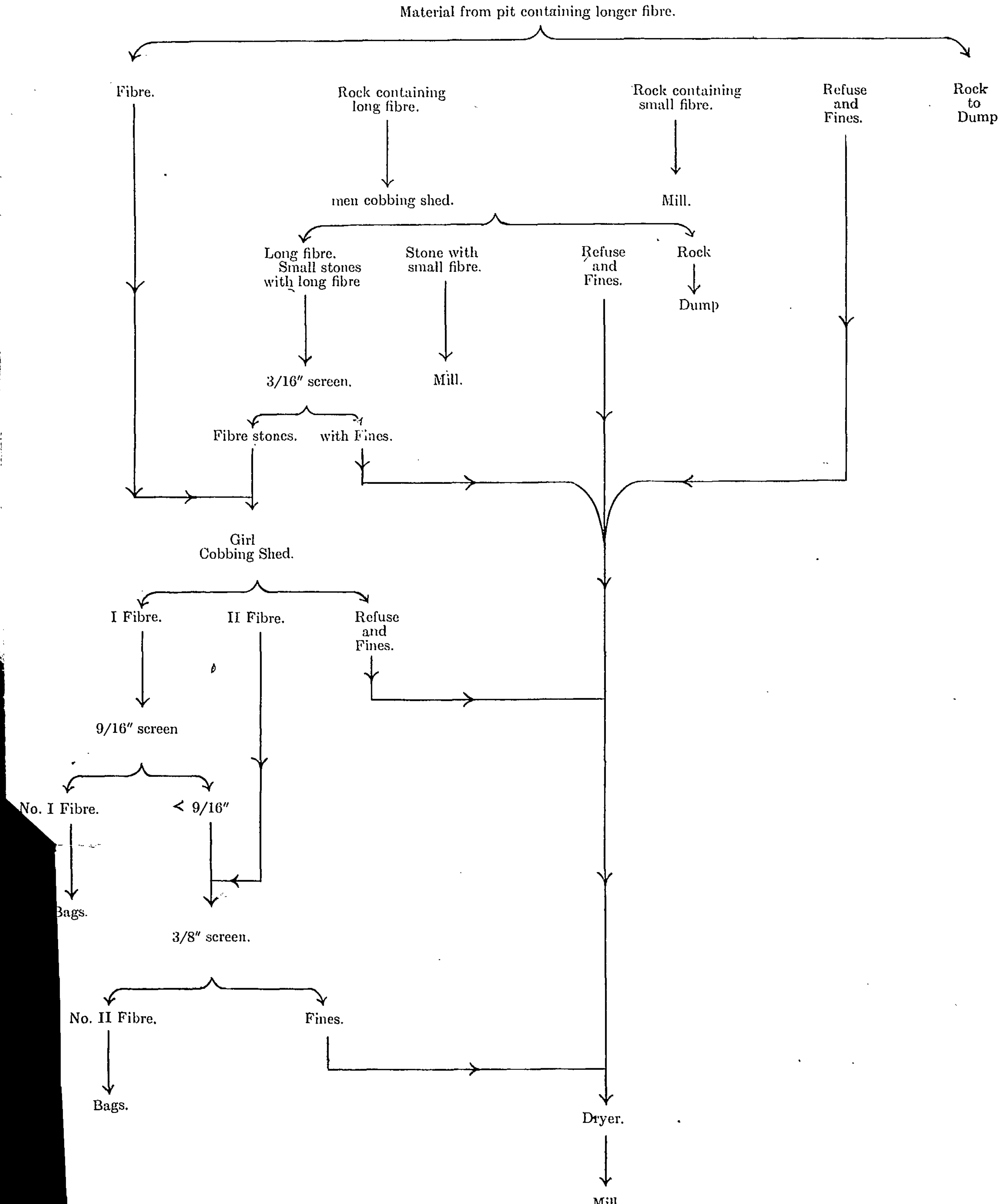
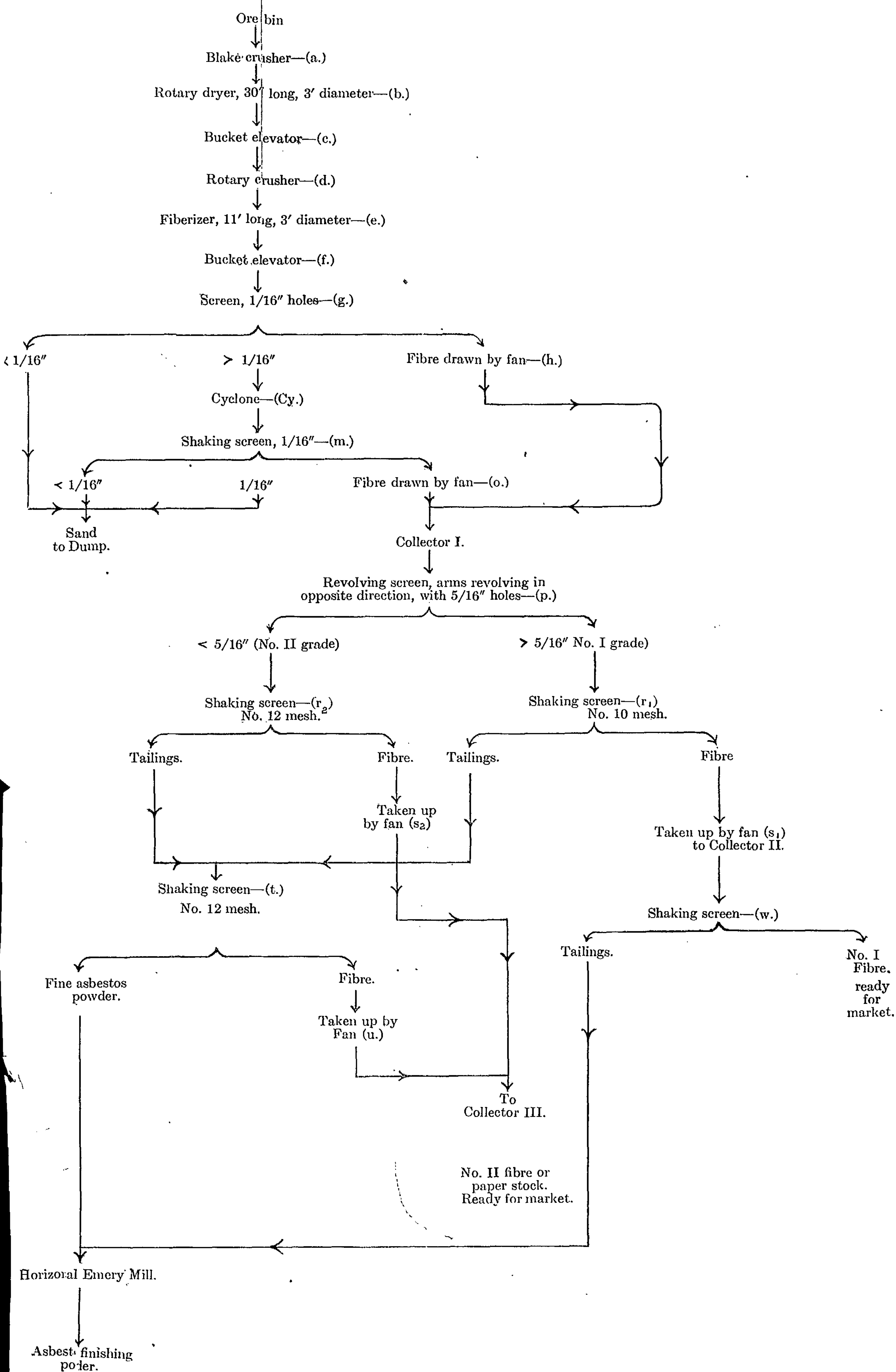


CHART II.



Ore bin
Blake crusher—(a.)
Rotary dryer, 30' long, 3' diameter—(b.)
Bucket elevator—(c.)
Rotary crusher—(d.)
Fiberizer, 11' long, 3' diameter—(e.)
Bucket elevator—(f.)
Screen, 1/16" holes—(g.)
< 1/16"
> 1/16"
Fibre drawn by fan—(h.)
Cyclone—(Cy.)
Shaking screen, 1/16"—(m.)
< 1/16"
1/16"
Fibre drawn by fan—(o.)
Sand to Dump.
Collector I.
Revolving screen, arms revolving in opposite direction, with 5/16" holes—(p.)
< 5/16" (No. II grade)
> 5/16" No. I grade)
Shaking screen—(r2) No. 12 mesh.
Shaking screen—(r1) No. 10 mesh.
Tailings.
Fibre.
Tailings.
Fibre
Taken up by fan (s2)
Taken up by fan (s1) to Collector II.
Shaking screen—(t.) No. 12 mesh.
Shaking screen—(w.)
Tailings.
No. I Fibre. ready for market.
Fine asbestos powder.
Fibre.
Taken up by Fan (u.)
To Collector III.
No. II fibre or paper stock. Ready for market.
Horizoral Emery Mill.
Asbest finishing po der.

CHART III.

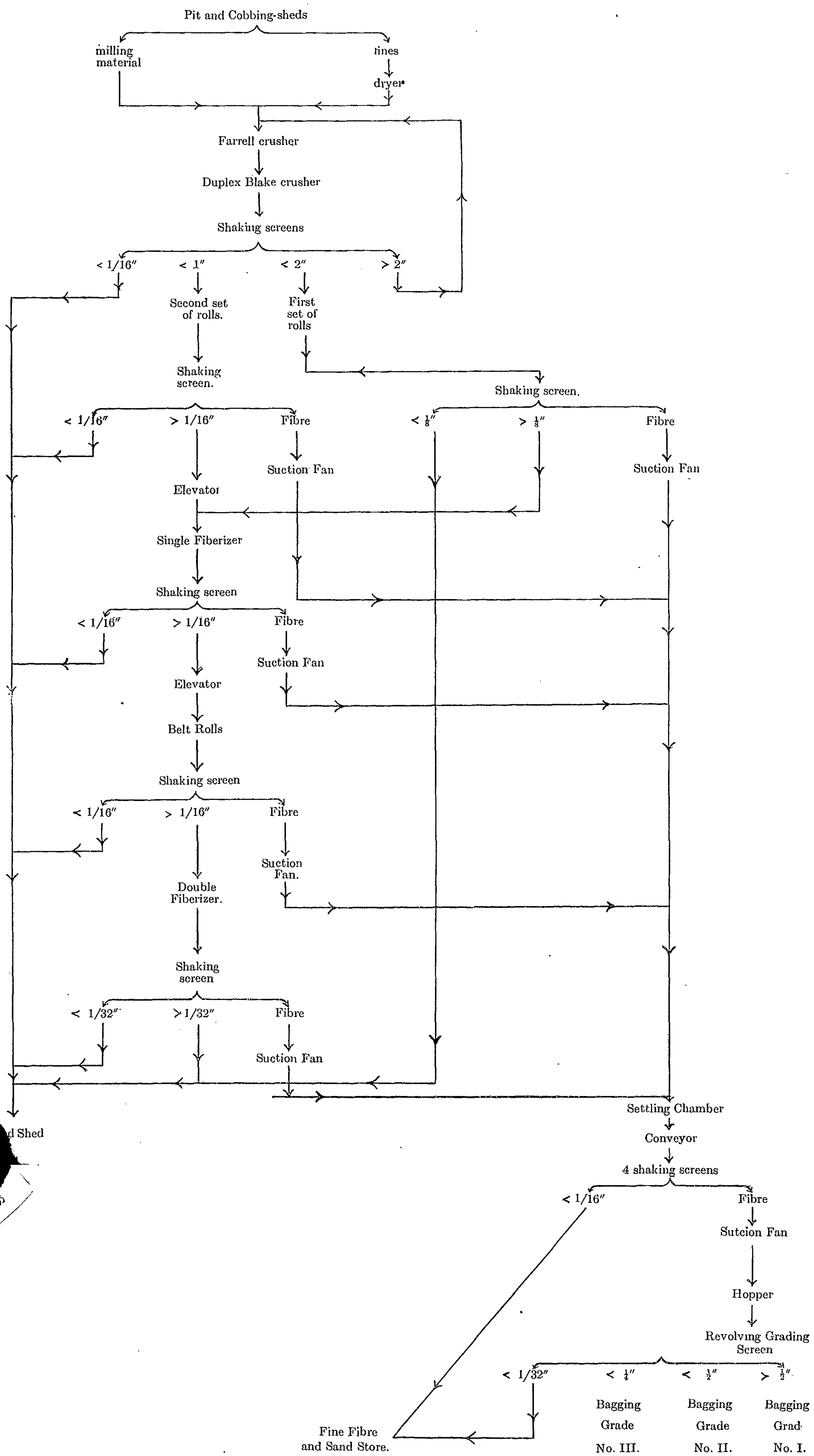
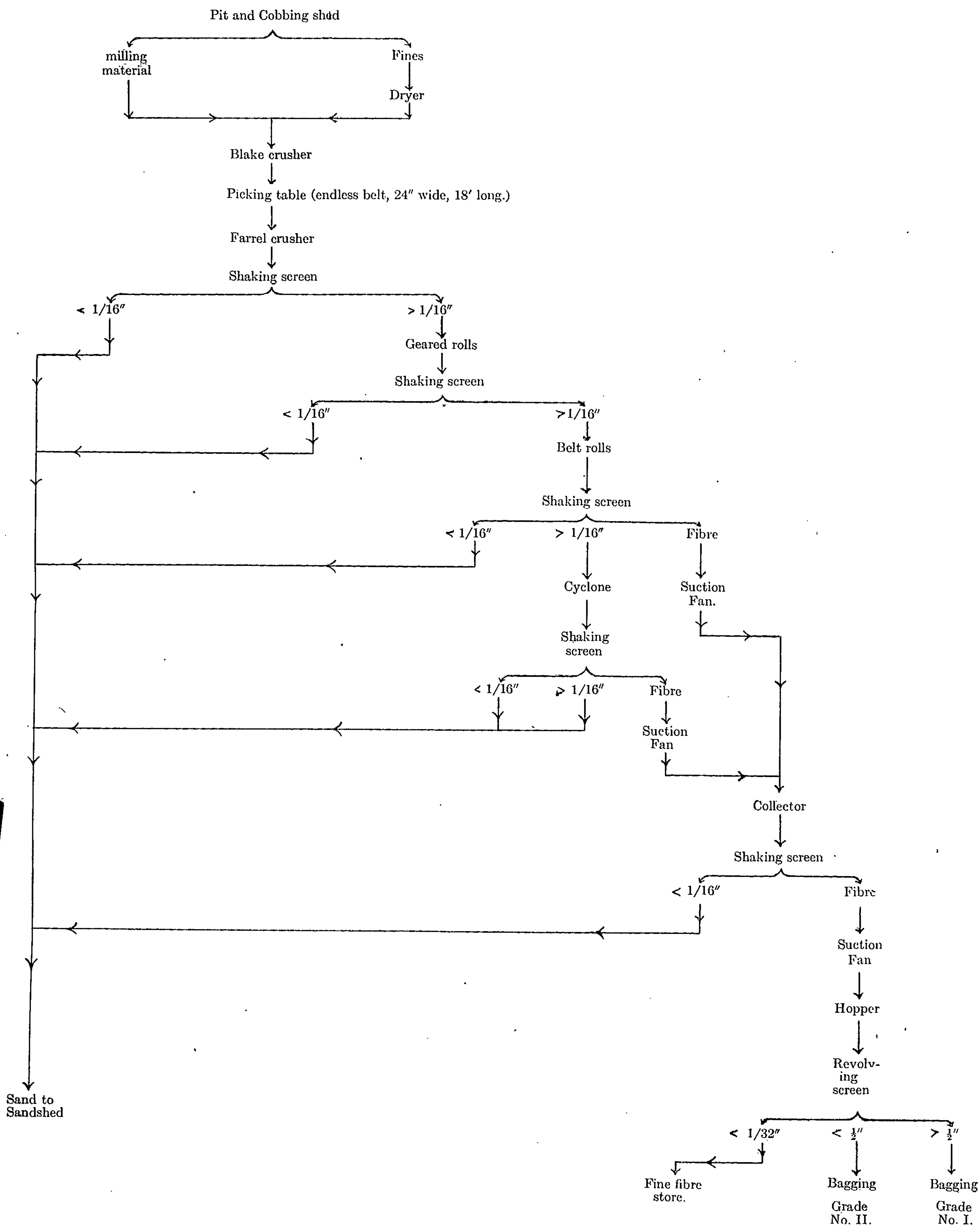
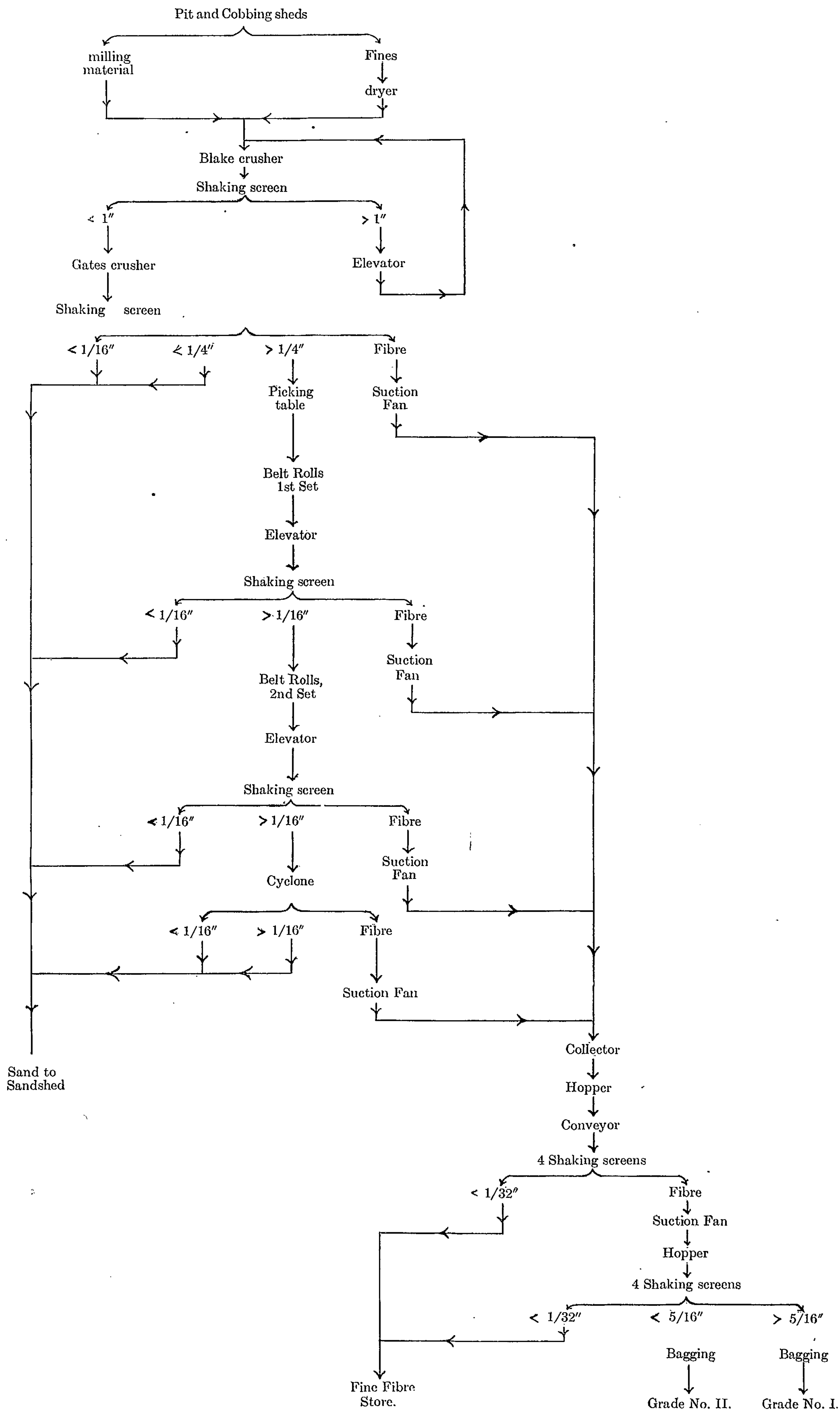

Pit and Cobbing-sheds
milling material
fines
dryer
Farrell crusher
Duplex Blake crusher
Shaking screens
< 1/16″
< 1″
< 2″
> 2″
Second set of rolls.
First set of rolls
Shaking screen.
Shaking screen.
< 1/16″
> 1/16″
Fibre
< 1/8″
> 1/8″
Fibre
Suction Fan
Suction Fan
Elevator
Single Fiberizer
Shaking screen
< 1/16″
> 1/16″
Fibre
Suction Fan
Elevator
Belt Rolls
Shaking screen
< 1/16″
> 1/16″
Fibre
Suction Fan.
Double Fiberizer.
Shaking screen
< 1/32″
> 1/32″
Fibre
Suction Fan
d Shed
Settling Chamber
Conveyor
4 shaking screens
< 1/16″
Fibre
Sutcion Fan
Hopper
Revolving Grading Screen
< 1/32″
< 1/4″
< 1/2″
> 1/2″
Bagging Grade No. III.
Bagging Grade No. II.
Bagging Grad No. I.
Fine Fibre and Sand Store.

CHART IV.



Pit and Cobbing shed
milling material
Fines
Dryer
Blake crusher
Picking table (endless belt, 24″ wide, 18′ long.)
Farrel crusher
Shaking screen
< 1/16″
> 1/16″
Geared rolls
Shaking screen
< 1/16″
>1/16″
Belt rolls
Shaking screen
< 1/16″
> 1/16″
Fibre
Cyclone
Suction Fan.
Shaking screen
< 1/16″
> 1/16″
Fibre
Suction Fan
Collector
Shaking screen
< 1/16″
Fibre
Suction Fan
Hopper
Revolving screen
< 1/32″
< ½″
> ½″
Fine fibre store.
Bagging
Grade No. II.
Bagging
Grade No. I.
Sand to Sandshed

CHART V.



Pit and Cobbing sheds
milling material
Fines
dryer
Blake crusher
Shaking screen
< 1″
> 1″
Gates crusher
Elevator
Shaking screen
< 1/16″
< 1/4″
> 1/4″
Fibre
Picking table
Suction Fan
Belt Rolls 1st Set
Elevator
Shaking screen
< 1/16″
> 1/16″
Fibre
Suction Fan
Belt Rolls, 2nd Set
Elevator
Shaking screen
< 1/16″
> 1/16″
Fibre
Suction Fan
Cyclone
< 1/16″
> 1/16″
Fibre
Suction Fan
Sand to Sandshed
Collector
Hopper
Conveyor
4 Shaking screens
< 1/32″
Fibre
Suction Fan
Hopper
4 Shaking screens
< 1/32″
< 5/16″
> 5/16″
Bagging
Bagging
Fine Fibre Store.
Grade No. II.
Grade No. I.

end of a feeder, after the rock passes the Blake crusher and corrugated rolls.

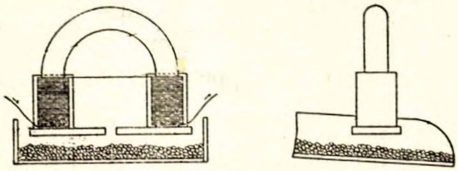


FIG. 27—Electric Magnet for the Extraction of Iron, in the Manhattan Asbestos Co's Plant.

In the mill of the Broughton Asbestos Company, at East Broughton, six magnets (Fig. 28) are placed over the shaking screen which receives the first crushed material from the jaw breakers.

There is no question that through the employment of the designs above indicated the efficiency of a mill is increased, while much breakage in the different pieces of apparatus, especially in the fast revolving machines like the cyclone is prevented. Of the fiberizing machines the cyclones appear to be adopted in

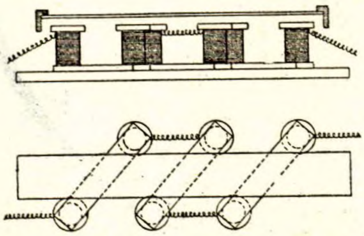


FIG. 28—Arrangement of electric magnets over screen in the mill of the Broughton Asbestos Co.

most of the mills. In some of the newer mills other machinery has been introduced to take the place of the cyclone. So in the chart for mill No. III we find that the fine crushing is done by two pairs of belt rolls in connection with a single and a double cylindrical fiberizing apparatus. In another mill the material passes twice in succession through a set of rotary crushers and a beater of recent design, the construction of which is kept secret. It is claimed for this new departure that the fibre is not so much torn up and that the repairs are few and not so costly as those in the cyclone machines.

The different grades of fibre are made as a rule in most of the mills at the end of the process by sizing in shaking screens or in revolving screens with arms moving in opposite directions. A new departure has been made in a mill of recent construction. Here the material, after having been crushed in succession in a jaw and rotary crusher and a beater, falls on a double shaking screen, as illustrated in Fig. 29, the upper one having 7-16 inch

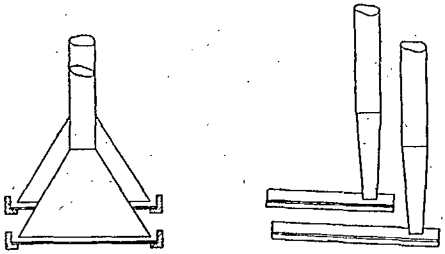


Fig. 29—Double shaking screen.

and the lower one 1-16 inch mesh, allowing the sand to pass away. The fibre is graded in this way into Nos. I and II. Each grade is taken up at the end of each screen by suction fans and deposited in separate collectors. The overflow from both screens passes again through a rotary crusher and beater and a double screen as before, while the two grades of fibre so produced are taken up and also deposited in collectors. It is claimed for this arrangement that the higher grades do not contain so much of the smaller fibre as when produced in the revolving screens.

The sand from all the shaking screens falls generally into a long hopper with a rubber belt conveyor at the bottom, which transports all material to the outside. Where the dumping ground is not on the same level with the mill the sand is carried by conveyors into elevated sand-sheds or large reservoirs from which cars are loaded and sent to the dump. (See plates X and XIII).

In the mills at Danville the bulk of the sand and tailings from the shaking screens is manufactured into asbestic, a fine asbestos powder which enters now largely into the construction and inside finish of fireproof buildings.

In one of the largest mills recently erected, all the tailings are pulverized in giant vertical Emery mills.

General Features of the Mills in the District.

With a few exceptions, the mills visited by the writer are located near the mines, that is, within 500 feet, indicating that the transportation of the ore to the mill is a most important factor. In the location of all the newer mills due consideration has been given also to the dumping ground and to the prevention of covering valuable ground. For this reason the mills have been built away from the quarries.

Concerning the sites on which mills are built we may distinguish between—first: a sloping or terraced site (Fig. 30); second: a flat site (Fig. 31). In the former case advantage is taken of the sloping condition of the ground, all material is conveyed by gravity, and heavy elevators are few. An example of this kind is the mill of the Union mine at Black Lake.

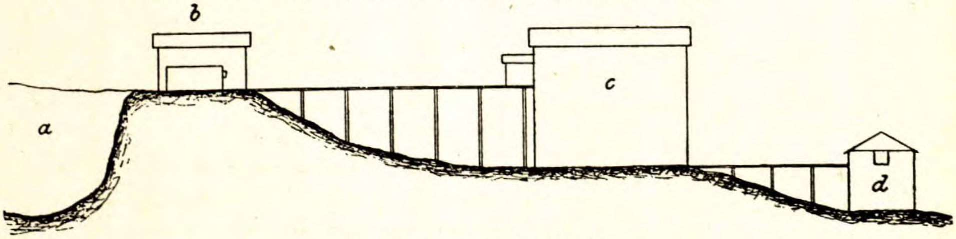


Fig. 30—Type of a sloping mill.

(a) Pit. (c) Mill.
(b) Dryer. (d) Storehouse.

Mills on the flat ground, however, are the common rule. The disadvantages are that more elevators are required, which wear out rapidly, cause stoppages of the mill on account of breakage and annoy the mill man.

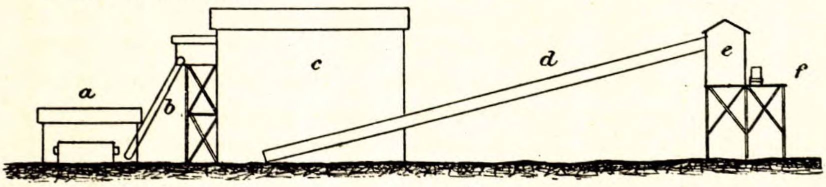


Fig. 31—Type of a flat mill.

(a) Dryer. (d) Sand conveyor.
(b) Elevator (e) Sand shed.
(c) Mill. (f) Elevated track.

The first crusher either precedes the dryer or is placed in the upper story of the mill at the base of the ore bin. In the first case, with one or two exceptions, all material coming from the mine goes through the dryer which with the crusher is placed in a separate building. This arrangement is now adopted in all the newer mills, as the powerful toggle movement of the jaw breakers, when placed in the upper part of the building, causes a heavy vibration in the structure of the latter and requires heavy construction.

The usual form of an asbestos separation plant is a three or four story building. The ore is received in a big ore bin, placed in the upper part of the building or in an addition, allowing the same to pass through the crushing machinery by gravity, elevators being used between the apparatus for middlings and for recrushing. In the majority of cases, however, the ore passes on straight without recrushing in the same apparatus. Sometimes all the fine crushing apparatus and fiberizers are placed in one line and on one floor as at the mill of the Johnson Asbestos Company at Black Lake (Fig. 32). Small elevators convey the material from one

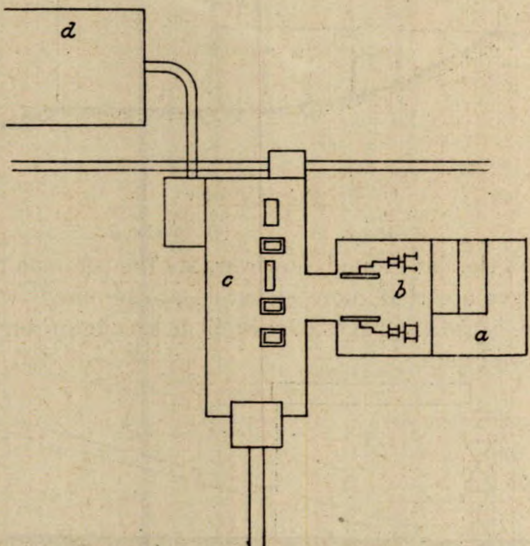


Fig. 32—Sketch of Milling Plant of the Johnson Asbestos Co., Black Lake.

(*a*) Boiler. (*c*) Mill.
(*b*) Engines. (*d*) Storehouse.

apparatus to another and it is claimed for this arrangement, that the machinery can be watched better and is more accessible than when placed on different levels. The screens receiving the material from the crushers are, as a rule, placed for the purpose of greater accessibility all on one floor, while an endeavour is made to do the same in all the newer mills with the shaking screens for the fibre.

An example of this kind is the mill of the American Asbestos Company (Fig. 33), where all the screens for the crushed rock or for the extracted fibre are placed on one floor.

In mills of recent construction, in order to avoid complete stoppage caused by breakage of machinery or otherwise, the whole milling plant is divided into two portions, constructed on exactly the same lines, but run independently of each other. This innovation was noticed in the mills recently built at East Broughton and at the American Asbestos Company's plant. In the latter this principle is even carried further; the two sections are again subdivided into different parts, each one embracing a certain group of machinery and being run by special electric motors.

PLANT.

In addition to the mill itself, other buildings are used. The boilers, as a rule, are placed in a separate building, the mill engine and all accessory machinery such as dynamos, and compressor in

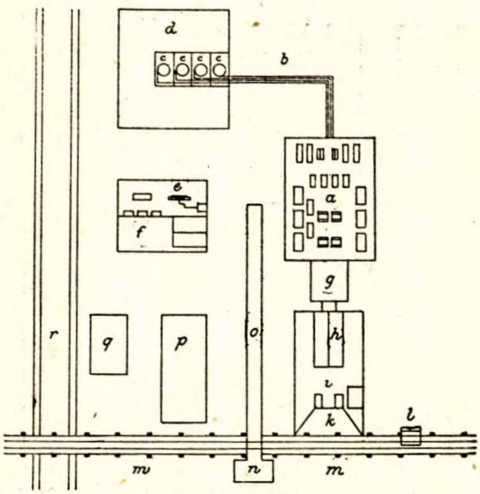


FIG. 33—Sketch of milling plant of the American Asbestos Co., Black Lake.
(*a*) Mill. (*b*) Blowing pipes. (*c*) Collectors. (*d*) Storehouse. (*e*) Engine and dynamo. (*f*) Boilers. (*g*) Reserve ore bin. (*h*) Rotary dryers. (*i*) Crushers. (*k*) Ore bin. (*l*) Scale. (*m*) Elevated track. (*n*) Sand shed. (*o*) Sand conveyor. (*p*) Machine shop. (*q*) Coal bunkers. (*r*) Side track of the Q. C. R.

a shed adjoining the mill, while the rotary dryer, on account of the danger from fire, is located in a shed at some distance from the mill. As a rule, a carpenter, millwright and machine repair shop is run in connection with the mill.

The store houses are all separate buildings with rail connection. The plant of the American Asbestos Company at Black

Lake is housed in six buildings (Fig. 33), a dryer and a crusher building, the mill proper, the store house, the boiler and engine house, the machine repair shop and coal bunkers. The middle part of the big store house is taken up by four compartments, serving as bagging rooms, each one with a large collector near the roof which receives the different grades of the fibre from the mill.

The main feature of the plant of the Beaver mine (Fig. 34) is the placing of all boilers, milling machinery and apparatus in one

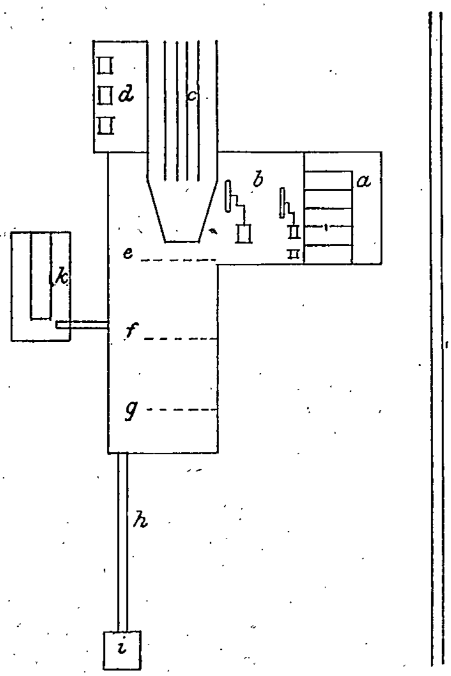


FIG. 34—Sketch of milling plant of the Beaver Asbestos Co., Thetford.

(a) Boilers.
(b) Engines.
(c) Tramway to ore bin.
(d) Hoists.
(e) Crushers.
(f) Cyclones.
(g) Screens.
(h) Sand conveyor.
(i) Sand shed.
(k) Rotary dryer.

big building. The quarries being near by, the hoists have been conveniently placed in an addition to the latter.

Most of the mill buildings are made of wood, they are either boarded vertically and the cracks battened, or they are double boarded, the boards covering joints in every case.

The roof are made of shingles, of tarpaper, or of galvanized iron to cover the sides and roof, thereby saving high premiums for insurance. Its disadvantage for mill buildings is that it makes the building difficult to heat in winter, owing to its high conductivity. In some of the newer mills the dryer buildings are made of brick with iron roof, or entirely of iron, as at the Beaver mine.

Some mills are painted, others are not. In the former case red mineral paint is the kind most used, which not only aids in preserving the wood from decay, but also protects it, to some extent, from fire. All mining and milling plants are now provided with the necessary appliances to guard against destruction by fire. For this purpose duplex pumps are kept constantly under steam, while hydrants and hose are placed at different points throughout the mill. The Asbestos and Asbestic Company, at Danville, having suffered from a disastrous fire in the year 1900, which destroyed their milling plant, keep a large duplex pump with a capacity of 1,000 gallons per minute steadily under steam, in order to be prepared in case of fire.

POWER.

The motive power is steam everywhere. The boilers used are of the fire tube type, with a length varying between ten and twenty feet, a diameter ranging from thirty-six to seventy-eight inches and a capacity of from 20 to 175 horse power. The pressure used varies from 80 to 110 pounds per square inch. It is a good practice for the larger mills to have a boiler capacity considerably in excess of the engine plant. This insures good efficiency and allows one boiler to be shut down for repairs without shutting down the mill. This is of special importance in plants where the boilers, in addition to delivering steam for running the mill machinery, may have to supply steam for heating, drying, pumping, running the compressor, the machine and carpenter shop and, where the mine is near by, for hoisting. With one exception, all chimneys are iron or steel stacks.

STEAM-SAVING APPLIANCES.

Owing to the increasing scarcity of fire wood and to the advanced price of fuel, especially of coal, all the larger plants have installed now, apart from economic steam engines, steam saving devices.

One consists in covering the pipes and sometimes boilers with asbestos or asbestos cement. Another, which is now generally in use, is the heating of the feed water by exhaust steam.

These feed water heaters consist generally of a water chamber divided into several compartments. The partitions are so arranged that they direct the flow of the feed water back and forth through the heater, using various groups of tubes in succession. It is claimed that a saving of one per cent. is effected for each increase of 11° F. in the temperature of the feed water as delivered to the boilers. Thus, taking feed water at 60° and raising it to 200° by a good heater means a saving of about 13 per cent.

Another effective device and one which is in use in most of the Thetford mines is the Dakin feed water heater. These heaters contain several filter compartments whereby the lime, magnesia and other impurities in the water are eliminated; the oil from the exhaust steam is extracted at the same time and the feed water is heated to about 200°.

The mechanical draft system is also employed in some of the plants and is reported to give excellent results. There are two different kinds in use: the forced and the induced draft system.

In the former, compressed air or steam is delivered to the closed ash pit of the boiler and thence finds its escape through the fuel on the grates above. In the mills of the Bell Asbestos Company each ash pit of the 125 horse power boiler is supplied with two steam jets entering on each side of the door. Only screenings are used as fuel and the grates have narrow, longitudinal openings, arranged diagonally.

Under the induced system a vacuum is created in the furnace which draws from the latter the gases generated in the process of combustion. As the draft is thus rendered positive and practically independent of all conditions, except the force of the compressor, it is only necessary to provide a short outlet pipe to carry the gases to a sufficient height to permit of their harmless discharge to the outside. The principal advantages of this system are: abolition of a long chimney, maximum efficiency of the boiler (all other conditions being equal), and utilization of the lower grades of coal screenings, etc.

The cost per horse power per year varies, of course, a great deal. In some plants where good steam saving appliances are adopted the cost is as low as $35.00, in others, where no such appliances are in use, as high as $47.00.

ENGINES AND MOTORS.

The mill engine used is mostly of the simple single expansion, non-condensing type. These include engines with common valves, piston valves and Corliss valves, engines with throttle governors and automatic cut-offs. Compound engines are used in five mills.

These include tandem compound and cross compound, engines with receivers and without, engines with condensers and without. Triple expansion engines are not in use.

The smallest capacity of the mill engines employed is fifty horse power, the largest five hundred horse power. In some of the mills, where there is a second or reverse ore bin, the first part of the plant, generally the dryer and the crusher, is run by separate machinery, so that in case of stoppage of the mill the continuous ore supply coming from the mine may be disposed of and sent to this reserve ore bin. The rock breakers are the most irregular users of power. In all the newer mills they are driven by separate engines or electric motors. This removes one of the chief causes of irregular loading of the mill engine and saves the production of dust in the mill, which is bad for the machinery and unhealthy for the men.

Electricity is used as a motive power only in one mill. Its introduction in the district is of recent date. The St. Francis Hydraulic Power Co. has built a power station at the rapids of the St. Francis river about six miles distant and the American Asbestos Co. of Black Lake was the first concern to use electricity in its newly constructed mill. At this Company's works an auxiliary steam plant is installed, to be used in case of accident in the transmission of electric power.

The main advantages of the use of electricity are: that electric motors require less attention and repairs than steam engines, and at the same time they are more efficient in transforming electricity into work than steam engines are in transforming calorific power of steam into work. The loss in transmission is less with electricity and it may be said that wherever electricity has been applied to mill work it has been very successful.

In regard to the division of power in the mills for different motors to drive different parts of the machinery, it must be said that the economical advantage which electricity affords in this respect in machine shops, namely, the running of individual machines which are operated intermittently with a separate motor, does not exist in the mills under consideration, since the milling plants run continuously.

Most of the plants are lit by electricity generated in dynamos of a capacity of from 75 to 500 candle lights. In some of the plants the dynamos are used to drive the smaller pieces of machinery in the day time, such as those used in the carpenter and machine repair shops.

AMOUNT OF POWER USED.

The horse power required per ton of ore treated in a double shift varies, of course, in the different mills with the quantity and kind of rock treated, with the apparatus employed, and it will even vary in the same mill, owing to slight changes of velocity or of the speed of feeding and discharge and also of the size of the material fed to the breakers. For these reasons average figures cannot be applied to every individual mill and they, can therefore, be of only a general value.

Most of the mills have sufficient reserve capacity to obviate the necessity of forcing any of the machinery and permit the temporary suspension of a machine for adjustment and repairs.

From the data at the disposal of the writer it appears that for every ton of rock crushed and treated from 1 to 1.25 horse power, on an average, is required, so that a mill treating about 250 tons of asbestos rock in two shifts per day requires a capacity of the machinery of from 250 to 310 horse power, providing at the same time a sufficient reserve capacity. From 75% to 90% of the power originally supplied is used in crushing alone, the balance in screening and blowing. The capacity of the mills ranges from 75 tons to 500 tons in a double shift. Most of the mills, however, treat between 150 and 250 tons.

COST OF LABOUR IN MILLS.

The cost of labour employed in the mills varies as much as the power necessary to run them. While some mills are laid out and constructed so that little attendance is necessary, others are cramped in room, the machinery employed is not easily accessible and the general mechanism is such as to require extra help to watch the same.

If exact figures in this respect were at hand, they would show that the number of tons treated per man varies greatly even in mills of practically the same construction.

This variation depends upon the following factors:—

(1) The difference in the care exercised with which the different grades are manufactured.

(2) The size of the plant, since a large mill can always be run with less labour per ton than a small one.

(3) On the favourable ocation and design of the mill to minimize laboulr costs.

However, in the absence of accurate data of all the mills the following two examples are given of labour employed in mills which have a fairly good plant and working under ordinary conditions.

One mill treats 150 tons of asbestos rock per day or 75 tons in one shift. The labour employed per shift to run this plant is as follows:—

1 engineer	$ 2.00
1 fireman	1.75
1 millwright	4.00
1 foreman	2.00
1 oiler and helper	1.75
3 men feeding crusher, $1.25	3.75
1 fireman on dryer	1.25
1 sand man	1.50
3 men for bagging, $1.25	3.75
13 men	$21.75

The total amount expended on wages is, therefore, $21.75, or per ton of milling rock: $21.75 ÷ 75 = $0.29. This mill produced on an average 7 tons of fibre, hence the labour expended per ton amounted to $21.75 ÷ 7 = $3.11.

In another mill 250 tons of rock, on an average, are treated in two shifts. The labour employed is composed of the following:

1 engineer	$ 2.00
2 firemen	3.50
1 millwright	4.00
1 foreman	2.00
3 helpers, $1.50	4.50
2 sandmen, $1.50	3.00
3 men feeding crusher, $1.25	3.75
2 men for dryer, $1.50	3.00
4 men for bagging $1.25	5.00
19 men.	$30.75

The average cost of labour per ton in this case amounted to $30.75 ÷ 125 = $0.25. The mill produced, on an average, 12 tons of asbestos fibre, the cost of labour amounted, therefore, to $30.75 ÷ 12 = $2.56.

The capacity of a mill and the quality of the product depend largely upon the intelligence and reliability of the men employed in the various departments. A saving made in the wages may be more than offset by losses in efficiency of the machines due to ignorance or neglect.

So many various considerations enter into the successful accomplishment of the separation of asbestos from the rock and the production of very fine grades of fibre that it would be out of place to generalize on the subject of wages expended in the mills.

PERCENTAGE OF ASBESTOS ROCK IN THE TOTAL ROCK MINED.

There is considerable variation in the quality of the rock mined. While one mine may deliver a high percentage of crude and a poor milling rock, another may not be able to produce any crude at all, yielding, however, a milling material rich in short fibre.

It is evident, therefore, that the percentage of milling rock in the total rock mined varies from day to day in every mine, unless special precautions are taken to mine only a certain chute of ore of known quality.

The mill has to depend upon the mine for a regular supply of ore and any changes in the condition of the latter are felt at once in the mill.

As far as experience has shown, the lowest percentage of asbestos milling rock of the total rock mined is 20%, the highest 70%. On an average, the milling rock furnished by the mines may be taken as from 30% to 60% of all the rock mined.

PERCENTAGE OF FIBRE IN THE MILLING ROCK.

The variation in the percentage of fibre in the milling rock is just as great as in the percentage of milling rock in the total rock mined. But taking it all round, the writer is of the opinion, judging from the different milling statements before him, that an extraction of from 6 to 10% of the milling rock is effected in the majority of the mills. There are exceptions of higher extraction, but generally speaking a rock of fairly good milling quality should yield a percentage within the above limits.

PERCENTAGE OF CRUDE IN THE TOTAL ROCK MINED.

As to the production of crude, the same has lessened to a very large extent, owing to the general introduction of mechanical treatment, and is practised now only in a few mines which work on richer ground. In these mines, as a general rule, the quantity of crude of Nos. I and II quality can be put down as from one to two per cent of the total rock mined, but it is known that one or two mines produce a somewhat higher percentage than this.

GRADES.

The output of the mines is, to a certain extent, differently graded. As to the crude, there are only No. I and No. II qualities made, the former measuring about one inch and the latter from one-half to one inch in length.

The milling fibre is generally divided into three grades, but sometimes additional special qualities are made. The qualities of the general run are designated as follows: First grade, long spinning fibre, second grade, spinning fibre, and third grade fibre, or paper stock. Two examples of an extraction for three consecutive months in two different mines may be given here.

The average percentage of the different grades in one mill was:—

First grade, long spinning fibre	20.8 %
Second grade, spinning fibre	8.00%
Paper stock	71.20%
	100.00

and another mill yielded:—

First grade, spinning fibre	15.6%
Second grade, spinning fibre	32.2%
Paper stock	53.2%
	100.00

On an average the asbestos output of the mines consists of ten per cent. of crude, handcobbed or machine product, twenty per cent. of No. I and No. II mill fibre and from seventy to seventy-five per cent. of paper stock.

PRODUCTION OF CRUDE BY MECHANICAL TREATMENT.

Several methods have been introduced to extract the crude by machinery. The most common one consists of a Blake crusher, Cornish rolls, the necessary shaking screens and picking tables. At the Union mine the ore is crushed by a Chilian mill and then further opened up by a cylindrical fiberizer, similar to the kind described on page 58. Shaking screens of different sizes in connection with suction fans complete the separation of fibre, crude and fines, the latter being delivered to the mill for treatment. The rock delivered to the Chilian mill is reduced previously by handcobbing to walnut size and contains from forty to fifty per cent. of asbestos. About eight tons of rock can be treated in one shift and it is claimed that the work performed by this mill is satisfactory.

CHAPTER IV.

COST OF EXTRACTION, MARKET AND PRICES, STATISTICS AND STATUS OF THE INDUSTRY.

COSTS OF EXTRACTION.

In the operation of asbestos mines and mills the cost of mining and milling is obviously a matter of great importance. A number of important factors enter into it:

(1) The quantity of ore treated.

(2) Cost of labour.

(3) The quality of the ground in which the mine is working. Owing to the variation of the latter, the total cost will vary in different mines and any generalizations as to comparative cost of mining and treatment per ton of asbestos are purely idle, being matters entirely dependent upon the quality of the rock, the percentage of fibre contained therein and the kind of plant employed.

If the writer, therefore, furnishes in the following an idea of the cost for which a ton of asbestos can be extracted, it must be fully understood that this example cannot be applied to every mine.

The writer has chosen the example of a mine which has been working for years on fairly good ground; all the rock and fibre from the mines are sent to the mill. Mill and mine are working only in day shift, the quantity of milling material treated per day ranges between eighty to ninety tons, or about sixty per cent. of the total rock mined. The production of asbestos of all grades is on an average 7.5 tons per day, or about 9.5% of the rock milled.

The expenses per day for three consecutive months are as follows:—

(1) Mine:—

2 pit foremen	$ 4.00
2 engineers, $1.75	3.50
2 air drillers, $1.75	3.50
2 helpers, $1.50	3.00
1 blacksmith	1.75
1 helper	1.50
3 car and derrick men, $1.25	3.75
26 miners, $1.25	32.50
1 boy	0.75
Power	7.50
Explosives	3.60
Machine and miners' supplies	1.15
	$66.50

(2) Mill:—

1 foreman	$ 2.00
1 millwright	4.00
1 oiler	1.75
3 men feeding crusher	3.75
1 dryer fireman	1.25
1 sandman	1.50
3 baggers	3.75
1 fireman, boiler	1.75
1 engineer	2.00
Fuel	23.94
Bags	10.50
Repair machinery	6.47
Oil and supplies	1.50
	$64.16

The operating expenses therefore, were:—

(1) Per ton of total rock mined

$66.50 ÷ 125 = $0.53.

(2) Per ton of milling rock:—

mining: $66.50 ÷ 80 = $0.83.

milling: $64.16 ÷ 80 = $0.80.

(3) Per ton of asbestos:—

mining: $66.50 ÷ 7.5 = $8.86.

milling: $64.16 ÷ 7.5 = $8.55.

(4) Total cost of production per ton of asbestos mined and milled:—$17.41.

Based upon the above table of expenses this total cost of $17.41 is composed of the following items:—

Wages	$ 76.00 ÷ 7.5 =	$10.13
Power	31.44 ÷ 7.5 =	4.19
Bags	10.50 ÷ 7.5 =	1.40
Machinery repairs and supplies	7.62 ÷ 7.5 =	1.01
Explosives	3.60 ÷ 7.5 =	0.48
Oil, grease, waste, etc.	1.50 ÷ 7.5 =	0.20
	$ 130.66	$17.41

The high figure for fuel is caused by the absence of any steam saving appliances and by the employment of a mill engine of the older type, which is a large steam consumer.

It is estimated that if the capacity of the mining and milling plant in question is increased to 300 tons of milling rock or giving from twenty-five to thirty tons of asbestos, making at the same time extensive improvements and provisions for the saving of steam, the above cost can be lowered to $14.50 per ton of asbestos produced.

To this cost must be added the expense for general management, offices, insurance, marketing, amortization, etc.

MARKET AND PRICES.

That the great excellence of the Canadian mineral is now universally acknowledged is evidenced by the fact that most of the larger countries, keeping pace with the development of new applications, import the asbestos in large quantities and every year witnesses a considerable increase in the exports of this mineral, Canada having thus become practically master of the field. The United States has been so far the largest buyer of asbestos, mostly of fibre and paper stock, while England, Germany, France and Italy and, lately, Russia buy large quantities of crude and also of the better classes of fibre. There appears to be no doubt that there is a ready market at the present time, for all the asbestos the mills can produce, as there is no surplus unsold on hand at any of the mines. New applications and uses for the asbestos are being discovered continually, especially since the paper stock or the short fibre has been put on the market, through the improved methods of separation.

Previous writers on the subject ventured to predict that other countries like Russia and Africa, where mining was carried on on a somewhat extensive scale some six or eight years ago, would in time successfully compete with the Canadian mines and that the monoply so far held by the latter would be weakened and even destroyed and that, as a consequence, the prices would drop to a lower figure. Nothing of the kind has happened and although new discoveries of asbestos are frequently reported, they have invariably proven of unimportant extent or of unsuitable quality and the profitable extraction of large quantities of the mineral is solely confined to Canada. As an evidence of the faith in the future of the Canadian industries it may be mentioned that a powerful American Company has not only acquired some of the best asbestos mines, covering large tracts of first class ground, but have put up the largest asbestos separating plant in the district and, probably, in the world with a view to increasing the output necessary to meet the increasing demand at the present time.

The prices per ton at present are:—

No. I crude	$175 to $200
No. II crude	110 to 125
Fibre No. I (special)	75 to 80
Fibre No. II	50
Fibre No. II } Fibre No. IV } paper stock	20 to 25

STATISTICS.

The full returns of output and values since the commencement of the industry in 1880 are given in the following table, compiled by the Section of Mines, Geological Survey of Canada:—

PRODUCTION OF ASBESTOS IN CANADA, 1880-1895.

Calendar Year	Tons (2,000 lbs.)	Value
1880	380	$ 24,700
1881	540	35,100
1882	810	52,650
1883	955	68,750
1884	1,141	75,097
1885	2,440	142,441
1886	3,458	206,251
1887	4,619	226,976
1888	4,404	255,007
1889	6,113	426,554
1890	9,860	1,260,240
1891	9,279	999,878
1892	6,082	390,462
1893	6,331	310,156
1894	7,630	420,825
1895	8,756	368,175

PRODUCTION OF ASBESTOS AND ASBESTIC IN CANADA, 1896-1904.

Calendar Year	Tons (2,000 lbs.)	Value
1896.—Asbestos	10,892	$ 423,066
Asbestic	1,358	6,790
1897.—Asbestos	13,202	399,528
Asbestic	17,240	45,840
1898.—Asbestos	16,124	475,131
Asbestic	7,661	16,066
1899.—Asbestos	17,790	468,635
Asbestic	7,746	17,214
1900.—Asbestos	21,621	729,886
Asbestic	7,520	18,545
1901.—Asbestos	32,892	1,248,645
Asbestic	7,325	11,114
1902.—Asbestos	30,219	1,126,688
Asbestic	10,197	21,631
1903.—Asbestos	31,129	915,888
Asbestic	10,548	13,869
1904.—Asbestos	35,068	1,154,566
Asbestic	13,087	13,006

Mr. Obalski, of the Department of Lands, Mines and Fisheries for the Province of Quebec, gives the following statistics for the last four years:—

	1901		1902	
	Tons	Value	Tons	Value
Crude No. I	2,083	$ 348,579	1,319	$ 240,401
Crude No. II	2,660	263,855	3,131	305,312
Fibre............	14,659	450,193	15,502	412,388
Paper stock	14,054	211,688	10,682	203,869
	33,456	$ 1,274,315	30,634	$ 1,161,970
Asbestic	6,831	10,114	9,764	12,783

	1903		1904	
	Tons	Value	Tons	Value
Crude No. I	930	$ 117,847	1,645	251,818
Crude No. II	2,354	227,919	2,727	265,961
Fibre............	9,650	311,248	7,771	229,801
Paper stock	16,327	259,956	23,336	439,215
	29,261	916,970	35,479	1,186,795
Asbestic	9,906	13,292	13,149	13,124

According to these statistics the total production of the mines for the years 1901, 1902, 1903 and 1904 is composed approximately of:—

16,850 tons of crude.
47,580 " fibre.
64,400 " paper stock.
39,650 " asbestic.

Total....168,480 tons.

EXPORTS OF ASBESTOS FROM CANADA.

Statement showing the amount of Asbestos, exported from Canada during the years ended June 30, 1895 to 1904.

Year ended June 30	Great Britain	Australasia	Belgium	British Africa	France	Germany	Holland	Italy	Newfoundland	Russia	St. Pierre	United States	Totals
						QUANTITIES							
	Tons	Tons	Tons	Tons	Tons	Tons	Tons	Tons	Tons	Tons	Tons	Tons	Tons
1895	2,202	....	12	....	....	358	28	....	....	......	....	5,993	8,593
1896	1,769	....	205	....	272	1,463	....	....	....	......	....	5,879	9,588
1897	3,388	....	....	....	....	1,157	....	....	....	......	....	6,424	10,969
1898	1,939	....	115	....	....	1,800	....	....	....	......	....	14,570	18,424
1899	1,418	....	237	....	....	377	....	....	....	......	....	12,488	14,520
1900	1,732	....	414	....	....	2,541	....	....	....	......	....	13,477	18,164
1901	3,324	136	2,211	....	240	2,235	206	167	1	......	78	18,117	26,715
1902	4,088	....	827	....	365	2,270	....	469	....	......	....	25,053	33,072
1903	2,813	....	964	26	192	1,119	110	568	2	......	....	24,867	30,661
1904	4,375	1	1,354	121	1,154	1,894	173	560	4	20	....	24,980	34,636
						VALUES							
	$	$	$	$	$	$	$	$	$	$	$	$	$
1895	118,852	....	1,110	....	....	27,036	2,800	....	....	......	....	343,277	493,075
1896	96,863	....	15,375	....	12,107	117,918	....	....	....	......	....	240,416	482,679
1897	236,598	....	....	....	....	67,766	....	....	....	......	....	206,552	510,916
1898	94,539	....	7,800	....	....	43,295	....	....	....	......	....	364,734	510,368
1899	66,623	....	13,100	....	....	12,052	....	....	....	......	....	361,401	453,176
1900	70,749	....	16,260	....	....	80,916	....	....	....	......	....	322,984	490,909
1901	136,294	692	161,468	....	25,397	85,345	4,480	2,975	58	......	778	447,086	864,573
1902	201,474	....	41,912	....	30,245	89,868	....	23,940	....	......	....	743,763	1,131,202
1903	98,167	....	22,226	70	19,740	28,646	7,275	21,455	102	......	....	757,724	955,405
1904	116,866	33	13,428	5,000	53,412	47,560	10,200	28,311	245	400	....	709,381	984,836

STATUS OF THE INDUSTRY.

Since the introduction of mechanical separation which has enabled the operators to extract the small fibre from the large dumps covering in some localities valuable ground, the industry, as a whole, has taken an altogether different aspect, in fact it has been revolutionized in every direction. Many mines which were working on poor ground and could not produce the better qualities have had a chance to realize on the abundant quantities of small fibre, while the larger companies could turn the immense dumps into realizable assets, thus adding considerably to their yearly dividends. Since the year 1896 the demand for fiberized asbestos has steadily increased from year to year owing to the numerous new applications of the lower grades. Additions to the already existing mills have been made, new and more modern mills designed and erected, the capacity of the mining plants increased and the result is, that we possess today an industry which is one of the most prominent economic resources of the country. In order to appreciate better the rapid advance made for the last eight years, it may be mentioned that, in 1896, only six mills were in operation, with a total maximum capacity of approximately 900 tons, while today there are not less than sixteen mills in existence, with a combined maximum capacity for treating 3,500 tons of asbestos rock per day, and, if all the plans of the larger companies working in the district are realized, the capacity of the industry will be increased during the year 1905 to 4,500 tons of asbestos rock per day. It must be mentioned, however, that some of the smaller mines work only intermittently and that a steady production of asbestos from these sources cannot be relied upon.

There are, altogether, fourteen companies incorporated, of which ten are operating their mines and mills, employing about 1,500 men. At present there is a shortage of good miners and, at the time of the visit of the writer, it was difficult to operate the mills and mines to their full capacity on this account. The wages paid for 1903 amounted to about $410,000.

CHAPTER V.

Asbestos Mines and Prospects.

THE THETFORD DISTRICT.

There are four companies working in this area: The Johnson Asbestos Co., the Bell Asbestos Co., the King Bros. Asbestos Co., and the Beaver Asbestos Co.

The Johnson Asbestos Company claims to be the first producer of asbestos in the country, having commenced as early as 1877. Its organization took place in 1879. The works are situated on the northeast portion of lot 27 of the sixth range of the township of Thetford. The Company owns over 1,000 acres of asbestos land in this and in the Black Lake area. The Bell and the Johnson companies are working one great quarry, the division being only a small serpentine ridge in the direction of the east-west line. The Johnson quarry, at its deepest point, is approximately 165 feet which is reached by several terraces, which form the bases for the divisional operations. The shape and dimensions of the quarry are shown in Fig. 7. Seven cable derricks are in operation and most of them are centrally located on one side of the quarry, thus facilitating the hoisting of the rock and its transportation. The quarry shows sometimes small dikes of a whitish granulite, running through the formation in irregular fashion. Near one of these dikes, between the two main pits *A* and *B*, an outcrop of asbestos can be noticed and it is stated that this spot produced a very large amount of long silky fibre.

This rich ground extends to the eastern quarry *B*, where a close examination of the walls reveals the existence of a large number of asbestos veins with long fibre in a massive dark green serpentine. The percentage of crude in this pit is high and appears to be much higher than in most of the mines of the district.

In the western pit *A* a granulite dike runs through the serpentine in a northerly direction, extending into the Bell pit, and, near this dike, the serpentine appears to be rich in asbestos veins, yielding good milling material.

The extension of asbestos-bearing ground towards the south is established by several outcrops which were accidentally discovered in making a deep ditch for a pipe line to the new mill.

The output of milling material is handled by two mills, one, the old mill near the western quarry, having a capacity of approximately 100 tons and another mill, of recent date, with a capacity of 200 tons in double shift.

Some of the old dumps are also worked over and all the good material is sent to the mills. The plant in the old mill consists of two horizontal boilers, one 50 h.p. mill engine, driving a rotary dryer, 18 feet long and 30 inches in diam., dynamo and crusher and another mill engine of 90 horse power, driving the mill proper containing two Blake crushers, two pair of belt rolls, picking table, fiberizers, screens, blowers, etc.

The 200 ton mill is located in a southerly direction from the old mill. The mill engine is a 250 horse power Corliss engine, 18 inches by 42 inches, fed by two boilers of 350 horse power. All the fines of the mine are dried in a rotary dryer located near the mill and driven by a 15 horse power slide valve engine. In the summer season much of the fines is dried on a large platform close to the rotary dryer and it is claimed that by this arrangement considerable expense is saved in hot and dry seasons.

The mill process is the following: The rock goes first through a Blake crusher, from here it drops on a picking table, where boys pick out the waste rock, No. I fibre for cobbing and any iron that may have accidentally dropped into the rock material. It passess then through a second Blake crusher, from there over shaking screens to a pair of geared rolls; then again over a shaking screen to a pair of belt rolls; after this the loose fibre is taken up by suction fans while the residue is treated in two cyclones. Two dynamos of 125 and 250 lights, respectively, supply light and, in the day time, power for the large machine shop, which is equipped with all appliances for making new machinery and most of the repairs. Haulage is done by side dumping cars holding about four tons each and drawn by small geared locomotives, system: Smith.

The dumping ground is placed outside the range of the present workings in a southerly direction. As there is no sloping ground on the property, all the tracks to the new mill and dryer are elevated, a large part of them being on trestles, thus allowing the rock to be dumped directly into the ore bins.

Apart from the above mentioned main buildings, there are on the ground: two very large store houses, carpenter's shop, girls' cobbing shed, men's cobbing shed and a number of small buildings for hoists and accessories.

It may be said that the Johnson Company is one of the most successful companies in the district, having produced the largest quantity of crude. Their product has always been regarded as one of the best on the market.

The average number of persons employed in the summer is about 200 and, in the winter, 150, all of whom live near the mine in comfortable houses owned by the company. These houses form a conspicuous part of the town of Thetford, their neat and clean condition contributing, in a large measure, to the generally comfortable appearance of that place.

This company also owns and operates a property and mill at Black Lake, which will be dealt with under the Black Lake group of mines.

The Bell Asbestos Company commenced its operations in 1889. It took over the business of John Bell & Sons, asbestos manufacturers, and the freehold asbestos estates at Thetford, Hayden and Belmina, in the townships of Thetford and Coleraine.

The company has been very successful from the start, dividends as high as 22½% having been paid on its share capital of £200,000. Mr. Thomas Sheriden was, until his death early in 1892, the resident manager. Mr. George Smith, M.P., the present manager, succeeded him. This company was one of the first to realize the importance of mechanical treatment of asbestos rock. The main operations were carried on on lot 27 A, range V. It had in store from its earlier operations large dumps, which, on account of having been placed close to the quarries, not only covered valuable ground but interfered with the progress of the works.

The reworking of these dumps, which represented a valuable asset not alone effected their removal but proved a profitable undertaking. In 1895 a mill was constructed for the treatment of about 100 tons. Since then a great many improvements and additions have been made, the present capacity being 250 tons in a double shift.

The main pit is alongside the Johnson mine and has attained a depth of 170 feet, an average width of 175 feet and a length of 500 feet. (See Fig. 7). The bottom of the pit is composed of a number of terraces from which all operations are carried on. Numerous asbestos veins, producing first class milling material, occur contiguous to a granulite dike about the middle of the quarry. Very substantial veins of asbestos can also be noticed in the northeastern corner of the pit and at several places along the northern wall in a massive dark gray-green serpentine, slickensided in places. In this connection it may be stated that previous writers supposed the northwestern portion of this property to be practically devoid of all asbestos, and that all the best ground was situated towards the southeast. This is not in accordance with the facts. Apart from the valuable occurence in the northwestern corner of the large pit, recent development work in a northern direction from the main pit has disclosed a stretch of valuable ground as indicated on Fig. 7 and operations are now being pushed on these outcrops with a view to connect the uew with the old, large pit.

The latter is equipped with 11 inclined cable derricks, all located on the northern side, five double and three single drum hoists and several boom derricks for the removal of old dumps.

Only No. 1 quality is cobbed, the balance of the ore is sent to the mill for treatment. Haulage is done by three geared locomotives, (System: Smith). The unique type of the latter was evolved practically from the scrap heap, a dismantled hoisting engine being converted by Mr. Smith's ingenuity into a handy and serviceable locomotive. Side dumping cars of three and a half tons' capacity are used for transport.

The large mill and all the dumping ground are located in the northeastern part of the property, which is reached by a narrow gauge railway crossing the Quebec Central Railway by a substantial overhead bridge.

There are two separate power plants on the property, one located near the big quarry and the other one near the mill. The first one consists of two horizontal boilers of a capacity of 120 horse power, which feeds all the hoists. The other comprises the plant of the large mill and consists of two Laurie Corliss engines of 150 and 250 horse power respectively, two light dynamos, an eight drill air compressor, several smaller engines and four horizontal boilers with a capacity of 500 horse power with forced draft and Dakin feed water attachment. The mill has a capacity of 250 tons of asbestos rock and contains four crushers, two Blake, one Gates and one Dodge; also four cyclones. The rotary dryer has been replaced by a steam pipe dryer and it is claimed that this new method of drying has not only eliminated all danger from fire, but is also very efficient.

In the mill of the Bell Asbestos Company the cleaning of the fibre from dust and sand is performed effectively by a number of special apparatus, and it is acknowledged that the fibre produced in this mill is of superior quality, commanding a high price in the European market.

In order to test the feasibility of underground work, which would be of special advantage in the winter time, a shaft has been sunk in a northerly direction from the main quarry to a depth of eighty-seven feet. Several hundred feet of drifts were run in good asbestos ground, but it appears that the experiment was not successful.

Of other buildings on the property may be mentioned: a first class machine and car repairing shop, a millwright's shop and all accessories incidental to an undertaking of that character. About 200 men are employed.

The King Bros. Asbestos Company.—This company is working close to the Bell pit on lot 26, ranges V and VI, (see Fig. 7). The main quarry is 700 feet long and 165 feet deep, with an average width of 200 feet, the main direction of the works being N.W. 40°.

This quarry has been in operation for about twenty-five years, work having been begun, in 1879, on a little ridge, where the quarry now lies. It is reported that this large quarry has contributed about one-third of the total production since the inception of the industry. A section of the pit along its main strike is shown in Fig. 8. Work towards the depth and the side is conducted from a number of terraces, some of them having a depth of forty feet. The No. 1 crude from this pit is of excellent quality and is specially hand-cobbed, while all the other material goes to the mills. The quarry is operated by nine cable derricks of the tail rope type and the same number of powerful hoisting engines.

Steam for hoisting is generated by a small boiler plant in the vicinity of the works consisting of two boilers of a total capacity of 150 horse power. All machine drills, eleven in number, are operated by compressed air from a 14 drill compressor located in the new mill building. The dumping ground is located in the northern end of the property, rail connection having been established with the mine by an overhead bridge over the Quebec Central Railway.

The rock is transported by three geared locomotives, (System: Smith), and seventy-five side dumping cars, holding four tons each.

There are two mills in operation; the smaller, and older, one is located on the south side and the new large mill on the north side of the Quebec Central Railway track (see Fig. 7). The old mill has a capacity of approximately 125 tons; it is driven by a 16 x 36 inch Corliss engine of 150 horse power, fed by three boilers of a total capacity of 225 horse-power. The new mill has a capacity of 500 tons daily, is driven by a powerful Laurie cross compound engine, 18 x 34 x 42 inches, of 500 horse power, fed by a set of five boilers with a total capacity of 875 horse power, with the induced automatic draft system.

There are, on an average, 175 men employed. The resident manager is Mr. B. Bennett. Since the first of January, 1905, the mine and the whole plant, together with about 1,000 acres of asbestos land in Thetford and Black Lake, passed into the possession of Mr. H. M. Whitney, of Boston, the head of the American Asbestos Company operating at Black Lake.

The Beaver Asbestos Company was incorporated in 1890. The President of this Company is Mr. R. H. Martin, of New York. All the works are situated on lot 31, range C, Coleraine, county of Megantic, near the track of the Quebec Central Railway, one-half mile from Thetford station. Operations in the mines are suspended, but the mill is fed intermittently from dump material, which is piled up in large masses on the property. The whole milling and mining plant is centrally located in the immediate vicinity of the pits. The mill building is four stories high, with additions for boilers and all machinery. (Fig. 34.) There are three horizontal boilers with a total capacity of 375 horse power for mill work and another battery of two boilers with a capacity of 225 horse power for all the hoists and a 14 drill air compressor.

A 300 light dynamo driven by a 15 horse power engine furnishes light for all the works. There are installed three double drum hoists for the operation of the derricks and one single drum hoist for an inclined tramway to haul up the milling material to the upper story of the mill. Four cable derricks of the tail rope system are used in the operation of the pits.

A rotary dryer 35 feet long is placed in a separate small building constructed entirely of iron and the material is carried up by elevators, to the crushers. The mill contains three large jaw crushers, two pairs of corrugated rolls, one rotary crusher, two cyclones and eleven fans with a number of shaking screens, collectors, etc. The same is driven by a Corliss engine, 18 x 42 inches, of 250 horse power. The capacity of the mill in a double shift is 250 tons. All the pits being under water, no examination of them could be made.

THE BLACK LAKE MINES.

On the main serpentine ridge above the track of the Quebec Central Railway are situated: the Standard, the Manhattan, and Glasgow and Montreal mines, also the mines of the Union, the Johnson, the Syracuse and the American Asbestos Companies, the latter being located on the lower ground.

The Union Asbestos Company.—This company, which is composed of German capitalists, is operating on a property of about 104 acres in extent situated on the northwestern part of lots 27 and 28, range B of Coleraine. The mines are situated on a high ridge about one mile distant from Black Lake station and are at present the most elevated in the district, being as much as 900 feet above the track of the Quebec Central Railway. The mines were originally bought from Dr. Reed, of Reedsdale, in 1888, by Mr. Wertheim, of Frankfort, who turned the same over to the American Asbestos Co. Operations commenced the following year, when a steam plant with air compressor, hoisting machinery and derricks were put in and a mill was erected to treat the ore by mechanical process. In 1894 the mines were taken over by the present Company. There are eight large pits on the property at the top of the serpentine ridge, of which three are worked at present.

Enormous dumps on the side of the hill are being worked over, which, in conjunction with the asbestos rock from the mine, furnish excellent milling material. In all the pits party seams can be observed, which by their white colour may be readily distinguished from the other serpentine. The serpentine in the mine is of a grayish-green colour, massive in structure and is bordered on the northwestern side of the hill by a large dike of granulite. All the seams contain a greater or less number of asbestos veins, which have, at times, a thickness of one and one and a half inches.

Nearly all of this seamy rock is good milling material. The ore is conveyed to the mills in three ton dumping cars which are drawn by horses. All the fines are dried in a rotary dryer and are conveyed with the asbestos rock, by an inclined railway, to the big ore bin of the mill and are there automatically dumped. Two machinery plants are installed, one near pit No. 8 on top of the hill, the other on the slope of the hill in the mill buildings. The

No. 8 plant consists of a boiler, three hoists and a Rand 7 drill air compressor. There are four air drills, five cable derricks of the gravity type and four boom derricks in commission.

The output is handled in two mills, one for the production of fibre and the other one for crude. A description of the crude mill is given on page 79. The fiberizing mill contains the usual machinery, consisting of jaw crushers, fiberizer and cyclones and is capable of treating 100 tons per day. The boiler plant is composed of three horizontal boilers, of a total capacity of 115 horse power. A 60 horse power engine drives the mill. About 110 men are employed, on an average, in the mines and mills. They are conveniently housed in a large number of small cottages on the slope of the hill, forming a village in itself.

The whole plant is under the immediate supervision of Mr. Crabtree with Mr. Riehle as mining engineer.

Next to the Union Mine, in a northwestern direction, is the property of the *Johnson Asbestos Company* of Thetford, which is operating on lot 29. The main pit located on the slope of a hill, is about 200 feet long, 175 feet wide and approximately 90 feet deep. The mine is operated by means of one boom and one cable derrick. There is one 50 horse power horizontal boiler installed at the mine, also two double drum hoists.

The crude is all cobbed by hand and the fines and milling rock are dried in a rotary drier which is placed in a separate building near the mine and are then carried in carts to the mill. The latter is a large building four stories high and consists in the main parts of two crushers of the Jaw type, three pairs of belt rolls, two fiberizers (one single and one double), a number of shaking screens and all accessories for milling. The milling rock is delivered by an elevated tramway to the ore bin, which is placed at the upper story of the mill, while the fines are delivered below. The boiler plant is composed of two horizontal boilers of 125 horse power each, with a feed water heater attached; there are two mill engines, each of them is a tandem compound engine of 150 horse power. The mill is lighted by electricity generated by a 100 light dynamo driven by a small ten horse power high speed engine. The whole mill is heated by a McEachren heating apparatus.

The capacity of the mill is 250 tons in a double shift. There are no cyclones used in this mill, the fiberizing is performed by beating apparatus, such as illustrated in Fig. 20.

The Glasgow and Montreal Asbestos Company.—This company's mine adjoining the Johnson property to the southwest is one of the oldest in the district and was the first which made any attempt to solve the difficult problem of cobbing the ore by machinery.

Originally the mine belonged to Mr. Charles Lyonais, who sold it to the Scottish Canadian Asbestos Company in 1886, and in 1891 it was bought by the present Company. Operations have been conducted intermittently, on this property all over the slope of the serpentine hill in some fifteen pits. The mine was supposed to be sold to the New England Asbestos Company, but, as this Company went into liquidation before work was commenced under their management, the property reverted to the original owners, the Glasgow and Montreal Asbestos Company.

Plans are now under way to equip the property in the spring with a first class mining and milling plant. The present manager, Mr. R. Stather, is working under a lease from the Company with a force of about thirty men. He is opening up some new pits on the top of the mountain and getting the mine into working order for the spring of 1905.

The Manhattan Asbestos Company owns the property next to the Glasgow and Montreal. This Company was incorporated in 1901. The President is Mr. C. W. Stapelton, of New York. It took over the Frechette property, containing some seventy-five acres on Block A, Coleraine, formerly worked by the United Asbestos Company of London. The property forms a narrow strip of land 370 feet wide and about two miles long. On account of this narrow width, dumping ground in the vicinity of the works on the slope of the hill is limited. In order to provide a place for dumping the refuse rock, it was necessary to build a tramway 3,000 feet long, over which all the waste rock could be hauled as far as Cariboo Lake and placed on land which is not asbestos bearing.

In several pits which were examined, some fine asbestos veins could be noticed. In one pit a number of shots fired in the presence of the writer in an apparently barren wall of serpentine disclosed excellent asbestos rock, containing a large amount of No. 1 crude and first class milling material. That the ground contains some rich chutes of ore is evidenced by the fact that, according to the Manager's book, in one month in the year 1902, 302 tons of fiberized asbestos were produced in the Company's mill. The quarries are equipped with three cable derricks, one boom derrick and several double drum hoists, while the long tramway is operated by a powerful Bacon hoist, a 12 x 15 x 60 inch duplex winding engine with drums flanged for winding 4,000 feet $\frac{7}{8}$ inch rope. There are two boiler plants on the property, one at the mine, consisting of two upright boilers of a total capacity of eighty horse power, and another near the mill, which is composed of three horizontal boilers of a total capacity of 225 horse power. A seven drill air compressor furnishes the motive power for the air drills. The mill has a capacity of 150 tons and comprises a rotary dryer, Blake crusher, one pair of corrugated rolls, two cyclones and all accessories.

All the works are lighted by electricity supplied by a 100 light dynamo.

No regular mining operations have been carried on, lately, by the Company, but contracts are let out from time to time to work the mine and mill on royalty.

The Standard Asbestos Company owns and operates part of Block A, Coleraine, adjoining the Manhattan Asbestos Company to the east, covering in all about 325 acres. This company took over the property of the Anglo-Canadian Asbestos Company, Limited. Operations were carried on by the latter company from 1890 to 1895 and several thousand tons of crude have been extracted.

A large amount of exploratory and development work has been done all over the property, showing in a more or less degree the extent of the asbestos bearing formation. At present all operations are carried on in a knoll of serpentine on the northern extremity of the property, where several large pits have been sunk. The main quarry has a length of 120 feet, a width of 70 feet and a depth of 40 feet and connection will be made with another large quarry adjoining, where the great bulk of the crude has been mined. The western extension of the first pit, where operations are now carried on, comprises a number of smaller openings and crosscuts exhibiting a very large number of asbestos veins yielding a first class milling material, as shown on plate No. IV. The veins are seen here intersecting the rock in every direction and they range in size from $\frac{1}{4}$ up to one and two inches. About sixty per cent. of all the rock mined is sent to the mill, the extraction of fibre from the milling rock being as high as ten and twelve per cent.

The main pit is equipped with two inclined cable derricks and two boom derricks, three air drills, one double and two single drum hoists.

Air for the drills is supplied by a five drill air compressor. The mill is in close proximity to the mine and the derricks dump the ore close to the ore bins. A section through the mill is given in Fig. 26 and a description of the same on pages 64, 65, 66 and 67. The boiler plant consists of three horizontal boilers with a total capacity of 240 horse power. A 150 horse power slide valve engine drives the mill and dryer, while the first Blake crusher between ore bin and dryer is driven by an extra 25 horse power high speed engine, the works are all lighted by electricity furnished by a 150 light dynamo.

This Company with its extensive asbestos bearing area should be able to contribute largely to the output from Black Lake, especially when it is considered that the work so far conducted has laid open a great number of places from which to draw ore, while the capacity of the mill, which is at present only 150 tons per day, can easily be doubled with a few additions to the present machinery.

About fifty men are steadily employed with Mr. W. A. Clearihue as Superintendent; Mr. R. T. Hopper, of Montreal, is the President and Managing Director of this Company.

The American Asbestos Company.—This new American company, of which Mr. H. M. Whitney of Boston is the head, has taken over the property of the late Mr. Murphy, lot 32, range B, Coleraine.

Two large pits are in operation. One is located near the road leading to Thetford, on the slope of the hill, and is about 150 feet long and 125 feet wide with a shallow depth. The other one is situated in an easterly direction from the latter and consists of a quarry of irregular shape about 175 feet in length and from 70 to 80 feet wide. Both pits exhibit a fair amount of milling rock and it is reported that the bottom of one of the pits is in excellent ground. Some years ago, this area was, accidentally, discovered by removing the drift in an excavation near the road, when several good veins, some measuring over one inch in width, were exposed. Some of the old dumps situated close to the open quarries, probably on valuable ground, interfering with the gradual systematic progress of open cast mining, are being removed now, the good milling material being sent to the mill. Work is at present vigorously pushed in both quarries, about 100 men are employed. Five cable derricks and two boom derricks with six hoists, three of them operated by electricity, are in operation. The mill is located near the track of the Quebec Central Railway, at a distance of about 1,000 feet in a northerly direction from the mines.

Haulage is done by a narrow guage locomotive and a number of large dumping cars, holding four tons each, of the tilting type.

The mill is recently built and is fitted out with machinery and apparatus to some extent different from that usually employed in the district. All the ore and rock material is weighed on a large Fairbanks scale placed on the track near the first ore bin. The rock is first crushed in large Blake crushers and is then sent through two large rotary dryers. A second large 350 ton ore bin between the dryer building and the mill proper serves as a reserve in case the mill for some cause should come to a temporary standstill. Dryers and crushers are run by separate electric motors while the mill proper is divided into different sections, each one of which is run independently of the others. The main feature of this milling plant is the separation of the different grades after the rock leaves the crusher, in the manner described on page 68. It is intended to make use of all the refuse of the mill as a fire-proofing material by grinding the same in powerful Sturtevant Emery mills. The completed mill is reported to have a capacity of 600 tons of rock per day. The motor power for the whole milling plant and for part of the hoists is electricity, which is furnished by the St. Francis Hydraulic Company from its main power station, 18 miles distant on the St. Francis river.

An auxiliary steam plant, consisting of two tubular Mumford boilers of about 300 horse power, is installed, furnishing steam for a 250 horse power Robb Corliss engine, which drives the large dynamo. A plan and description of all the buildings is given in Fig. 33. The latter are of very substantial construction with concrete floor and foundations and are covered with corrugated iron. The Company has a number of nice small cottages erected for its officers and men in the immediate vicinity of the mill, which by their neat condition contribute in a large measure to the pleasing appearance of Black Lake.

The Syracuse Asbestos Company.—This company recently bought the property of Dr. Reed, of Reedsdale, comprising lots 27, 28, 29, range A, Coleraine, covering in all about 500 acres. The main workings have been carried on on lot 27 near the road leading to Thetford, on a small ridge of serpentine, which strikes in an eastern direction through the country. From one pit, measuring 75 feet in length, 50 feet in width and of shallow depth, about 1,000 tons of rock have been taken, which carried good fibre, short and long, yielding a large percentage of milling material.

The serpentine is conspicuous on account of the occurrence of distinct seamy partings, generally of a whitish colour, most of which carry in the middle very fine silky veins of asbestos.

In the bottom of one excavation a number of veins, reaching in places a thickness of one and a half and two inches, of very fine fibre were noticed. There are a number of dikes of granite cutting the serpentine on this property and it appears that in the vicinity of these dikes milling material, as a general rule, is plentiful. Many shallow openings made all over the property on outcrops show more or less the occurrence of the mineral.

The machinery plant consists of two Ingersoll tubular boilers, one 7 drill air compressor and a small experimental mill containing crusher, fiberizer and screens, all driven by a small 25 horse power engine. The quarry is equipped with a hoist and boom derrick. About twenty men are employed. The Company, on the advice of its General Manager, Mr. N. E. Loomis, of Syracuse, intends to put up a mill of large capacity next spring, for which, plans are now being made.

THE EAST BROUGHTON MINES.

The East Broughton mines are situated about twenty-two miles distant from Thetford in a northeasterly direction. The serpentine area is situated to the west of the Quebec Central Railway. Only two mines are working here: those of the Quebec Asbestos Company and of the East Broughton Asbestos Company, operations on the old Broughton or Fraser mine having been suspended some years ago.

The Quebec Asbestos Company is working on lot 13, range VII, (Fig. 5), in a serpentine belt which has a width of about 150 feet and runs in a north-easterly direction.

The main pit is about 110 feet long, 65 feet wide and 15 feet deep. A description of the occurrence of asbestos in this peculiar formation is given on page 21. The quarry is operated by means of a cable derrick of the tail rope type and a steam hoist.

The serpentine is much softer than that found in Thetford and Black Lake and the asbestos veins are disseminated through the whole serpentine mass, yielding an excellent milling material. It may be mentioned that the colour and general aspect and texture of the East Broughton serpentine resembles very much the East Templeton species. The mill contains a rotary dryer, a Blake crusher, a rotary crusher, two beaters and two cyclones, elevators being very few. All the rock is first crushed and dried and then conveyed by a sixteen inch rubber belt to the rotary crusher, or to a large reserve ore bin, the latter being used only in case of temporary stoppage of the mill. The mill is laid out in such a way that another section of the same plant may be added at any time when required, which will be run independently, thus insuring the permanent operation of the mill, in case of breakage or of a temporary shut down from other causes.

The capacity of the mill is about 150 tons and it is stated that as much as seven and eight per cent. and occasionally ten per cent. of the total rock mined can be extracted as fibre.

The boiler plant consists of two boilers, supplying a 250 horse power Corliss mill engine. A small 15 horse power engine drives a 200 light dynamo. There are thirty-five men employed in all Mr. John Penhale being the general manager.

The Broughton Asbestos Company is working on the south-western extension of the same serpentine belt on which the Quebec Asbestos Company is working.

This belt widens out at some places to 600 and 700 feet; the enclosing rocks are the same, the usual altered slates and schists of the district with gashy quartz veins. There are two pits in operation. One pit has a length of about 200 feet, a depth of 40 feet and an average width of 100 feet. The serpentine here appears to be much crushed along the planes of fracture. Very fine silky veins can be noticed in some of the seamy partings, while the milling material in some parts of the quarry is plentiful. There is some variation in the colour of the veins. Some of the latter have a grass green colour, others a pale brownish or amber and others again are of a darker colour coming from a dark coloured serpentine. The black serpentine and asbestos veins lose their colour, however, when exposed for several days to the light and assume then their green tint again.

In the upper part of the quarry a dark, soft and clayey material appears in seams between the rock, probably a decomposed serpentine in a thickness from three to six inches, which becomes quite hard when exposed to the air.

The other pit is located at a distance of 100 feet in a north-easterly direction and exhibits similar features to those already described. On the northern wall there appear four apparently different zones of serpentine, parallel to each other and dipping under an angle of 50°, the lowest being a solid, massive rock, the second one a much shattered rock of blue colour, fifteen feet wide, then a green serpentine ten feet wide and the top zone a dark, solid rock. The second and fourth zones are rich in short asbestos fibre and yield the bulk of the milling material, while the first and third zones are poor.

Both quarries are operated by means of two booms and one cable derrick with three hoisting engines and are connected by a narrow guage track with the mill, which is located close to the pit No. 1.

The Company built an extensive milling plant two years ago, but the latter was destroyed by fire, caused by overheating the rotary dryer. The mill was rebuilt, a number of improvements made and work started in the spring of 1904.

This mill is built on similar lines to that of the Quebec Asbestos Company; electro-magnets are used for the extraction of all magnetic iron ore (see page 67), which is often met with in small knobs in the veins as well as in the rock. The boiler plant for the mill is composed of two horizontal boilers, one of 80 and the other of 120 horse power capacity. A 150 horse power engine drives the mill; crusher, belt conveyor and rotary are run by a 60 horse power engine and a 75 light dynamo by a 12 horse power high speed engine. The mill can treat in the summer about 140 tons in a double shift and in the winter, on account of the very wet condition of the serpentine, only 100 to 110 tons. Mr. H. H. Williams is the Manager of this excellently handled property.

THE DANVILLE MINES.

The Danville mines were first opened in the year 1879 and worked almost continuously from that time by Mr. Jeffrey of Montreal, until shortly before his death.

They were then taken over by the Danville Asbestos and Slate Company, Limited, and were operated from 1893 to 1895 with a force of about 400 men. A mill was built for the extraction of the smaller fibre and also for the manufacture of the ground waste material into asbestic.

In 1895 the mines were sold to the *Asbestos and Asbestic Company, Limited,* with a share capital of £500,000 in shares of £10 each.

The property taken over from the Danville Slate and Asbestic Company comprised lots 8 and 9, range III, township of Shipton, County of Richmond, Que. Seventy-five acres of the area was freehold asbestos property with factories and buildings and plant thereon and 600 acres of freehold land with growing timber, near Danville, with sawmill and slate quarry and about 200 acres of freehold land with buildings, machinery and dwellings thereon.

There were immense dumps on the property from operations extending over a period of fifteen years and the mill, besides treating the regular output from the mine, for a number of years was kept busy working over these dumps which yielded a large amount of asbestos fibre and asbestic. In 1900 fire destroyed the whole milling plant; a temporary two cyclone mill was put up and in 1902 a new mill of large capacity was built, being one of the largest establishments in the district. The principal quarry is located on a hill in the middle of a small area of serpentine and is about 1,200 feet long, on an average 175 feet wide and 175 feet deep, with a main northwest southeast trend. The serpentine in the pit is much fissured and affected by faults and is generally easily mined. The general character of the rock is good, veins one-half inch thick intersect the mass in all directions, while fine, short fibre is disseminated through the mass, giving excellent milling material. The larger fibre is still cobbed by hand. About sixty per cent. of all the serpentine mined goes through the mill, while the dump to a large extent is made up of rock from small granitic dikes, which traverse occasionally the sides of the pit. It must be said that the mine as a whole is a first class milling proposition and in this respect it compares favourably with some mines in the other districts. The mine is equipped with nine cable derricks of the tailrope type, two boom derricks and the same number of hoists, all of them being located on one side of the main pit on a plateau, from which the output is efficiently handled.

All the machine drills are run with compressed air from a 20 drill air compressor. Communication between mine and mill and dumps is effected by a narrow gauge railway, by means of two small locomotives and about sixty cars of the tilting type, of about six tons capacity each. The large mill handles about 500 tons of asbestos rock in a day. It consists of several separate buildings, as follows:—

(1) The Crushing Works, containing:—

2 single Blake crushers of	36 x 24	inches
2 duplex " "	40 x 10	"
2 " " "	40 x 6	"

(2) The Drying Building.—This is a solid brick building with iron roof, containing:—

4 cylindrical dryers, each 4 feet in diameter and 30 feet long.

2 elevators of 40 feet.

(3) The Grinding and Fiberizing Building, containing:

6 cyclones.

8 suction fans, each of 45 inches in diameter.

20 shaking screens.

6 revolving cylindrical screens.

The large crushers and dryers are driven by a 250 horse power and the mill by a 400 horse power engine, both of the tandem compound type. The sand residue is conveyed outside the building by an endless rubber belt 475 feet long. There are three grades made: Nos. I, II and III, while a part of the sand residue is manufactured into "asbestic." It is stated that the extraction of fibre from the milling rock is about ten per cent. In addition to this large mill the small two cyclone mill, as mentioned above, with the capacity of 200 tons and driven by a Laurie 250 horse power engine is still in operation.

The company owns and operates the line and rolling stock of a railway five miles long, from the mine to Danville station.

The principal boiler plant for the operation of the large crushers, dryer and the mill consists of seven horizontal boilers of 125 horse power each. There are three fire stations distributed over the works and one large duplex pump of a capacity of 1,000 gallons per minute is kept permanently under steam. A large store house, a well equipped repair shop and other buildings of lesser importance make up the balance of the plant of this enterprising concern.

The whole plant is lighted by electricity generated by a 200 light dynamo. About 300 men are steadily employed. Mr. James R. Pearson is the manager, associated with Mr. H. Williams as mining engineer.

ASBESTOS LOCATIONS AND PROSPECTS.

Apart from the mines mentioned above, there are many outcrops and locations of the mineral all over the serpentine areas so far discovered, which by reason of their appearance give encouragement for further exploitation. Amongst these may be mentioned the following:—

Lot 17, range IV, Thetford, belonging to Dr. Reed, of Reedsdale. There is an outcrop of serpentine on this property stripped for about 100 feet square on the slope of a hill. A small open cut shows a number of fine parallel veins of asbestos one-half and three-quarters of an inch in thickness, in a dark green and gray, massive serpentine. Distance about two and a half miles from Robertson station, Q.C.R.

Lot 13, range V., situated about two miles from Robertson station, belonging to Dr. Reed, of Reedsdale. A shallow opening in the hillside in a mass of shattered and crushed, light green serpentine shows similar conditions as those found in East Broughton.

The serpentine carried veins of one-half inch in thickness and a number of veinlets can be found all over the place; an area of 60 by 50 feet has been stripped disclosing what appears to be good milling material.

Near Kinnears' Mills, in the township of Leeds, several outcrops of serpentine have been found, but so far not much asbestos has been found in them. In the concession of Ste. Catherine on the road east from St. Sylvestre some exploration work was done, but nothing of importance was found.

East of the railway, in Thetford, serpentine is seen on lots 10 and 11, range VII; on lots 14, 15 and 16, range VIII; lots 14 and 15, range IX, and on lots 5, 7, 9 and 10, range X. The rocks in all these places do not belong to the productive variety. In Adstock several outcrops of serpentine can be found, but the rock also seems to lack asbestos in paying quantities.

Lot 14, range VII, ~~Thetford~~ Broughton*. This is the old Fraser property which was worked some years ago. The serpentine on this property has a slaty structure and contains in one of the outcrops a number of small veins. Mining, however, has been confined to a peculiar vein which was developed on the southeast margin of the serpentine close to the contact with the overlying schistose slates, which have at this place a dip to the southeast at an angle of 65°.

The asbestos vein, which in places assumes a thickness of ten and twelve inches, follows a wall of soft talcose rock or soapstone from twelve to fourteen inches thick. The quality of the asbestos is excellent, but the veins are irregular, splitting up sometimes into fine strings disseminated through the serpentine and at other places uniting and forming a continuous lead for about 100 feet. Some of the shorter fibre appears to be somewhat stiff and harsh in texture. Wherever the vein assumed a large size, the fibre was

*Dr. Ells, Bulletin on Asbestos, 1903.

soft and silky. Three shafts were sunk to a depth of 60, 62 and 75 feet respectively, following the slope of the soapstone. The serpentine belt is in parts very narrow, contracting in places to not more than fifteen feet in width, the veins being found close together.

Lot 31, range B, Thetford: A group of veins of large size and excellent quality was found on this lot by a prospector who was working for the Johnson Asbestos Company. The rock resembles in character that from the best mines in Thetford, contains apparently many large and fine veins of No. 1 quality, quite equal in quality to any found in the Thetford area. This discovery has added new value to the lower area adjacent to the south of the railway.

Lot 26, range A, Coleraine: Here several large pits have been opened, but most of them are now under water. Indications of veins are quite numerous, but the rock as a whole appears to belong to the harder and drier variety of rock, indicating an approach to the comparatively barren belt further to the southeast. A number of short fibre veins occur in this area, but as a whole the output appears to be mostly milling material. On lot 25 a little work of an exploratory character has been done and the rock here also appears to be of the harder variety.

Lot 32, range A: Some work of an exploratory character has been done on this lot, known as the Hayden property.

The rock here is a somewhat slaty serpentine of good character, but nowhere exhibited such massiveness as that of the Thetford areas. A good showing of veins was found and the fibre appears to be of satisfactory quality.

Lots 24 and 25, range III, Ireland: This property was at one time operated by King Bros, of Thetford. The elevation of the openings above lake level is about 500 feet.

The serpentine here presents a roughly bedded appearance with a dip to the northwest of 35° to 40°, in which the fibre was also found in zones, varying in length from one-quarter of an inch to one inch. Some No. I and II crude was obtained and some 500 tons of asbestos were extracted and shipped to Coleraine station, a distance of five miles.

On lot 26, range III, there is a knoll of serpentine, in which a number of veins of short fibre can be noticed. Around the sides of Silver mountain which is the prominent peak west of the lake small veins were also disclosed, but the district as a whole appears to be unproductive and no serious mining has been attempted.

Asbestos has been found on one of the islands of Nicolet lake, township of South Ham. The serpentine rock which forms the large island rises abruptly out of the water to the height of seventy feet and is apparently seamed all through with asbestos. Many openings have been made here, revealing in most of them asbestos of good quality. This mineral, however, presents many points of difference from that of Thetford and Black Lake. Mr. Willimott, of the Geological Survey, in his report in 1882 says: The asbestos consists of four varieties:—

1st.—Small veins, rarely exceeding half an inch in width; the fibres are not easily separable, which, the writer says does not detract from its commercial value.

2nd.—Apparently occupying a position at right angles to the veins above noticed is a coarse fibrous mineral resembling rope and evidently derived from the associated picrolite. The extreme length which these fibres may attain could not be determined, but judging from exposed portions it cannot be less than three feet.

3rd.—Veins somewhat resembling the latter in aspect, but much finer in texture. The fibre can be separated with great facility, though firmly attached at one end to the parent rock.

4th.—A steatitic asbestos rock resembling "mountain leather," forming important masses which enclose small concretionary pellets of asbestos, the centres of which contain a nucleus of serpentine. This is a peculiar formation which has been nowhere observed to so great an extent as here.

Bras du Sud Ouest.—The outcrops on the Chaudiere river at the Bras du Sud Ouest present also different features from those in Thetford and Black Lake. Here the rock is in many places a serpentine breccia, being only partially serpentinized as an alteration apparently from a pyroxenic mass. At several places where the serpentine is better displayed small veins of an impure asbestos are seen, but these are of no economic importance. The associated rocks are black, rusty slates with bands of hard grits and slate conglomerate. Diorite and granite are found in the immediate vicinity.

Des Plantes River.—Some asbestos has been found on the Des Plantes river which is on the north side of the Chaudiere. Here black and gray altered slates and quartzites are in contact with a dark, slaty serpentine, which is cut by dikes of a white granite. Some small veins of asbestos can be seen, but as no further work has been done on these outcrops no definite opinion can be expressed.

Wolfestown.—The asbestos area of Wolfestown is situated on the north-eastern extremity of a serpentine ridge which extends south-westerly with many interruptions from the road leading from Coleraine station to Wolfestown,. in the vicinity of Lake Nicolet.

On lots 23 and 24, range II the mines formerly belonging to the Belmina Estate but lately to the Bell Asbestos Company are situated. The rock here met with is of a hard variety at some points and at others it resembles the serpentine in Black lake It is probable that the ground will yield good milling material.

Near Brompton Lake.—On lot 26 and half of lot 25, range IX, Brompton, comprising in all about 350 acres, some work was done in 1889 by the Brompton Asbestos Company, a Montreal concern. It is reported that some of the fibre is of excellent quality. The rock is associated with great masses of diorite and slate containing white garnets and is different in many points from that of Thetford and Black lake. It is harder and darker coloured, but in places it becomes talcose in aspect. The veins are often brittle, without the fibrous character. The area as a whole has not been a producer to any large extent.

Some prospecting was done in *Tingwick*, on lots 11, 20 W. and half of lot 19. A shaft fifteen feet in depth was sunk and some good fibre was found, some of the specimens being one inch long. The serpentine seems to be largely developed in this region and results so far attained give encouragement for further development work.

Lake Chibougaman.—A new mineral belt has been discovered in the country southwest of lake Mistassini, near lake Chibougaman, by Mr. P. McKenzie of Montreal.

Mr. J. Obalski, Government Mining Engineer, who at the head of an exploration party was sent into that country, reports that there exists a belt of serpentine seven to eight miles long, on the northeast margin of lake Chibougaman and on the shores of McKenzie bay. This serpentine is of a greenish colour; resembles the serpentine from the Eastern Townships and contains in places a very fine silky fibre from one to two and a half inches in length. Some fibrous varieties of hornblende similar to the Italian asbestos have also been found with fibres five and six inches in length and it appears that this and the silky variety occur all over the area, justifying the exploitation on a larger scale. Mr. Peter McKenzie has organized a company which will prospect the area under question thoroughly in the summer season of 1905.

The distance of this mineral zone from Lake St. John is 170 miles.

CHAPTER VI.

ASBESTOS IN FOREIGN COUNTRIES.

UNITED STATES.

Most of the asbestos mined is of the amphibole variety, with the exception of the small amount of asbestos produced in Massachusetts and in Arizona, which was of the chrysotile variety. During 1903 the production of asbestos was principally from the Sall mountain, White county, Ga., also in smaller quantities from near Dalton, Berkshire county, Mass.; New Hartford, Conn., and Grand Cañon, Arizona.* The Connecticut Asbestos Mining Company, whose deposits of amphibole asbestos are in the town of New Hartford, Conn., has erected a complete plant for crushing and rolling the crude rock and for separating the fibre. This company treated a small portion of its production of 1903 and prepared it for the market. At the Bedford county, Va., deposits of the American Asbestos Company, a 40 ton plant for crushing and separating the asbestos is nearly completed. This company has mined a large quantity of crude rock and has it stored ready for treatment when its mill is completed.

The Sall mountain Asbestos Company, whose deposits are located at Sall mountain, White county, Ga., still continues to be the largest producer of asbestos in the United States. There was no production in 1903 from the other Georgia deposits of amphibole asbestos. This is also true of the North Carolina deposits located in Polk, Mitchell and Wilkes counties, where this variety of asbestos is known to occur in large quantities and it is true also of the Wisconsin deposits located near Stevens Point, Wood county, and of the Vermont deposits.

Notwithstanding its quantity, cheapness and ease of production and transporation, many of the largest manufacturers of asbestos products in the United States do not handle the amphibole variety.

*Pratt, "The Production of Asbestos in the United States," 1904, page 6.

It is quite common to find the chrysotile asbestos or fibrous variety of serpentine in small amounts associated with the serpentine rocks in various localities throughout the United States. At Gaspar, Wy., deposits of the chrysotile variety have been found that have warranted further investigation and development, This work has been done by the McConnel Asbestos Company of Pittsburg, Pa., but so far the output and shipments have been small.

There was also a small production of asbestos in 1903 from the Dalton locality in Mass.

The Vermont localities in Orleans and Lamoille counties did not produce at all for the last two years. The most promising deposits in that section are those of the Vermont Asbestos Company and the Tucker Asbestos Company. The former company's deposits are located about six miles northeast of Belvidere mountain and two miles northeast from the village of Lowell. The Tucker Asbestos Company's property is on the eastern slopes of Belvidere mountain, in the southwestern part of Lowell township, Orleans county, about five miles southwest of the village of Lowell. Development work was carried on in 1903 on both these properties and the latter offers perhaps at the present time the most favorable opportunity in the Vermont district for developing deposits of chrysotile asbestos.

On account of the interest manifested by Canadian asbestos men in the discovery of the chrysotile variety in Vermont, it may be of importance to give here a brief account of the results of the investigations conducted by Professor J. F. Kemp:—*

"Asbestos was discovered many years ago in various parts of Vermont. The revival of interest appears to be due to the fact that some seven or eight years ago a French-Canadian lumberman in the employ of Mr. M. E. Tucker discovered, while felling trees on the eastern side of Belvidere mountain, in the extreme western portion of Lowell, a vein of chrysotile and at once recognised its similarity to the Canadian product which he had seen in the Quebec mines. Mr. Tucker, therefore, began the search for the workable deposits and either through his own efforts or through the interest aroused in others the present developments have been attained. They bid fair to be commercially productive, although they are now in the initial stages of development.

"The asbestos is found in the town of Eden, Lamoille county and adjacent to the town of Lowell, Orleans county.

*"U. S. Mineral Resources, 1900," page 862.

"Near the town of Eden there are lots close together which exhibit the mineral in fair quantities and some extensive work has been done in 1900 by the New England Asbestos Mining and Milling Company.

"At no great distance east or northeast of the New England Company the line between Eden and Lowell runs across the serpentine belt in a northwesterly direction. Continuing northeasterly on the southern side of the serpentine belt, there is one of the openings which have been made by Mr. M. E. Tucker in Lowell.

"Some blasting has been done here and the serpentine is well exposed. About six miles northeast of this exposure and beyond Lowell village a belt of serpentine distinct from that at Belvidere mountain appears and in it Mr. Tucker and his associates have done some blasting and have exposed considerable fibre. The country rock throughout is a slaty mica schist. It lies to the southeast and east of Belvidere.

"As the mountain is approached, a great shoulder is found projecting to the south from the foot of the main peak. Wherever crossed by the writer it consists of serpentine. It rises 1,000 feet or more above the valley and on the top forms a sort of step against the remainder of the peak. To the north of the serpentine and rising above it as a precipitous wall a great mass of hornblende schist appears. It has a rather flat dip to the east and is broken into blocks by two pronounced sets of joints. It rises in a series of precipitous escarpments, 1,500 or 2,000 feet above the serpentine In places the hornblende schist has been altered to chlorite schist. Just to the south of the excavation made by the National Asbestos Company an important fault is visible which strikes into the mountain in a direction 15° west of north according to magnetic compass, but since local attraction sometimes appears in this region the observation may not be exact. At all events the fault brings the hornblendic or chloritic schist abruptly against the serpentine and cuts off the latter from extending further to the west. Several feet of fault breccia mark the location of the fault The serpentine belt appears to be a broad one, but its approximate width cannot be readily stated because it is concealed by forests and because the writer's observations were of necessity made without a map. It is evident that the location of the New England and the National companies is on the northern edge of the serpentine, while the prospects of Mr. Tucker are on the eastern edge and much lower down. The New England and National companies exposures are fairly near to the outcrops of the hornblende schist forming the mountain on the north.

"In all the exposures where the asbestos appears, the serpentine forms precipitous cliffs and the excavations have been made in the face of these escarpments. For a long time, therefore, the rock can be blown out from open cuts which will be above the general surface of the ground. In the openings made by Mr. Tucker, near Tucker's Mill, the conditions are very similar. A hillock or shoulder of serpentine projects from the mountain side and is bounded by gulches on the west, south and east. The openings near the town of Lowell are likewise situated in a ridge of serpentine and have been driven in on both sides and from the northern end."

The asbestos occurs in two distinct and contrasted varieties. In one case it forms veins which ramify in every direction through the serpentine. The asbestos fibres are perpendicular or at a high angle to the walls and vary from a maximum length, as at present exposed, of three-fourths of an inch down to not more than one-sixteenth of an inch. The variety is similar in all respects to the Canadian product but it is met only in the prospects owned by Mr. Tucker at Tucker's Mill and near Lowell. The second variety of asbestos is what, for lack of a better name, Professor Kemp calls "slipfibre" because it occurs upon the slickensided surfaces that are common to this exposure of serpentine just as to all others the world over. These fibres form layers of varying thickness, seldom more than a quarter of an inch, but as they run parallel to the slickenside surfaces they may themselves be of various lengths, from a fraction of an inch up to three or four inches. The fibre is coarser than that of the veins and will not furnish so good a grade. It is, however, more abundant.

Professor Kemp adds that it is likely that the region will become commercially productive. It is possible that in time larger veins may be discovered of first grade quality, but at the present time nothing but short asbestos, second and third quality, can be produced. The serpentine belt runs for great distances to the north and while it is impossible to report other definite discoveries the area within which the geological formations are favorable for the occurrence of asbestos appears to be considerable.

However, the serpentine has been already somewhat carefully prospected, with the result that no exposures and occurrences of the character as seen in Thetford and Black Lake have so far been observed.

The deposits of chrysotile asbestos in the Grand Cañon, Arizona, which are owned by the Hance Asbestos Company, were mined to a small extent, but the work was more of an exploratory nature. Mr. John Penhale, manager of the Quebec Asbestos Company, at East Broughton, has spent about ten months in the development of the asbestos occurrences on behalf of New York capitalists and he describes the serpentine, which occurs everywhere in the steep bluff in the Cañon, as a yellow-green, harsh rock, sometimes massive, sometimes in a crushed and disturbed condition, overlaid by sandstone. Asbestos veins are few, mostly in a horizontal position and parallel to each other and the fibre in most of the occurrences is frozen to a serpentine of opaque, cherty appearance. The fibre is whitish, with a yellow-greenish tint resembling much the Templeton asbestos. The quality of the asbestos is good and some of the fibres are two inches in length.

In 1903 a deposit of chrysotile asbestos was found in Arizona at the head of Pinto creek, twenty-three miles west of Globe, Gila county. This deposit has been located by Mr. M. L. Shackelford, of Prescott, Ariz. The asbestos bearing serpentine can be traced for over three miles and the asbestos deposits are as a rule found on the contact with the country rock. Samples of this asbestos have been examined and were found to be of good quality, the fibres varying from a fraction of an inch to two and three inches in length. The only work that has been done on this deposit up to the present time is the one year's assessment work so that there is not very much known as yet regarding the extent of the deposit or the percentage of asbestos that can be obtained in mining.

In Yancey county, N.C., about eight miles west of Spruce Pine, on the road to Burnsville near the junction of the North and the South Toe rivers, chrysotile asbestos has been found in some quantity on a hill which rises about 300 feet above the surrounding country. The fibre is of good quality and although but little work has been done on the deposit the serpentine has been proved to contain the asbestos for a distance of 250 feet in length, by 50 to 75 feet in width. A tunnel running about thirty-five feet below the outcrop encountered the same chrysotile asbestos at that depth.

NEWFOUNDLAND.

In the beginning of the nineties some excitement amongst asbestos men was caused by the alleged discovery of a fine asbestos in large quantities in the serpentines on the west coast, chiefly in the vicinity of Port au Port bay. The rocks with which asbestos bearing serpentines are most commonly associated in the Province of Quebec form a considerable belt along the west coast of Newfoundland. In these rocks, which consist of slates, sandstones, diorites and tremolites, are also to be seen large masses of serpentine similar to that at Thetford. Here and there also are great mountains of magnesian limestone and in the region of Grand lake and other isolated sections are found carboniferous basins. Still, this entire area, extending about 100 miles north and south and the entire width of the Island east and west, can be safely called a serpentine country and contains, according to Mr. James P. Howley's estimate, 5,097 square miles of serpentine rocks. Mr. C. E. Willis,* of Halifax, and Mr. Robert Jones,** of London, England, have spent considerable time in the investigation of these asbestos deposits and a brief account of the character of these deposits may not be out of place.

The serpentines with the granulite dikes which everywhere intersect the country rock contain vast deposits of minerals and are to-day, with the exception of the immediate coast line, nearly virgin fields for the prospector and miner.

The existence of asbestos in this great belt of serpentine has long been known and several well known geologists in their writings have predicted that it would be discovered in quantities sufficiently large to be of economic value. On the eastern coast of Port au Port bay, rising out of the sea to a nearly vertical height of 1,800 feet, is a mountain known as Bluff head. This mountain determines the southern boundary of the serpentines. For many miles north the coast line is precipitous and lofty, culminating at Cape Gregory in a bluff nearly 2,500 feet high.

At Bluff head and extending for about one mile north the beach is composed of conglomerate, very hard and highly polished on the surface by the action of the surf which breaks upon it. The beach is strewn with boulders of all sizes which have fallen down from the cliffs and nearly all of them contain seams of asbes-

*Canadian Mining Review, 1893, page 207.
**Asbestos, by R. Jones, 1897, page 55.

tos, while the conglomerate of the beach itself is filled with it. It was here that the asbestos first attracted much notice.

Long known to the fishermen of the neighborhood as "cotton rock," it came to the knowledge of the Honourable Daniel Cleary of St. Johns, who equipped a small expedition to do some prospecting in the neighborhood.

A great many claims were at once secured and in a short time some thirty square miles were taken up by prospectors and speculators. Development work was started, but it appears that no operations on a large scale were conducted on any of the properties. Most of the development work was done by the Halifax Asbestos Co. The work extended over many hundreds of feet along a gluch and some ten or twelve large cuts were made in the mountain side through the surface drift. In each opening small veins of asbestos were found, while the surface drift, which varied from three to twelve feet in depth, was in most cases saturated with loose fibre entirely free from the matrix, the result of the decomposition of the serpentine through the action of frost and weather.

The fibre is mostly short; specimens, however, of two inches in length have occasionally been found. It is claimed that the peculiar green tinge of the asbestos, the colour and composition of the serpentine and the granulite dikes and many other geological peculiarities go to prove the remarkable similarity of this region with the asbestos district of Quebec.

However, as already stated, nothing beyond work of an exploratory character has been undertaken on any of the properties and on account of the remoteness of the districts, the sporadical and erratic occurrence of the asbestos there is no likelihood that Newfoundland will ever become "Quebec's greatest rival ere long," as an enthusiast puts it.

ITALY.

Prior to 1880 asbestos was only mined in Italy but the uses being so limited on account of the exorbitant prices asked for good fibre, the production with very few variations remained the same. But when Canada came forward with its vast resources of the mineral the whole industry assumed a different aspect. Italian producers soon found that they could not compete with the Canadian mineral for the following reasons:—(1) Mining is more difficult on account of hand labour, which is compulsory owing to the character of the ground; (2) Supply is very uncertain; (3) The fibre is much more difficult to deal with than the Canadian asbestos, requiring different and more complicated machinery.

Further, it is also reported that the better class of fibre is limited.

Although the two species of asbestos, the Canadian and Italian are so entirely different in the physical properties, chemically speaking they are very similar and for certain applications may replace each other.

Italian asbestos is a fibrous form of hornblende and is different both in form and appearance from the Canadian species, which is generally termed chrysotile. Both the Canadian and Italian varieties possess some fine qualities and characteristics and each of them find its special application. Manufacturers even say that in some cases a mixture of both gives better results and is superior to the best quality of either of them used separtely.

The chemical composition of Italian asbestos is very nearly the same as that of the Canadian mineral, as may be seen from the comparative analysis made by Prof. J. T. Donald, of Montreal, page 9.

According to Mr. Alfred Fisher*, the General Manager of the oldest asbestos company in existence, the United Asbestos Company of London, England, Italian asbestos mining may be considered to have commenced with the nineteenth century.

We find that about one hundred years ago two enterprising citizens of north Italy conceived the idea that what had been done in ancient times might be undertaken for modern requirements and that a cloth made of this material would answer well for various purposes. They carried out some experiments in Lombardy which were considered to be, to a certain extent, satisfactory and which earned for them some honorary distinctions from Napoleon I, who was always ready to encourage sciences, arts and industries. The numerous crises which kept this part of Europe in a perpetual state of disquietude prevented the development of the trials and for a further space of years asbestos seems to have been looked upon as a substance of some interest to the mineralogist and geologist, but of little or no practical and commercial value.

It was not until the year 1866 that Signor Albonico, having given some attention to this product of the mountains of his native province, put himself into communication with a highly cultured

*Paper read at a meeting of the Institute of Marine Engineers, Stratford, England, April 12, 1892.

and intelligent Florentine cleric, Canon del Corona, with a view of obtaining his assistance in developing the economic uses of asbestos. They were subsequently joined by a distinguished Roman nobleman, the Marquis di Baviera.

The result of their endeavors was, that they produced some asbestos cloth and paper and were in hopes of obtaining a contract from the Italian Government for the supply of the latter for bank notes and other securities, but failed in this and, whatever prospects they may have had of better success in other directions, these prospects were frustrated by the outbreak of the Franco-German war of 1870-71.

Signor Albonico had, however, obtained concessions from several communes of the right to work this material on their respective properties and having transferred his rights to the Canon del Corona and the Marquis di Baviera, he thenceforward acted as their agent until the mines and mining rights were transferred to other parties.

The first district in which asbestos of commercial value was obtained was the Susa valley, which is approached from France through the famous Mont Cenis tunnel. On emerging from the tunnel on the Italian side, the line follows the southern mountain slope with a gradual descent, overlooking the town of Susa, which gives its name to the valley. At a point in the centre of the valley and on the northern mountain slope are the places from which the floss asbestos fibre, the appearance of which in gas stoves, is familiar to us, is obtained. In the same locality is also found a fine, white powder of asbestos, used for paint and other purposes. The ground from which these materials are obtained is about ten square miles in extent and the works are carried on at a height of from 6,000 to 10,000 feet above sea level. The temperature is, of course, low at such an elevation, but the inhabitants are hardy and robust and make willing miners. The works are reached by mule-paths for some distance, but the remainder of the way has to be travelled on foot and from four to five hours are required for the journey from the plain on which the railway and high road are situated. The first work done here in recent times dates from 1876. The mode in which the material is brought down the mountain side is by loading it on a kind of toboggan or sledge, which slides as easily over the rocks as over snow and so expert are the inhabitants at this work that two men can bring down eight hundredweight of asbestos in three hours.

The second of the districts is the Aosta valley, commencing at Ivrea, a town of some importance, about forty miles in a nearly northern direction from Turin. From Ivrea to Chatillon, a distance of a little under thirty miles, the railway passes through the heart of the asbestos properties which flank it on either side, the direction being northwesterly and at the latter town (Chatillon) the valley trends sharply to the west until the city of Aosta, the ancient Augusta, is reached.

The history of the asbestos mining industry in this province is as follows: In the year 1849 Signor Antonio Re, of Rome, finding himself implicated in certain political troubles, took refuge in this valley, where he lived for many years. In 1873 he became aware of the proceedings of the Marquis di Baviera and the Canon del Corona, and set to work to investigate the question of asbestos in the Aosta valley. He, like others, was aware of its existence, but until then the mineral found in this district had been thought of inferior quality and not serviceable for industrial purposes, so that no trouble was taken about it. In the year named, however, Signor Re undertook a search for some better qualities and having assured himself that such could be found in abundance he placed himself in communication with the London parties and they, being satisfied with the material, started working on a large scale.

It is impossible to give with any degree of exactitude the extent of the asbestos bearing ground in the Aosta valley, but as the valley is some seventy-five miles in length and varies in width from five to forty miles some idea may be formed of it. Notwithstanding the large quantity of asbestos that has been already obtained, enormous deposits remain untouched and the yield may almost be considered inexhaustible.

The quality of asbestos in the Aosta valley is not, however, similar to that in the Susa valley. It is of the kind known as "gray fibre." It is long, strong and soapy to the touch and is similar to that obtained in the third and perhaps most important of the vast asbestos areas.

The third district is situated in that portion of Lombardy known as the Valtellina. To reach it from the valley last described (Aosta) it is necessary to return to Turin. From thence a railway journey of about three hours and a half brings one to Milan. A further journey by rail of about two hours brings one to Como at the foot of the lake of that name. The route is then by steamer to Colico, situated at nearly the northern extremity of the lake.

A line is in course of construction from Colico to Lecco, which will bring the Valtellina area into direct communication with the rest of the country and which will greatly facilitate the transport of asbestos from the mines, obviating the necessity of putting it on board barges to be taken from one end of the lake to the other. After arrival at Colico, a railway journey of about two hours and a half brings one to Sondrio, the chief town of the district. The line follows the course of the river Adda. An affluent of the Adda, the Mallero, flows through the valley of Val Malenco. In this valley and others branching out from it to the east are the asbestos mines. In was in this region that Signor Albonico commenced his researches.

The district is divided into five Communes and the asbestos properties have an area of about 25,000 acres, or nearly forty square miles. The population numbers about 5,000, of whom a large proportion are engaged in asbestos mining. Throughout the whole of this extensive area the mineral is found in abundance and of the finest quality. There is in the United Asbestos Company's exhibit at the Crystal Palace a specimen of the crude mineral in one piece which for quality was considered to be the finest in the world and which weighed forty-five pounds, but even this is far surpassed by a block from the same Company's mines of the weight of nearly three and a half hundredweights.

For a distance of eleven miles of the twenty which form the length of the Val Malenco there is a good carriage road, but beyond that the ascent to the mines is by following mere goat-tracks and as the slope of the mountains is steep the labour of bringing the mineral to the road at the bottom of the valley is very great.

The surface of the ground is for about one-third of its extent pasture and woodland, the remainder being bare rock, which admits of easy examination and trial. A great portion of these mountains is as yet unexplored, but indications have been observed which lead to the conclusion that the supply of asbestos is practically inexhaustible.

The height above sea-level of the mines hitherto opened out varies from 3,600 feet to 7,200 feet. The climate is, for such an elevation, comparatively mild, there being some places at a height of 6,000 feet where work can be carried on during the whole year.

The inhabitants work willingly at the asbestos mines, in spite of the danger from landslides and avalanches.

For a long time the opinion was held that a certain depth, greater or less according to circumstances; the veins of asbestos would terminate in the serpentine rock, but recent experience has proved that, by following the direction of the vein, it is recovered. The fibre at the greater depths is of better quality, and less indurated than that near the surface. The work is carried on by means of shafts and galleries, dynamite being used for blasting purposes.

The Italian ore is taken out in lumps, forming hard, closely compacted bundles of fibres, varying from light gray to brown. Sometimes threads of many feet may drawn from such bundles and the fibre then has the appearance of flax.

All asbestos mined during the day is bagged up and at once transported to the factories without any further preparation. Here the contents of the bags are cleaned from the powdery admixture generally found in all Italian mines. After this cleaning process the crude asbestos is separated into three grades: (1) the long fibre for spinning and weaving, (2) the short fibred material for the manufacture of mill board and paper, (3) the powdery substance, part of which is reserved for conversion into cement and paint and the remainder sold to agriculturists for manure.

RUSSIA.

Mr. Riehle, Mining Engineer at the Union Mines, Black Lake, Que., made an extensive tour in the year 1902 through the region of the new asbestos discoveries in the Ural mountains and Mongolia on behalf of the Asbest and Gummiwerke, Alfred Calmon, Hamburg, and in the following a brief account is given of these new occurrences:—

Ekaterinburg.—The asbestos mines are situated thirty verst from the station of Bajenowa. The entire district is covered with heavy drift material containing auriferous sand and precious stones, such as: emerald, amethyst, topaz, spinel, beryl, etc., in fact some of the best emerald mines are situated in this district. The country is fairly even and generally is not of a mountainous character. It is densely timbered and for this reason prospecting work is a very difficult task in that region. The formation is a weathered serpentine much decomposed, and has undergone evidently many disturbances. The asbestos is found in cracks or fissures similar to the slickensides in Thetford and Black Lake and it is to some extent discoloured. It is of a fine and silky texture; it is true asbestos, a form of fibred tremolite and hornblende and its principal value for manufacturers lies in its tensile strength.

It is not nearly as silky as the Canadian chrysotile, the fibre is a little coarser, of slightly yellow colour and is well adapted for spinning purposes. Most of the asbestos is short, fibre of two and two and a half inches in length is very rare. There are two companies working in the district: the "Poklewsky Kosell" and the "Korrewo Company." The former is the largest company in the district and employed at one time 5,000 men. But the drawbacks for a healthy and steady progress of the industry are great, the principal ones being the shortness of the season which lasts only six to eight weeks and the remoteness of the district.

The mines are remarkable for the fact that even with a production of 1,500 to 1,700 tons of asbestos per season, the mining work is all done without the aid of machinery or explosives. The ground carries more asbestos to a given area than the Canadian mines, but the veins are not so thick nor is the colour very white. Mining operations are carried on upon a very antiquated system, while a proper milling plant does not exist. Experiments in milling are, however, in progress and are vivid reminders of what occurred at the Quebec mines years ago. The working force at these mines numbers as a rule up to 1,700 men in the season and is recruited from the Russian Muzhiks or peasants. The wages paid ordinary labour are about thirty-three to thirty-eight cents a day with free sleeping quarters. These mines, as a rule, suffer from a scarcity of labour during the harvesting time. Adjacent lakes will prevent these mines from ever attaining the depths of our mines owing to the very porous and disturbed nature of the rock, the lakes being on nearly the same level as the mines.

Mongolia.—Asbestos occurs in a country about twenty-five days' journey to the south from Lake Baikal. The whole region is very hilly and some parts are even mountainous. It is very inhospitable, covered heavily with forests, and the valleys are all swamps, through which travelling is exceedingly difficult. Some of the mountains attain a height of 2,000 and 3,000 feet. A nomadic tribe of Mongolians, the Buriats, not industrious nor very intelligent, roam through the country herding cattle for a living.

Asbestos occurs in the Boo-koo-sun mountains and in the El-cheer and the Otkinsky Karoo ranges. The most important occurrence lies in the El-cheer range. Here the serpentine as a rule is massive, but of a much decomposed nature. Freshly broken, it is a semi-opaque rock of a greenish tint, but, when exposed to the air it loses its colour, changing to gray. The asbestos is of a brownish tint and of excellent quality, the fibre being from one-quarter of an inch to one and a half inches in length. No mining has been attempted in these inhospitable regions and on account of their remoteness it is not very likely to be undertaken in the near future. About three days' journey due south from the Mongolian frontier in Krasnorgash some brownish-yellow asbestos has been found in concretionary masses of a similar character as those in Templeton. The veins, however, cannot be distinguished well in the rock, owing to the similarity of colour; only when the asbestos is fiberized by hand is the true composition of the rock revealed. No mining is carried on in this country owing to its inaccessibility.

*Siberia**.—It was reported in the middle of 1903 that various discoveries of asbestos deposits had been made in different parts of Siberia, the principal one being situated in the Irkutsk district, one and a half miles from the Kitoi river, and a company has been organized to develop them. Preliminary tests are said to show that at a depth of one foot the asbestos is equal in quality to the Canadian and superior to the Italian product. The Kitoi river affords ample water power and cheap transporation to the railroad.

Finland.—In the beginning of 1904 a communication was received calling attention to the occurrence of asbestos of commercial quality in central Finland. A company has been organized to explore these deposits and during the present year has been actively engaged in this work. It is stated that large quantities of the mineral have been exposed ready for quarrying and preparation into merchantable form. In colour the asbestos is pure white and by its soft, fibrous nature, it is suited for spinning and for manufacture into board and insulating materials. The property is situated about half way between Kuopio and Joensu, near the railroad, connecting these towns.

QUEENSLAND.

For many years asbestos has been known to occur in the serpentine belt which extends in a northwesterly direction from Balnagowan, near Keppel Bay, to Yaamba, Princhester and Marlborough in the Rockhampton district.

Near Princhester there are some old workings which were opened many years ago to determine the character of the asbestos depos-

*Chemical Industry, 1903, page 720.

its there. Recently Mr. E. K. Ogg, of Rockhampton, visited the locality and from the old workings obtained samples of the asbestos for the purpose of making an examination and to determine their value as a commerc'al commodity.

The country rock is serpentine and the veins of asbestos occur in all sizes up to a foot or more in thickness. The asbestos in the larger veins is coarse in texture, but one sample from a seam about two inches in thickness showed asbestos of much finer quality. All the samples were much ironstained and partly decomposed by the action of surface water, the workings not being deep enough to obtain the asbestos unaltered.

Messrs. Hall and Stokes in a paper read before the Royal Society of Queensland* described the asbestos deposits occurring near the junction of Tilpal, Princhester and Glen Prairie, and in their summary regarding the occurrence of asbestos and the prospects of establishing an industry in this mineral state their belief "that, on proper search being made, veins of asbestos of good quality and payable size will be discovered and that a permanent industry will be the result." They also think that "a wide knowledge of the modes of occurrence and methods of working may lead to search being made in other serpentine areas."

The material obtained recently, when microscopically examined shows the fibres to be finer than the best quality of Italian asbestos, but no further comparison could be made, as the sample was too much decomposed, neither, for the same reason, could the structure of the individual fibres be examined to determine their fitness for weaving purposes.

SOUTH AUSTRALIA.**

Asbestos has been mined in this country in Red Hill, about nine miles easterly from Broken Hill, in the Rockwell paddock where for a long time prospecting had been going on on the side of the hill, in which asbestiform rock was known to exist. Several veins of true asbestos similar to the Italian variety have been discovered and mining has been carried on for some time by the Australian Asbestos Manufacturing Company. It is reported that specimens of twenty-eight inches in length have been found. The staple article ranges from a striated salmon tinted variety,

*Proceedings of the Royal Society of Queensland, 1890 to 1893, Vols. VII, VIII and IX, page 120.

**Canadian Mining Review, 1891, page 200.

known as picrolite, from near the surface to a beautiful white, flossy fibre of considerable length and good tensile strength, taken from the shallow depth of twenty feet.

On the top of the hill veins of coarse chrysotile, the Canadian variety, are found in a ferruginous gangue of what appears to be chromic iron ore. Lower down a promising vein has been opened, while to the eastward is a deposit of amianthus which seems to be of considerable extent.

NEW SOUTH WALES.*

Liversedge reports a dark green coloured asbestiform mineral, but no mining has been attempted. As a rule asbestos in this country is closely associated with chromic iron ore deposits and other minerals. The colour of the asbestos is generally white or of a light greenish blue, densely compacted, but easily separated into fibres. The "Native Asbestos Company," established for working up the Australian ores, is located in Melbourne, Victoria.

NEW ZEALAND.**

The New Zealand Asbestos Company of Christchurch exploited veins of asbestos on the Upper Takaka river, in the province of Nelson, but the enterprise failed after considerable time and money had been spent on the outcrops and no asbestos is being produced at present.

AFRICA.

Asbestos has long been known to occur in West Griqualand and at one time mining was carried on over an area of 30,000 acres. The asbestos, according to Mr. H. T. Odds,† has a peculiar lavender blue colour caused by the large proportion of iron protoxide it contains. It differs from the other varieties of asbestos, such as the Italian, Canadian and Russian, not only in that it is blue in colour, but in being of lower specific gravity. It is generally found in veins, seldom less than two and more often four and five inches wide, formed of closely compacted parallel fibres which run from wall to wall of the vein without break or fault. The grain is very fine and even in the rough state the fibres are singu-

*Asbestos, by Jones, 1897, page 73.

**Mineral Industry, 1898, page 62.

†Paper read before the Institution of Mining and Metallurgy in London, January, 1899.

larly distinct. The fibres are somewhat elastic and easily separable by the fingers. Several veins are found always in regular extent and the fibre always lies at right angles to the sides of the deposit. The enclosing rock is a dark brown shale. The character of the rock varies considerably; in some places it is soft, in others hard. The better quality of asbestos occurs in the hard rock. The composition of the asbestos is given as:

Silica	51.1
Protoxide of iron	35.8
Soda	6.9
Magnesia	2.3
Water	3.9

The output during the year 1898 was on an average about 100 tons a month and the prospects for an increase seemed very bright. Native labour was employed under European supervision. Very little skilled labour was required, the mining being mostly surface work, or by shallow adits run in the sides of the hills. The cost of extraction of one ton of asbestos, even with the primitive mining methods, was on an average only twenty-four dollars.

It has most of the striking qualities of white asbestos. It is uninflammable, heat proof and unaffected by atmospheric influences and is a non-conducting material. It is stronger than the ordinary asbestos. In cobbing it breaks away from the matrix with a clean fracture and without any fragments of the latter adhering. It is a most efficient covering for preventing loss of heat and condensation and consequently in economising fuel. The following gives the average results of two sets of experiments made in 1896; column No. 1 showing results with bare pipes; No. 2, with pipe covered with blue asbestos mattress with one inch asbestos cord over it; No. 3, pipe covered with one and a half inch blue asbestos cord with small asbestos string between:—

	No. 1	No. 2	No. 3
Lbs. water condensed per hour	12,225	3,152	3,484
Lbs. water condensed per sq. ft. per hour	1,698	0,437	0,484

In the above experiments the average steam pressure was 95 pounds, and the average engine room temperature 57°, surface of each pipe, 7.2 square feet. The asbestos can also be used for packings and joint materials. The wool is capable of being spun into very fine yarn of great tensile strength, which can be woven into netting twine, ropes and cordage of all kinds. A composition is also made from the blue asbestos for rendering cement and other materials unattackable by acid liquors or vapors.

With all these merits the business connected with this mineral has not been prosperous. At the annual meeting of the Cape Asbestos Company on October 11th, 1898, it was stated that the operations of the previous year showed a loss of £3,808. Although the blue Cape asbestos was claimed to be as good as, or superior to, the white or Canadian asbestos for many special purposes, it was nevertheless admitted that the introduction of this mineral into the trade was not making the rapid progress that was looked for. In 1898 the sales amounted to £9,000; in 1890 to £15,000; in 1897 to £15,550, while the first six months indicated a business of £9,000. To cover, however, all the expenses sales of at least £25,000 would be required.

In 1901, according to official reports, the production sank to £1,600 and in 1902 nothing was stated in the reports.

CHAPTER VII.

COMMERCIAL APPLICATION OF ASBESTOS.

The manufacture of asbestos goods forms at present a very important industry in America and Europe. It appears that a stimulus was given in that direction through the discovery of asbestos in Canada. Up to 1878 goods manufactured of asbestos were few, owing to the difficulty of spinning, the only kind of asbestos of commercial value known at that time was the Italian variety. According to Mr. Alfred Fisher, the General Manager of the United Asbestos Company, London, asbestos was first used in the United States in the year 1868-69 in connection with the manufacture of roofing felt and cement, but it was reserved to some enterprising Scotchman to first bring asbestos to the notice of engineers in Great Britain. A company was formed in the year 1871 called the Patent Asbestos Manufacturing Company, Limited, and works were established in Glasgow and operations commenced. Through the services of the priest Corona, the Marquis di Baviera, Signor Albonico and Messrs. Furse Bros., of Rome, properties and concessions from the communal authorities to work asbestos in

Italy, were obtained and when a few years later another company called "The Italo English Pure Asbestos Company," of London, came into existence and backed up by powerful influence secured mining rights and established a manufactory in Turin, keen competition for supremacy commenced. The result was that all these companies were amalgamated in the year 1880 by the formation of the "United Asbestos Company, Limited, under the presidency of Sir James Allport, of the Midland Railway.

The rapid progress made since the beginning of 1880 is seen from the consumption of the Canadian mineral which increases every year. The extent to which certain asbestos goods were to become commercial necessities was clearly demonstrated when the great fire in the Iroquois theatre in Chicago occurred. All asbestos dealers and manufacturers were kept busy for a considerable time in filling orders for fireproof theatre curtains and like material.

The application of asbestos seems to vary greatly in different countries. While in the United States large quantities of short fibre are used to manufacture pipe coverings of all descriptions, the European market principally calls for long fibre to be used for spinning, braiding and weaving.

ASBESTOS IN ITS SPUN STATE.

Concerning the spinning of asbestos it must be said that there are various difficulties to be overcome; first of all the fibre has not sufficient strength to withstand all the operations to which other fibres, such as those of vegetable origin, as flax, or cotton, etc., or of animal origin, such as wool, silk, etc., have to be submitted. Moreover, a difficulty is found in preventing the asbestos fibres in the thread from slipping past each other.

While fibres like wool and flax, etc., have a rough surface, the surface of a single asbestos fibre is as smooth as that of glass threads, so that in trying to twist a number of single fibres together they slip. Continuous study of the nature of the asbestos fibre and experimentation have to a certain extent overcome these difficulties and the manufacturers have succeeded in turning out a single asbestos thread, which, although not weighing more than an ounce per 100 yards, has a pretty fair strength.

Asbestos in its spun state is very largely used in the shape of yarn or wick as steam packing, such as the packing for small glands, valves and cocks, or for piston packing, for piston rods, valve-stems, throttle-valves, etc. In the application for these purposes the heat resisting qualities of asbestos have been found to make it specially suitable for superheated steam in the large triple and quadruple expansion engines used on the fast ocean steamers. Asbestos packing has stood the test where all other packings, such as soapstone, flax, cotton and even metallic packings have failed. It is durable, reliable and economical. Durable in that it is not affected by the heat or moisture and less than other packings by friction and pressure. Reliable, because it does not require to be frequently renewed, the regularity of motion in the piston is preserved and as a consequence all the machinery connected with it runs more smoothly. Economical, for the reason that being to some extent self-lubricating a saving in oil is effected, and from its elasticity, caused by its fibrous nature, the joint is kept perfectly tight a longer time than with any other class of packing. The most common asbestos packing is made by either twisting or braiding asbestos wick or yarn together into a rope, but a great many other kinds of asbestos packings are in the market. Wire is sometimes used to increase the durability and strength of the packing and to increase the elasticity an india-rubber core is sometimes inserted. To add to the lubricating property of asbestos packing, it is often manufactured with a filling of powdered soapstone or graphite. A very superior kind of asbestos packing consists of asbestos cloth rolled into any desired thickness with rubber between the layers. In a similar manner, by uniting layers of asbestos cloth, a flat packing, generally called asbestos and rubber sheeting is made, which can be cut into rings of any shape and form to serve as a superior flat joint packing instead of mill-boards.

There is a great diversity of opinion as to the utility of india-rubber cores in packing. The opinion is expressed that if the cores are properly made and are of the right quality of rubber there is no trouble with the packing.

Asbestos tape made in a similar way as the sheeting, can be bent into the form of a ring and used for the same purpose as the sheeting, having the advantage of leaving no waste to the consumer. Such packings of combined asbestos and rubber are very much in use, owing to the advantage they have over the ordinary asbestos packing of being more resistant to moisture and also of withstanding a still higher pressure. A so-called asbestos block packing is made by uniting a number of layers of asbestos cloth by means of india-rubber, then placing a flat rubber back crossways at the edge of the layers and covering three sides by a cotton cloth, leaving one side of uncovered asbestos to face the piston rod. The rubber back increases the elasticity of the packing, while the friction acts against the edges of a number of asbestos cloth layers. This packing has great power to withstand steam pressure.

A very efficient steam pipe packing, manufactured by the United Asbestos Company, of London, England, consists of two rings of asbestos metallic cloth which are combined in one by means of a jointless copper or other metal ring, the vertical copper wall forming in combination with the asbestos an absolutely steam tight joint. The disadvantages attaching to metallic jointing are thus overcome by combining it with the useful properties of asbestos.

There are a number of devices of steam packing used in stuffing boxes on the market. In one of these every asbestos thread has a core of fine wire, thus presenting a uniform surface of asbestos to the moving parts, rendering the packing suitable for wet or dry steam and adding greatly to its strength and durability.

Asbestos in its spun state is used in the construction of drop curtains, to serve as fire screens in theatres. On account of the ease with which they are manipulated, the asbestos curtains have been substituted for iron and steel curtains in many theatres both in Europe and America.

It may not be out of place to mention that recent investigations made by various municipalities in the United States regarding the safety drop curtains supposed to have been made of asbestos have shown that in many cases but little asbestos was used in their construction and that the materials employed were found to have been heavy jute, linen or cotton sheeting or canvas.

Garments made of asbestos cloth are used as a protection against fire and also against injuries from acids. As to the former application, while its adoption on account of the great expense involved is not likely to be effected for general use by fire departments, still at least two men should be provided with asbestos suits, to enable them to enter burning buildings in case of necessity. These asbestos suits for firemen are provided with asbestos masks, which not alone protect the face but also the smoke respirators.

A complete asbestos fireman's suit consists of a pair of strong boots protected by an iron sole, asbestos pants and gaiters, asbestos pocket, asbestos apron, gloves, mask and head gear.

Process of Manufacturing Asbestos Cloth.

The United Asbestos Company, of London, England, according to Mr. Alfred Fisher, its General Manager, treats the crude Canadian asbestos in the following manner: The blocks of fibre or rock are crushed and opened up in special machines in such a way as not to destroy the fibre and are passed thence to "shaking" machines, where the long fibre is separated from the short and particles of rock removed. The treatment of the long fibre in the Carding and Condensing Department is very similar to that in a textile factory, but its appearance would be scarcely encouraging to one who had been accustomed to wool or cotton. The fibres of the latter, examined under the microscope, exhibit a notched or serrated appearance. It is to this structure of the fibres that the ease with which they may be twisted without slipping is due. The peculiar nature of asbestos presents many difficulties to spinning, which have, however, been overcome by special appliances. The fibre coming from the condensers in the form of condensed thread without any twist is coiled in cans and taken to the Spinning and Doubling Department, where it is twisted into threads. The thread then passes to the Weaving and Braiding Department, where it is made into various forms of yarn packings and into tapes and cloth.

Asbestos Rope.

Fireproof asbestos ropes in use in fire departments are generally of two kinds: one entirely of asbestos, the other with a core of steel wire which greatly adds to its strength.

Tests have been made by the German Government with Wertheims (Frankfort) wire cored asbestos ropes and it was found that a three-quarter inch asbestos rope with steel wire core carried nearly 2,000 pounds and then only one of the seventy odd strands of which the rope consisted broke. These tests made by the German Government are also interesting regarding the stretching of the asbestos ropes. With a weight of 100 kilograms attached the three-quarter inch rope only stretched three-tenths per cent.; with a weight of 400 pounds it stretched less than one per cent.

The asbestos rope without the steel wire core is sufficiently strong for ordinary fireman's purposes. A half inch rope will carry fully 200 pounds, a three-quarter inch rope over 300 pounds and one inch rope is safe for 500 pounds.

The weights of these ropes run as follows:—

½ inch rope, weight about 10 lbs. per 100 feet.
¾ inch rope, weight about 20 lbs. per 100 feet.
1 inch rope, weight about 40 lbs. per 100 feet.
1¼ inch rope, weight about 70 lbs. per 100 feet.

The wire core does not materially increase the weight.

The ropes are by no means heavy and are very strong and can be conveniently used as life lines. They are not slippery and are not injured by water.

ASBESTOS AS AN INSULATING MATERIAL.

Asbestos is used in various ways for the purpose of preventing the radiation of heat from pipes, boilers, tanks, etc., and as an insulating material it is claimed to be superior to most of the other non-conducting materials because of its heat resistance and because it adheres, being fibrous, better to smooth surfaces than powdery substances. The variety of pipe and boiler coverings in the market is very great and the number of companies who make the manufacture of it a specialty shows what an important position this article has gained in the United States.

Steam Pipe Coverings.

Experiments have long shown the great economy effected by covering steam pipes*. The waste of heat in using 100 feet of two inch pipe uncovered for the conveyance of steam from seventy to eighty pounds pressure for one year of 3,000 working hours costs 64s. 6d. with coal at 8s. 4d. per ton. But by using the least efficient of insulating coverings this loss is reduced to about one-fourth of that amount and with the best procurable to about 10s. a year. Other experiments have shown that the loss incurred by using uncovered or inefficiently covered steam pipes is considerably more and probably the truth lies between the two, for a steam pipe is usually under pressure for more than ten hours a day and coal cannot always be had for so low a price as that mentioned.

Then it must be remembered that the loss by radiation varies according to the surface exposed and the difference in temperature between the two bodies. The condensation which takes place in

*Jones Asbestos, 1897, page 217.

a steam pipe has two very serious features, for if it be carried into the cylinder, it may cause a breakdown and secondly, it must be borne in mind that only about one-tenth of the heat put into the steam is available for producing power, consequently, every unit lost by radiation from a steam pipe leading to an engine means the loss of ten times as much heat from the coal burnt. This may appear enormous, but it is nevertheless true and even much more so in the case of the more common kinds of engines, because in these, the available part of the heat is often not over the one-twentieth part of the whole. In such cases it is no uncommon thing to find one-half of the coal thrown away by allowing the boilers and steam pipes to remain unprotected.

The most common way to prevent the radiation of heat from pipes, boilers, etc., is to mix loose asbestos fibre, after freeing it fairly well from stone admixtures, with other materials which either serve to increase the non-conducting qualities of asbestos or to make the composition adhere better to the surface of the pipes. Such a mixture, made into a uniform paste with water, is laid on smoothly with a trowel as a thin covering around the pipe. Several layers are usually put on, allowing each to dry thoroughly before the next is applied. To finish off, canvas or oil-cloth is used, which prevents the covering from falling off, should it become cracked in the course of time.

Another mode ot using asbestos for covering pipes is effected by forming it into sectional pieces, which are placed on the pipes and connected by means of iron bands or canvas (Fig. 35). This

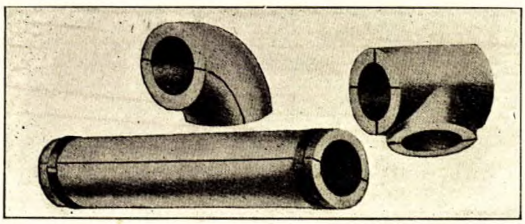


Fig. 35.

mode of applying asbestos has the principal advantage that it can easily be put on and taken off the pipes and that the same covering may be used for a great length of time. Special sectional pieces of such covering are made to fit elbows, tees, crosses and other fittings.

The "Asbestocel Covering," manufactured by the John Manville Company, of New York, is constructed of successive layers of plain and corrugated asbestos felt and on account of the numerous air cells thus produced effectually prevents radiation (Fig. 36).

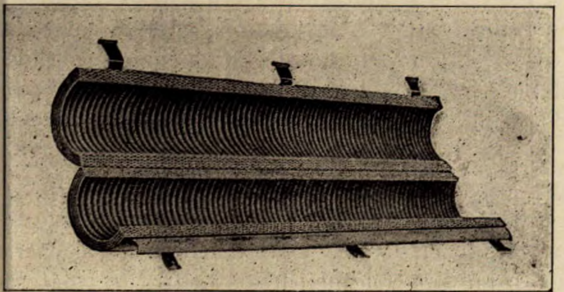


FIG. 36.

The sectional pipe covering, as illustrated in Fig. 37, is composed of a moulded asbestos core one-half inch thick and one-half

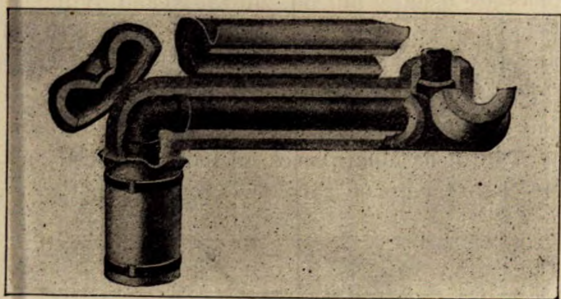


FIG. 37.

inch of corrugated wool felt, which binds the moulded portion, making it tough and durable. This form of construction produces an excellent non-conductor.

Removable Boiler Coverings.

The subject of covering steam boilers and pipes in Great Britain has been brought into special prominence by the rule of the Board of Trade in London that all steam pipes and boilers of marine engines shall be tested by hydraulic pressure to double the working pressure at certain intervals. Before testing the pipes and boilers, the cover must be removed. This rule pointed to the desirability of producing satisfactory removable boiler and pipe covering. The idea of making quilts of mattresses composed of asbestos cloth filled or stuffed with non-conducting material is not new, for this was done by the United Asbestos Company in London as early as 1885. But the way in which these quilts or mattresses were prepared was somewhat defective, as the fibre or other material with which they were filled shifted its position, the result being that some parts of the mattress became choked and other parts empty. All these defects have been removed and the mattresses as they are now made especially for modern warships, are efficient and durable. The weight of this covering is only one and a half pounds to the square foot; it is easily applied and may be removed and replaced without trouble.

It is made in blocks of standard size 6 x 36 inches and of a thickness of one inch up. The method of application is very

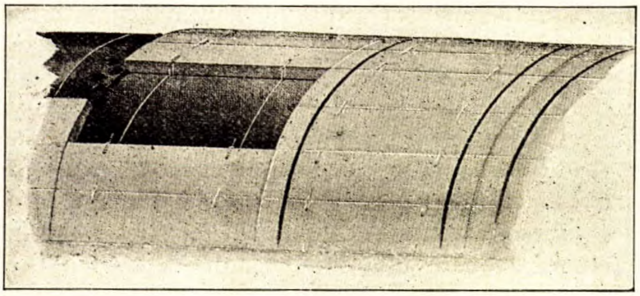


Fig. 38.

simple, as will appear from the illustration, (Fig. 38). Wires are passed around the boiler at about four inches from the ends of every course of blocks. A special T hook or fastening engages the wires and the blocks are slipped under the hook, which holds them firmly in place. This method of fastening permits the removal when necessary, of a single block, without disturbing the others.

ASBESTOS MILL BOARD.

Manufactured into millboard, asbestos finds a variety of uses. The millboard serves as a joint packing for steam pipes, cylinder covers, steam chest covers, etc. and is greatly appreciated for its durability, economy and cleanliness. It will adapt itself to uneven surfaces and forms a perfectly tight joint which with very little care can be removed and replaced without injury. For special purposes, especially where there is much water in the steam pipes, asbestos millboard can, by special treatment, be made perfectly waterproof and is then known in the trade as "asbestonite." Asbestos millboard is also used for other purposes, such as the construction of fireproof deed boxes, etc.

Manufacture of Asbestos Millboard.

The manufacture of asbestos millboard is somewhat similar to that of ordinary cardboard. In the works of the United Asbestos Company, London, after some preliminary treatment, the asbestos fibre is run with water into the tanks of beating engines. Each of these tanks is provided with a rotating beater, which maintains a thorough circulation, taking up the fibre, opening and drawing it out, and then sending it forward to be soaked for a time until it comes round again to the beater. The binding ingredients are here added and thoroughly mixed with the fibre, when the pulp is passed into the vat of the millboard or paper machine, where it is kept in a state of agitation until gradually drawn off. The water passes through a fine wire gauze on a revolving cylinder, leaving a thin coating of pulp on the cylinder. This is then transferred by means of an endless band to a second rotating cylinder, where it gradually accumulates until the desired thickness has been reached. It is finally cut across and removed in the form of a square sheet of millboard. As the sheets contain a large percentage of moisture, they are next placed between sheets of zinc and passed under hydraulic pressure and then hung in drying rooms. A final pressure is applied, their edges are trimmed and they are then ready for the market.

In this process the chemical composition of the asbestos undergoes little if any change and, excepting the binding materials which have been added, chemical analysis shows the composition of the best millboards to be practically the same as the fibre from which they are made. It will be observed that nothing would be easier than to adulterate millboard pulp while in the beating engines and large quantities of china clay and other ingredients are used by some manufacturers in this process. It has the effect not only of increasing the weight but also reducing the cost, to the detriment, however, of the finished material.

A patent has been granted recently to T. H. Ibbotson, East

Greenwich, and R. Meldrum, Blackheath, England, covering a process for the manufacture of millboard asbestos fibre,* the main features of which are as follows:—

Asbestos of one-eighth of an inch to two inches long (100 lbs.) is thoroughly mixed in a beating machine with a magnesium chloride solution, of specific gravity 1.25-1.5 (250 to 500 galls.). Finely divided magnesium oxide (50-150 lbs.), which should weigh at least twenty-five pounds to the bushel, is then added and the mixing continued. The pulp obtained is filtered and the comparatively dry residue left on the filter-bed is subjected to a pressure of 200 to 300 pounds per square inch in a hydraulic press and allowed to dry in the air. The hard slabs obtained are next washed with water to remove soluble salts, immersed in a twenty per cent. sodium or potassium silicate solution and afterwards again immersed for fifteen minutes in magnesium chloride solution. They are then air dried and afterwards treated with the silicate solution.

ASBESTOS PAPER.

The manufacture of paper from asbestos** has met with many difficulties owing to the natural affinity of asbestos for water. Only a few kinds of asbestos are suited for the production of a good paper and then special treatment of the fibre is necessary. Most of the paper made contains only about one- third of its weight of asbestos. It is reported that a good class of asbestos paper was at one time made in Paris, but the principal defect of all asbestos papers is the natural tendency to work up more like blotting paper than ordinary writing paper. It is difficult to obtain a glassy surface of the paper to enable the pen to glide smoothly over it and prevent the ink from running. An invention to remedy this defect would certainly tend to stimulate the manufacture of asbestos paper. Much has been accomplished in this direction, but still even the best writing paper produced is too tender and although itself fireproof the writing upon it does not withstand a red heat.

ASBESTOS ROOFING.

Asbestos roofing is one of the newer applications of asbestos. It is the result of new processes by which the strength, durability and uniformity of the mineral has been much increased. An older

*Chemical Industry, 1903, page 1088.
**Johns, Asbestos, 1897, page 292.

form of asbestos roofing which is being used extensively all over the States consists of a strong canvas, combined with a superior quality of felt, made expressly for the purpose with Manila lining. These materials are rendered waterproof and are then cemented together with short asbestos fibre with a special acid and waterproof composition and compressed into a compact flexible sheet like leather.

Another form of asbestos roofing consists of pure asbestos paper saturated with asphaltum; a third one is composed of two heavy layers of pure asbestos felt compound, forming a strong flexible weather-proof roofing sheet. It is ordinarily finished with a coat of asbestos roof covering consisting of ground asbestos and coarse sand.

A new invention and one which probably will revolutionize all systems of roofing has just been patented in Austria. It appears that the very fine fibre—the tailings from the mechanical separation—are ground again with a certain percentage of serpentine, then mixed with some other ingredients—asphalt and the like—and the whole pressed into sheets and subjected to hydraulic pressure.

It is claimed that this roofing is very durable and of easy application. Large factories for the manufacture of this kind of roofing are now being built in Austria and Germany and it is understood that negotiations are in progress for the establishment of a factory in New York.

ASBESTOS AS A FIRE-PROOFING MATERIAL.

Wall Plaster and Asbestic.—These new materials came into prominence when the Danville Asbestos Company of Quebec commenced operations in the year 1896. They are composed of asbestos and serpentine and are consequently incombustible and fire-proof. Their value, therefore, as a protection against fire when used for plastering walls and ceilings is undeniable.

Asbestic is now used in fireproof buildings in cities like New York, London, Montreal and Chicago and forms one of the principal fireproofing materials. It is generally made in two qualities, in rough "asbestic" and what is called the "finish." The former may be applied to the walls of a new building, upon brick, metal laths, plain boards, or expanded metal and when dry will form a coating of the nature of asbestos felt board, which is now so much in use in the United States. This coating is then covered again with the "finish," which is a carefully prepared pure asbestos fibre of remarkable fineness.

The application of asbestic for the purposes above specified has not received the support in other countries that it deserves, which is shown by the fact that when asbestic was first introduced in 1897 the production in Canada was 17,240 tons, while the production for 1904 was not more than 13,987 tons. There are immense quantities of tailings from the mills stored at the different mines and if the demand for this new material could be increased to a far greater extent than it has been, all these immense dumps would be turned into available assets.

Another application of the fine asbestic plaster is the construction of the so called *Salamander* decorations as made by the United Asbestos Company in London. The fine fibre for this use is mixed with some pulverized ingredients and special liquids and then moulded and pressed into forms. The product so manufactured is light in weight and is more easily applied than other embossed decorations and on account of its fibrous nature it grips walls and ceilings with great tenacity and power.

*Uralite** is the name given to a new fireproof material composed of asbestos fibre, chalk, sodium bicarbonate and silicate, invented by a Russian artillery officer and chemist named Imschenetzky. It is a non-conductor of heat and electricity and is practically waterproof. The manufacture of uralite consists in teasing the asbestos fibre and freeing it from sand and other foreign substances, after which a little whiting is added and the mixture is run through a disintegrator and is then separated again by air blast and sifted. A quantity of whiting equal in weight to that of the asbestos is made into a paste and the asbestos is added and thoroughly mixed. The mixture is delivered to a revolving blanket and passed through a series of rolls, where it is partly dried and compacted. Fourteen or fifteen thicknesses are passed to a revolving drum and a solution of sodium silicate and sodium carbonate added to serve as an adhesive, The layers are subjected to a pressure which is finally increased to 200 lbs. per square inch and left for 1.5 hours, after which they are dried for one day. When dry they are gradually heated in a gas-fired oven, cooled, steeped in a solution of sodium silicate, washed, dried and again heated. These operations are repeated till the proper hardness is attained.

*Mineral Industry, 1900, page 50.

"*Manderite*" is a dense, firm, highly burnished fireproof asbestos sheet which is susceptible to decoration of any form and is used for wainscotting, ceiling and side walls. It is also especially adapted for interior fireproofing of cars and steamships.

"*Ceilinite*" is a flexible asbestos felt product reinforced with an asbestos cloth and intended primarily for the fireproofing of the inner roof of electrical passenger coaches. When in use the fire resisting sheet is held in place by a thin sheet of another metallic substance put on as a facing board.

Corrugated fireproof paper or *Asbestocel* consists of corrugated asbestos paper, backed by a plain or flat layer of the same material. Being flexible it can be readily handled and cut into any desired lengths, which makes it specially adapted for wrapping heated pipes and other surfaces requiring thin, flexible insulation, lining floors, etc.

"*Asbestocel Sheets*" are built up from successive layers of asbestocel paper, the plies being laid on each other so that the corrugations of the one run at right angles to those in the preceding ply. By this method the sheets contain a large number of air cells, which greatly improves the insulating power of the sheets. The sheets are easily sawed to fit any sized surface and conform readily to the curve of boilers, furnaces, etc.

Recently asbestos has been used in the manufacture of "*fireproof bricks*"* and tests made by the British Fire Prevention Committee (Stone, February, 1901) on gypsine, a fireproof material composed of hydraulic lime, sand and asbestos pressed into bricks, showed remarkably good results. One side of a 9 inch partition of gypsine bricks set in hydrualic mortar and lightly coated with a layer of fire clay was submitted for an hour to a temperature which rose to 2,050° F. The material was in no way affected and the temperature of the outer surface was never sufficiently high to ignite a match held against it.

A. Truchenetsky** has patented a method of manufacturing fireproof decorations by treating asbestos with a solution of alkaline silicate of soda, the colloidal silicate uniting the threads of asbestos. A dilute solution of an alkaline silicate is used and the mass is then immersed in a saturated solution of alkaline bicarbonate. This deposits the silica between the asbestos particles.

A new composition the principal ingredients of which are

*Mineral Industry, 1901, page 44.
**Mineral Industry, 1899, page 46.

shellac and asbestos, has been invented in Germany and application for patent has been made. The advantages claimed for it are cheapness of raw material and hardness and lightness of weight. It is fireproof and can be handled about as readily as wood.

Asbestos Paints.—The manufacture of fireproof paint has of late years assumed considerable importance. Nearly all the manufacturers of asbestos goods make asbestos paints in various colours.

These paints are suitable for rough woodwork, such as joints, rafters, beams, stairs, warehouses and wooden structures of all kinds. Numerous public experiments have been carried out from time to time proving the remarkable fire resisting qualities of asbestos paint.

Asbestos Board.*—For the purpose of preparing accumulator casings, insulating boards from asbestos sheet, cardboard or cloth, the material is impregnated with potassium or sodium water glas of specific gravity 1.1. By this impregnation it becomes so soft that it may be "lapped" without breaking. The cardboard, etc. is then so shaped by the use of the "lapping machine" that the sides of the accumulator casing produced are composed of two layers and the bottom boards of three layers. The casing, after drying in a drying chamber at 125° C., is next submitted to a second process of impregnation with resin, wax or paraffin, at a temperature of 200° C. during from six to eight hours. The material, after this process, it is said, becomes so solid and hard that it may be "treated by planing, grinding or sawing" like "horn, ivory, or vulcanite." It is also heat resisting, water and acid-proof.

Testing Asbestos Board.—According to "L'Industrie," asbestos board of good quality weighs about 1 kg. per sq. metre for each mm. of thickness. It ought to resist a dynamometric tension of 400 to 500 grains per square mm. of section. In order to judge the purity of asbestos board it should be reduced to a paste with warm water and thoroughly macerated. The paste is then transferred to a sieve of No. 30 to 32 wire cloth and washed several times to remove foreign matter. The residue is dried without calcination and weighed. The loss in weight from the amount originally taken should not exceed 20 to 25%.

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*Chemical Industry, 1899, page 500.

Testing asbestos board by calcination is less conclusive than the washing test, since it does not show if it contains such foreign matter as china clay.

*Asbestolith-tiling for Floors.**—A new product called asbestolith, a German invention, is now being made by the Sall Mountain Asbestos Company at Saulter, White Co., Ga. It consists principally of short fibred asbestos and is used chiefly for the preparation of cement and tiling for floors, for which it is claimed to have advantages, among them impermeability to water and elasticity as high as that of wood, a hardness equal to that of cement, greater durability than asphalt and lightness in weight, while it is, moreover, a non-conductor of sound. It is said that it will not crack, warp or bend and shows greater resistance to abrasion than stone, brick or marble.

ASBESTOS IN ELECTRICAL MACHINERY.

A new method of insulating metallic surfaces has been patented by John A. Heany, Philadelphia.** This method consists in applying to the metallic surface first a paste or cement, second in imbedding asbestos in fibrous or flakey form in the cement and finally covering the asbestos with a solution of chemical or metallic salts combined with a gluey or albuminous substance containing lime.

Asbestos is used in the form of millboards in the construction of dynamos. It is used in tubes and elbows for turning corners: Battery plates are sometimes wrapped in asbestos paper and asbestos gloves lined with rubber serve to handle electric wires with comparative safety.

A composition for the insulation of metallic conductors consists of a layer of asbestos which covers the surface to be insulated, and a coating of oil combined by boiling with litharge and red lead until free acids of the oil have been expelled.

MISCELLANEOUS USES AND MANUFACTURING PROCESSES.

Uses for clean fibre.—Asbestos fibre is to some extent used, especially in England and the States, in connection with gas fires. The gas is made to rise through asbestos fibre and is then lighted. The asbestos fibre glows brightly while the gas is burning with a blue

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*Engineering and Mining Journal, 1899, I, page 22.
**Engineering and Mining Journal, 1902, II, page 55.

flame and this not only serves to distribute the heat but imitates the pleasant appearance of an open hearth wood or coal fire.

Cold Storage.—For the preservation of meat and all kinds of provisions specially constructed ships, containing the necessary refrigerator apparatus and chambers, are in universal use. In the large American cities special cold storage buildings have been erected. Nearly all of these have double walls surrounding the cold chambers with some kind of non-conducting material. For this purpose asbestic has been found specially suitable and in recent construction for cold storage this article is used very extensively.

Asbestos as a Filter Medium.—Very fine fibre which has been subjected to a process of cleaning is used to a large extent as a filter medium. It resists the action of alkalies and acids and after filteration it can be easily cleaned by hot water or steam, or in case of a hard tenacious residue the filter can be thrown into the fire and when the residual matter has been consumed the fibre will be found unimpaired and ready to be applied to the same use.

There are many different kinds of asbestos filters in use, as the "Maignen's Filter rapid," which consists of a hollow perforated cone of earthenware, over which a specially woven asbestos cloth is stretched; the "Nibestos Filter," which consists of an upper and lower earthenware vessel divided by a strainer of same material upon which is fixed a sheet of specially prepared asbestos cloth and above this again another sheet of much finer texture. This filter is said to render excellent service in the purification of water.

In the Laboratory.—In the laboratory asbestos in its various forms is a very useful substance and can be employed very readily in many ways on the lecture table. Asbestos twine is used in binding together parts of apparatus exposed to fire and strong acids. To prevent a spreading of a crack in the neck of a retort or flask it is only necessary to bind it with asbestos yarn or twine soaked in a solution of sodium silicate and then treated with a solution of calcium chloride, a perfectly insoluble cement being thus formed. Asbestos wool mixed with a solution of silicate of sodium makes a fireproof cement of great strength and also serves to mend cracks in stoneware. It can be made insoluble by subsequent treatment with calcium chloride, silicate of calcium being formed. Asbestos paper and card can be obtained of all degrees of thickness and are employed as substitutes for wire gauze and the sand bath in small operations involving the heating of glass vessels. Asbestos paper and silicate of sodium are very useful for mending cracks in glass apparatus.

*Asbestos Leather.**—A new use for asbestos is in the manufacture of asbestos leather, which is made by dividing asbestos into very fine fibres, immersing and thoroughly coating them with a solution of rubber and afterwards evaporating the solvent, the fibres then cohere perfectly. A mass may be pressed or rolled into any desired form and the product is said to resemble leather very closely in its structure and general characteristics.

TREATMENT OF ASBESTOS FOR RENDERING IT WATERPROOF.†

Asbestos articles which are naturally hygroscopic are rendered waterproof by the following process:—The articles for use at ordinary temperature are coated with chrome glue, alum glue, or chrome alum glue, or they are coated first with a solution of resin soap and afterwards treated with a solution of calcium chloride, which forms with the soap an insoluble compound on the surface and in the pores of the article. When the articles are to be subjected to high temperatures, they are either coated with water glass, or a glass or porcelain enamel is burnt on to their surface.

*Improved Treatment of Asbestos Diaphragms to enable them to Resist Disintegration.***

To prevent the disintegration, under the action of liquids, of sheet asbestos made without the addition of any binding material, it is heated to a temperature below that at which vitrification occurs by immersion in a bath of molten aluminum at 600°-700° C. Sheet asbestos treated in this manner forms an excellent material for diaphragms in the electrolytic production of alkali.

Application of Asbestos to the Manufacture of Fire Resisting Materials of Construction and Refractory Materials.‡

Asbestos reduced to a fibrous powder, mixed with powdered clay and refractory earths, made into a paste with water and moulded into the required shape, dried and burnt, furnishes a valuable refractory material. This material may be used for bricks and paving, as well as for furnaces, retorts, crucibles, etc.

*Mineral Industry, 1898, page 63.
†Chemical Industry, 1901, page 1212.
**Chemical Industry, 1902, page 1143.
‡Chemical Industry, 1903, page 555.

In addition to its refractoriness, it is claimed to be light and very hard and is useful for accoustic insulation.

*Process of Using Fibrous Asbestos in the Form of a Liquid or Plastic Mass.**

To powdered fibrous asbestos is added sulphate of alumina and a solution of agar-agar, to form a plastic or liquid mass, which will set hard and with the addition of suitable filling material, can be used as a covering or insulating material, as an impregnating liquid or for the production of articles made entirely of this material.

*Process for Making Moist Rolls of Asbestos, Suitable for Spinning.***

Short fibred asbestos or similar material is converted into a pulp and run as a broad endless web on the paper machine. After draining and pressing, the web is reeled in the usual manner, being slit longitudinally during reeling into strips of a suitable width, which form an apparently coherent roll. If preferred, the web may be slit after reeling by cutting the whole roll transversely into a number of discs. Still another method of slitting consists in directing the web of pulp in the moist state under a series of jets of air, steam or liquid, which have the effect of dividing it into a series of strips which can be reeled as a coherent web. The strips, in whichever way prepared, are subsequently unreeled and subjected to the action of suitable twisting machinery to form threads.

Behaviour of Asbestos in Non-Luminous Flames.

Mr. S. Sauberman, (Chem. Zeitung, 1902,) calls attention to the behaviour of asbestos yarn when heated in non-luminous flames. This yarn is prepared by arranging pure serpentine asbestos, as free as possible from iron, in the roving machine in such a way that, after carding, it is spread out between two layers of cotton. By this means it becomes mixed with a certain definite percentage of cotton and can be spun into very thin threads in which the asbestos fibres lie approximately parallel to one another. When a yarn composed of such fibres is placed in a Bunsen flame, the cotton is first burned away, after which the

*Chemical Industry, 1903, page 699.
**Chemical Industry, 1903, page 757..

asbestos fibres give up water and become brittle. Then they begin to soften and finally fuse together to form apparently homogeneous rods which become welded in the flame and give out a constant bright white light. This takes place even in the less hot parts of the flame. When cold, the threads are white, hard, brittle and porous and in general resemble unglazed porcelain. The fracture shows no signs of the fibrous formation of the asbestos. Microscopic examination proves that the fusion is not confined to the surface and it is only at those parts where knots have been left in the fibre that there occur little nests of externally fused matter containing asbestos fibres. The composition of serpentine asbestos is changed by this treatment from $H_4Mg_3Si_2O_9$ to $Mg_3Si_2O_7$, whilst that of hornblende asbestos remains as before, viz.: $Mg_3CaSi_4O_{12}$. The light emitted by this mineral when heated can be greatly increased by soaking it in solutions of salts of the alkaline earths, or better of nitrates of the metals of the beryllium group. A thread prepared in this way and weighing 0.02 grm. when heated in the non-luminous flame of acetylene burning at the rate of 10 litres per hour emitted a light of from 12.5 to 13.5 normal candles. The complex silicate forms a very intimate mixture with a basic oxide, traces of which are retained, even on treatment with various solvents.

The Use of Asbestos in Mines.

The application of asbestos in operating mines is confined to insulation of steam connections. The problem which confronts the mining engineer is how to secure good results with a steam boiler at the mouth of the pit and a pump several hundred feet underground, or a fan several hundred yards away from the boiler, necessitating the use of long lines of steam pipe which must be covered with a non-conducting material to prevent the radiation of heat.

This pipe often runs close to the tracks in slopes and along haulage roads, or is hung perpendicularly in shafts, where it meets with the roughest usage and is often subject to the constant drip of water, sometimes strongly charged with sulphides.

Of what form and of what materials to make an insulator that will be of service under such trying conditions is the question that must be solved. That the pipe must be covered is scarcely a matter of debate. Assuming the pipe to be 4 inches internal diameter and the run, say 1,000 feet, the exposed iron surface will be 1,250 square feet, *i.e.* the equivalent of a flat surface 125 feet long by 10 feet broad.

Assuming further, a steam pressure of 70 lbs., we have a body at the temperature of 316° Fahr., 1,250 square feet in extent, constantly radiating into an atmosphere about 250 degrees cooler than itself, with results which anyone familiar with condensation of vapors can easily predict. Theoretically, it would take over 8 tons of coal per annum to remedy the waste in each 100 lineal feet of pipe, or, at $3.00 per ton, $24.00 per 100 feet, making a total waste on the line of pipe in question of $240 per annum, aside from the expense involved, the water of condensation clogging the cylinder and valves of the pump would stop the motion of its pistons and injure the machinery.

With the pipes properly insulated by the application of good non-conducting covering, all this loss can be prevented and perfectly dry steam delivered at great distances from the boiler.

The loss from radiation under such favorable circumstances is infinitesimal and compared with the loss of waste through friction and other causes is not worthy of note. It is difficult to obtain reliable data owing to the difficulty of making accurate observations on apparatus of so great a length. In a recent test, however, of a system of piping carrying hot water under pressure at 400° Fahr. the total loss in a travel of 10,000 feet, chargeable to radiation, was placed at 3%. These tests were made by competent engineers and with the use of every means known to science. All of the pipes in question were insulated with 1½ inches in thickness of asbestos.

Having considered the possibilities of the case, we now revert to the main question:— What material, if any, will answer the purpose?

Such material to fully answer the question must fill the following requirements:—

1.—It must be a non-conductor of heat.

2.—It must be unaffected by heat.

3.—It must be unaffected by water.

4.—It must stand rough usage.

An extensive list has been offered by enterprising vendors of articles and devices for fire-proofing, water-proofing, etc., which have one after another been discarded for some fatal defect.

It may be interesting to review a few of these to see in what way they fall short of the standard, that is, durability under heat, water and rough usage.

In the case of hair felt, the oldest form of pipe covering in use and one of the best non-conductors of heat known, on account of the great number of air cells it contains, experience has demonstrated that it is short lived under heat and that it disintegrates rapidly when wet. The various fire-proof linings used under hair felt do indeed prolong its life, but do not give it real durability and for mine work it cannot be recommended. An extended list of paper pulp and wool felt materials, usually made up in sectional or cylindrical form appears in the market as fire-proof material. Some of these have a thin sheet of asbestos as a lining, placed there more for appearance than use, as a close examination will show the asbestos to be too thin to afford much protection.

The best type of this covering is made of alternate layers of wool felt and asbestos sheeting, laid up in cylindrical form so as to leave air spaces. But this covering, while efficient and durable, under ordinary circumstances, will not stand the exposure of mine shaft, the wool felt will char, leaving the asbestos.

The disintegrating effect of heat and moisture on organic substances is well known. Hence these and similar coverings containing a large percentage of hair, wool and other organic matter will be rapidly destroyed in mines and the general proposition is laid down, that no covering should be adopted for use in mines that contains organic matter in its composition.

The various forms of non-conducting cements, while more durable under the heat, are too easily injured by rough usage to last long in a mine. These non-conducting cements are of two kinds: those containing heavy clays or earths with animal or vegetable fibres as binders and those made from asbestos and infusorial, or fossil earths. The former are only nominal pipe coverings, as they do not retain the heat and have no real value The latter have merit, but are not of service for use in mines.

In connection with these cements or plastic coverings we find in use several made by mixing magnesia or plaster with asbestos. The asbestos acts as a binder and adds to the strength of the plastic compound, which is formed into sections or slabs, but the objection urged against the use of cement in mines holds good against this form of material, it will not be found durable.

Experience has shown that in the case of the various forms of non-conducting coverings the materials used in their make up, other than asbestos, cannot be recommended for use when exposed to great heat, continued moisture and rough usage and that whatever durability they possess is due to the asbestos fibres which they contain.

It is an established fact that the non-conducting property of a material depends not so much on the elements of which it is composed as on their mechanical arrangement. A material which is made up in solid and compact form, so that its particles are in close contact will be a poor non-conductor of heat. If, however, this same material be so made up as to form numerous air cells between its particles of fibres it will then prove an excellent non-conductor of heat and only such fire resisting substances which admit of such cellular structure are useful as non-conductors of heat. Asbestos for instance, in the compact form of mill board or sheeting is only a fair heat-insulator, while in the loose or fibrous form it is one of the best non-conductors of heat known.

In conformity with these well proven facts, the non-conducting covering which answers for all mining purposes is made from fibrous asbestos.

The asbestos is taken in its crude or natural state and by special processes it is cleaned from all foreign substances and the long silken fibres are selected and separated and divided until they may be formed into as loose and fine an aggregate as cotton batting. Asbestos thus treated is not alone a good non-conductor but will stand the intense heat to which it may practically be subjected and being free from all organic substances it is unaffected by water.

The material prepared as described is shaped by special machines into cylindrical form, of sizes to fit pipes of any diameter and of any required thickness.

These cylinders or sections of asbestos are then cut on one side so as to open and slip over the pipe, after which they are neatly jacketted with suitable material and provided with bands and buckles to hold them in place.

For mine work, under favorable conditions, the jacket is a light cotton duck, which is afterwards coated with a waterproof paint to keep the covering as dry as possible. But in very wet places and under trying conditions a jacket of asbestos and wire cloth is substituted. This is a special material formed by uniting layers of asbestos through the meshes of wire cloth, after which the material is waterproofed. This forms a jacket of great strength and durability, unaffected by heat and impervious to moisture.

These jacketings are to give finish to the coverings and also to prevent any excess of moisture in them, which in filling the air cells would deteriorate its insulating properties. The covering does not depend on the jacket either for its strength or for its protection, as the asbestos fibres from which it is made have in themselves great strength and will stand very rough handling. If they are wet they dry out again without in any way injuring the covering.

FRITZ CIRKEL, M.E.

Montreal, June 6th, 1905.

APPENDIX.

ABSTRACT FROM THE MINING LAW OF THE PROVINCE OF QUEBEC.

SEC. 5.—MINING CONCESSIONS, THEIR FORM AND DIMENSIONS.

1436. Mining concessions are divided into three classes and each of them respectively, in addition to the usual allowance of five per cent. for highways, in each case, shall be of the following form and dimensions, viz:—

1. In unserveyed territory:—

The first class contains 400 acres:—52 chains in width, by 80 chains and 80 links in depth;

The second class contains 200 acres:—26 chains in width, by 80 chains and 80 links in depth;

The third class contains 100 acres:—13 chains in width, by 80 chains and 80 links in depth.

2. In surveyed townships:—

The three aforesaid classes respectively comprise: one, two and four lots, as regularly divided, or more or less, as the case may be, if such lots, being of irregular form, contain more or less than one hundred acres each, in superficies.

1439. All mining concessions, comprised in an unserveyed territory, shall be surveyed by a provincial land surveyor, acting under the instructions of the Department of Crown Lands, and be connected with some known point in previous surveys, so as to be laid down upon the office maps of such territory, of record in the Department.

Such surveys are made at the cost of the applicants, who are required to furnish with their application to purchase the plan of surveyor establishing the position and dimensions of the concessions they desire to purchase, with the field-notes and *proces-verbaux* of the operations; the whole in conformity with the present law and to the satisfaction of the Commissioner.

Sec. 6.—ACQUISITION OF MINING LANDS.—DUTIES OF PROPRIETORS WHO SELL THEIR RIGHTS.

1440. All lands, supposed to contain mines or ores, belonging to the Crown, may be acquired from the Commissioner of Crown Lands:—

1. As a mining concession by purchase, or
2. Be occupied and worked under a mining license.

1441. The mining rights belonging to the Crown in the lands of private individuals may also be acquired in the manner indicated in the foregoing article.

1442. Overy owner of mining land is bound, whenever he sells, transfers or alienates his rights in such land, to give notice thereof to the Commissioner within thirty days of such sale, transfer or alienation.

Sec. 7.—PRICE OF MINING CONCESSIONS.—RESERVES OF THE RIGHT OF CUTTING TIMBER THEREON.

1.—PRICE OF MINING CONCESSIONS.

1443. When it concerns superior* metals, no sales of mining concessions, containing more than four hundred acres in superficies, shall be made to the same person. The Lieutenant-Governor in Council has, nevertheless, the right to grant to any person, upon sufficient proof of his capital and resources, a larger extent of territory, but not to exceed one thousand acres.

When it concerns inferior* metals, it shall be lawful for the Lieutenant-Governor in Council to determine for each mineral the extent of the mining concession which may be granted to the same person.

1444. With such applications to purchase and the production of the documents mentioned in this law, applicants are required to pay to the Department of Crown Lands the entire price of the mining concessions which they desire to purchase at the following rates:—

1. If for the mining of superior metals on lands situated more

*The words "Superior Metals" include the ores of gold, silver, lead, copper, nickel, and also graphite, asbestos, mica and phosphate of lime, and the words "inferior metals" mean and include all the minerals and ores which are not included in the preceding definition and which are of appreciable value.

than twelve miles from a railway in operation, five dollars an acre, and if on lands situated less than twelve miles from such railway, ten dollars an acre;

2. If for the mining of inferior metals, the price shall be fixed by the Lieutenant-Governor in Council.

1446. Unless stipulated to the contrary in the letters-patent:

1. In concessions for the mining of superior metals, the sale of such concession shall give to the purchaser the right to mine for all metals which may be found therein;

2. In concessions for the mining of inferior metals, the sale of such concession shall give to the purchaser the right to mine for inferior metals only.

RESERVE OF RIGHT OF CUTTING TIMBER ON MINING CONCESSIONS.

1448. The holders of licenses to cut timber have, under such license, the privilege of cutting on all mining concessions granted within their limits pine timber measuring twelve or more inches in diameter on the stump, and spruce timber measuring nine or more inches in diameter on the stump.

This privilege shall, however, finally expire after a period of three years from the date of the issue of the deed of sale.

1449. The letters-patent for Crown land, sold as mining concessions, within the meaning of this law, shall contain a clause reserving all trees of pine or spruce timber in favor of the Crown; and, subject to the provisions of the preceding article, the Commissioner may grant to any person whomsoever the right of entering upon the said lands and cutting and taking therefrom, according to the regulations, the trees so reserved and making and keeping in repair across the said mining concessions all roads necessary for such operations.

1450. The purchasers or proprietors of such mining concessions have, in the case of the two preceding articles, the right to cut and take away for their own use such trees as they may require for the construction of the buildings and dependencies necessary for their operations.

SEC. 8.—CANCELLING OF SALES OF MINING LANDS.

1451. Mining lands shall be sold on the express condition that the purchaser shall commence *bona fide* the mining of the minerals therein contained within two years from the date of purchase and that during such delay the purchaser shall in such working spend a sum of not less than five hundred dollars, if for superior metals, and of not less than two hundred dollars, if for inferior metals.

The Commissioner may cancel the sale of such mining land in default of the performance of the conditions herein mentioned, according to the mode followed for the cancellation of sales of public lands.

Letters-patent shall be issued only on satisfactory proof that the foregoing conditions have been fulfilled.

Sec. 9.—LICENSES.

EXPLORATION AND PROSPECTING LICENSES.

1452. Any person, firm or company may, without a license, prospect and search for mines or ores upon public lands not already occupied as mining concessions or otherwise.

When any such person, firm or company may desire to enjoy the benefit of such license he shall obtain from the Commissioner such license for such purpose on conforming to the provisions of the following article:—

1453. The application for an exploration and prospecting license shall contain as exact a description as possible of the land required, to the satisfaction of the Commissioner, and shall be accompanied by the following fees, as the case may be:—

1. If the mine is upon private lands, two dollars for every hundred acres; every less number of acres to count as one hundred;

a. In surveyed territory, five dollars for every hundred acres; every less number of acres to count as one hundred;

b. In unsurveyed territory, five dollars for each square mile.

Such license is valid for three months and may be renewed.

1455. Whoever, under such license, searches and prospecss as aforesaid shall make a report to the Commissioner, or to the inspector of the result of his operations.

1456. The holders of such license may afterwards purchase such mine by paying the prices mentioned in article 1444 and by conforming to the present law and also to the regulations passed in virtue thereof.

FORM OF MINING LICENSES.

1460. There are two descriptions of licenses for mining known as follows, to wit:—

1. Private lands' license, where the mining rights belong to the Crown.

2. Public lands' license.

GRANTING AND DURATION OF LICENSES.

1461. Mining licenses are granted on payment of a fee of five dollars and of an annual rental of one dollar per acre.

2. Every such license is valid for one year from the date of issue and is transferable only with the consent of the Commissioner.

3. It cannot be granted for an extent of over two hundred acres in superficies, unless the Lieutenant-Governor in Council otherwise decides.

4. The licensee may, before the expiry of his license, and not later than ten clear days thereafter, renew such license on payment of a like fee of five dollars or of any such other sum as may be determined by law at the time of its issue and of an annual rental of one dollar per acre.

5. No such mining license can be renewed except upon payment of the said fee and of the said annual rental.

POWERS OF LICENSEES ON PRIVATE LANDS.

1465. The holder of a mining license or the owner of mining rights on private lands is aushorized to work the mines thereon with the consent of the private person, or on his refusal by compelling him thereto in the manner provided by the following articles.

ARBITRATION FOR MINING ON PRIVATE LANDS.

1466. Every holder of a mining license or every owner of mining rights on private lands or their representatives who wish to mine on the land of such private person must first cause to be served a notice in writing stating:—

1. That they intend to mine on the land of such private person;

2. That they are ready to pay the damages arising from such mining operations to be assessed by mutual agreement.

1467. The notice shall give a delay of one month from the date of the service to the said private person to answer and make such agreement, if present, and, if absent from the Province, double delay, and in the latter case the notice shall be inserted in French and English three times in a newspaper of the district, if there is such newspaper, if not, in a newspaper of an adjoining district.

MISCELLANEOUS PROVISIONS RESPECTING APPLICANTS FOR AND HOLDERS OF LICENSES AND PERSONS WORKING MINES.

1491. Every applicant for a license to mine upon public lands has a right to plant a wooden picket at each corner of the lot for which he desires to obtain such license.

1492. Every such applicant, after having staked out the location of his land in the manner determined in the preceding article, is bound to give written notice thereof without delay to the mining inspector.

1493. Such notice shall give the name of the applicant, indicate the place where the land is situated, contain a complete designation and description of the land and mention where such applicant erects his domicile under penalties.

1494. The discoverer of a new mine on public lands is entitled to a free mining license, valid for twelve months, for the area allowed by article 1461, or by any regulations which may be issued under it and in force when such discovery is made; provided that such discovery has been immediately reported in writing to the inspector of the mining division.

1495. Any one who does not immediately report such discovery shall be deprived for the space of one year of the right to mine on public lands.

1496. No person is considered to be the discoverer of a new mine, unless the place of the alleged discovery is in a region unknown as a mining region, or at least at a distance of thirty miles from the nearest mine.

1497. Every person holding a mining license, upon renewing the same, is bound, under penalty of the refusal of such renewal, to make to the inspector of the mining division, in addition to the annual statement which he is bound to furnish in virtue of the following article, a full and true statement, under oath, of the work performed and of the minerals obtained by him during the term of such license, which statement may be entered upon the expiring license.

1498. Every owner of mining rights, whether he mines himself or by others, and every person working mines must, during the first ten days of the month of January in each year, furnish a sworn statement of his operations for the past year, indicating the quantity of mineral extracted, its value at the mine and the number of workmen employed, as well as a list of the names of persons killed or injured in working the mines.

1499. No title to a mining concession or license shall, without the formal consent of the proprietor of the soil, give a right to mine or to open pits of galleries, or to erect machines or stores in fields, yards or gardens, or upon lands close to dwelling houses, or boundary fences or dwellings, nor even to enter such yards or habitations.

1500. Every person who prospects or mines for minerals upon lands adjoining a mining division is subject to the provisions of this law, as if he worked within the limits of such mining division.

Sec. 10.—SPECIAL PROVISIONS RESPECTING MINING.

WATER-COURSES AND EXCAVATIONS.

1509. Every miner who makes a pit, shaft or any excavation whatever to a depth of four feet and over is bound to enclose the same with a fence at least four feet in height, if he discontinues working the same for a period of eight days.

1510. All owners of claims and mining locations, bounded by water-courses on rivers upon public as well as upon private lands, may make use of such water-courses on rivers in working their respective claims or locations, but without hindering each other.

1511. Evers dispute arising between the parties on the subject is settled and decided by the inspector of the mining division and whosoever disobeys tee order of the inspector is liable to penalties.

In the Lake St. John region acbestos has been found in sufficient quantities to justify mining operations. On Asbestos Island in Lake Chibogomo fine veins of asbestos were discovered and commercial asbestos was found, for a distance of from 600 to 700 feet on the west part of this island.

The serpentine of this region is similar to that of the Eastern Townships, but somewhat darker in colour.

On the north shore of McKenzie Bay, there is a continuous development of fine greenish serpentine and Mr. Obalski entertains the opinion that regular prospecting would lead to the discovery of commercial asbestos.*

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*Abstract from the report to the Provincial Government of Quebec February, 1905, by J. Obalski, Mining Engineer and Inspector of Mines.

BIBLIOGRAPHY.

Canadain Mining Review—1890, page 150.
" " " —1891, " 200.
" " " —1893, " 207.
" " " —1894, " 163.
" " " —1898, " 22.
" " " —1902, " 146, 152.

Cataloga Della Mostra fatta dal Corpo Reale Delle Miniere—1900, pages 139 and 148.

Chemical Industry—1891, page 95, 200.
" " —1893, " 207.
" " —1899, " 500,
" " —1900, pages 275, 537.
" " —1901, page 1212.
" " —1902, pages 396, 707, 979.
" " —1903, " 110, 225, 555, 649, 720, 757, 1088.

Chemische Zeitung —1897, page 285.
" " —1902, " 95.

Cirkel, F.—Occurrence of asbestos in Templeton, Paper read before the General Mining Association of the Province of Quebec. Vol. I, page 118.

Cirkel, F.—Asbest in Canada, Zeitschrift fur praktische Geologie, 1903, page 122.

Donald, J. T.—Paper on asbestos read before the General Mining Association of the Province of Quebec, Vol. I, page 27.

Ells, Dr.—History, Occurrence and Uses of Asbestos, Canadian Mining Review, 1891, page 59.

Ells Dr.—Bulletin on Asbestos, 1903.

Engineering and Mining Journal—1899, I, page 22.
" " " —1902, II, " 55.
" " " —1903, II, pages 780, 895, 866

Fisher, Alfred—Paper on asbestos, read at a meeting of the Institute of Marine Engineers, Stratford, Essex, April 12th, 1892.

GEOLOGICAL SURVEY OF CANADA, REPORT—1863, pages 472, 608, 824.

" " " " —1876-77, pages 207, 262, 483.

" " " " —1886, page 2 J.

" " " " —1887-88, pages 27 B 106 K, 161 R.

" " " " —1889-90, pages 143, 151 K.

" " " " —1890-91, page 19 S, (Dr. Ells, paper read before the American Institute of Mining Engineers.)

" " " " —1894, pages 81, 84, 87 J.

" " " " —1896, pages 93 A, 16 S.

" " " " —1899, pages 73, 105 J.

JONES, ROBERT—Asbestos, 1897.

KLEIN, L. A.—The Canadian Asbestos Industry, Paper read before the General Mining Association of the Province of Quebec, 1891, 1892 and 1893, Vol. I, page 143.

L'INDUSTRIE—1897.

MERRILL, GEORGE—Notes on asbestos and asbestiform minerals, Smithsonian Institution, 1895.

MINERAL INDUSTRY—1898, page 62.

" " —1899, " 46.

" " —1901, " 44.

" " —1902, " 50.

MITTHEILUNGEN DES TECHNISCHEN LABORATORIUMS DER KOENIGLICHEN TECHNISCHEN HOCHSCHULE ZU BERLIN—1898.

NOTIZIE STATISTICHIE SULLA INDUSTRIA MINERALIA IN ITALIA DAL 1860 al 1880, pages 252, 294.

OBALSKI, J.—Mining Operations in the Province of Quebec, 1901, 1902, and 1903.

ODDS, H. T.—Paper on blue asbestos, read before the Institution of Mining and Metallurgy in London, January, 1899.

PRATT, HYDE—Production of asbestos in the United States, 1904.

PROCEEDINGS OF THE ROYAL SOCIETY OF QUEENSLAND—1890-1893, Vols. VII, VIII and IX, page 120.

TSCHERMAK MINERALOGIE, WIEN—1888, page 95.

UNITED STATES MINERAL RESOURCES—1900, page 862.

WERTHEIM, ED.—Uses of asbestos, paper read before the Asbestos —Club, Black Lake, September 24th, 1891.

INDEX.

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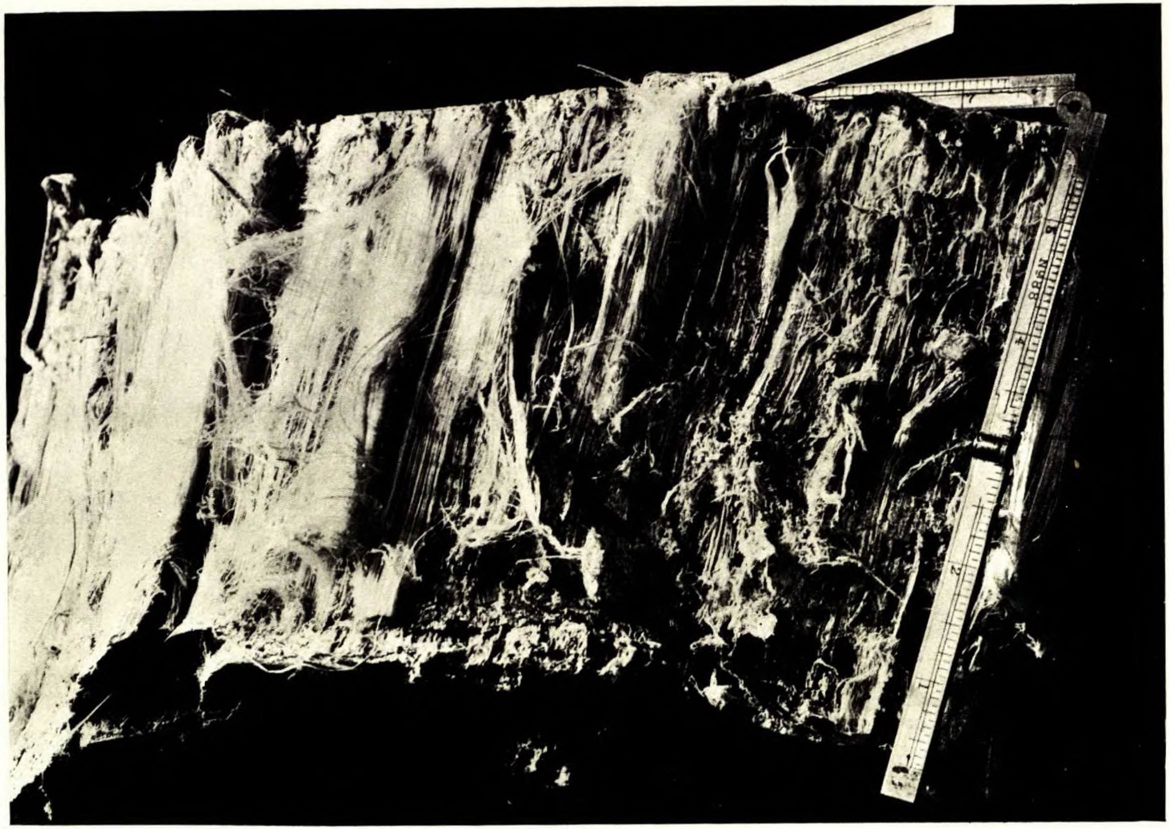
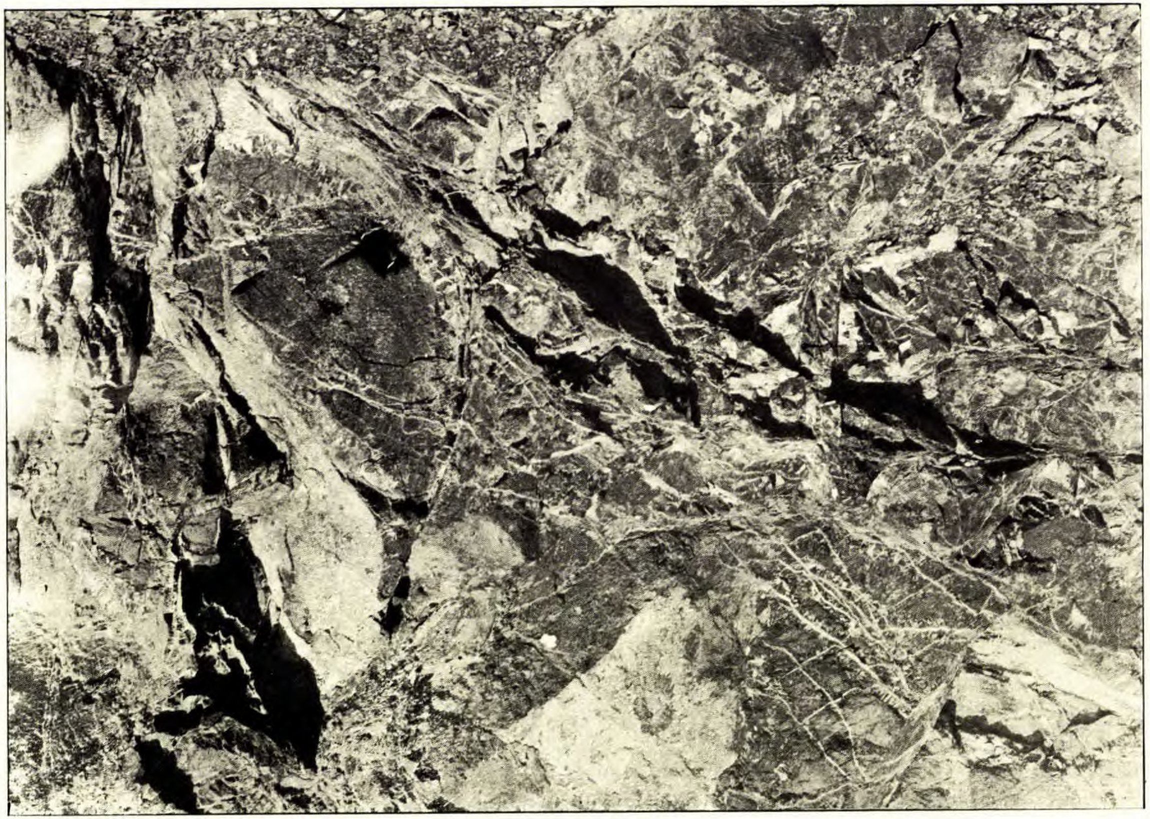
PLATE I.



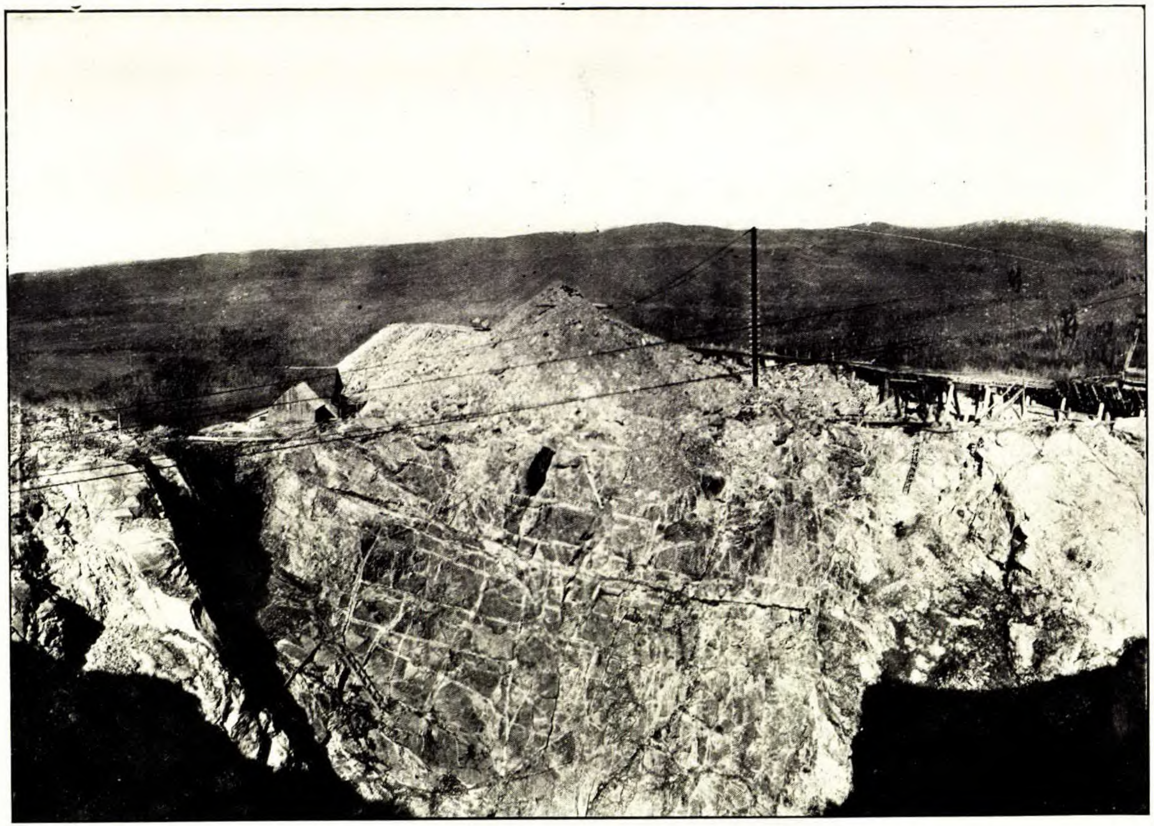
Canadian Chrysotile Asbestos.

PLATE II.



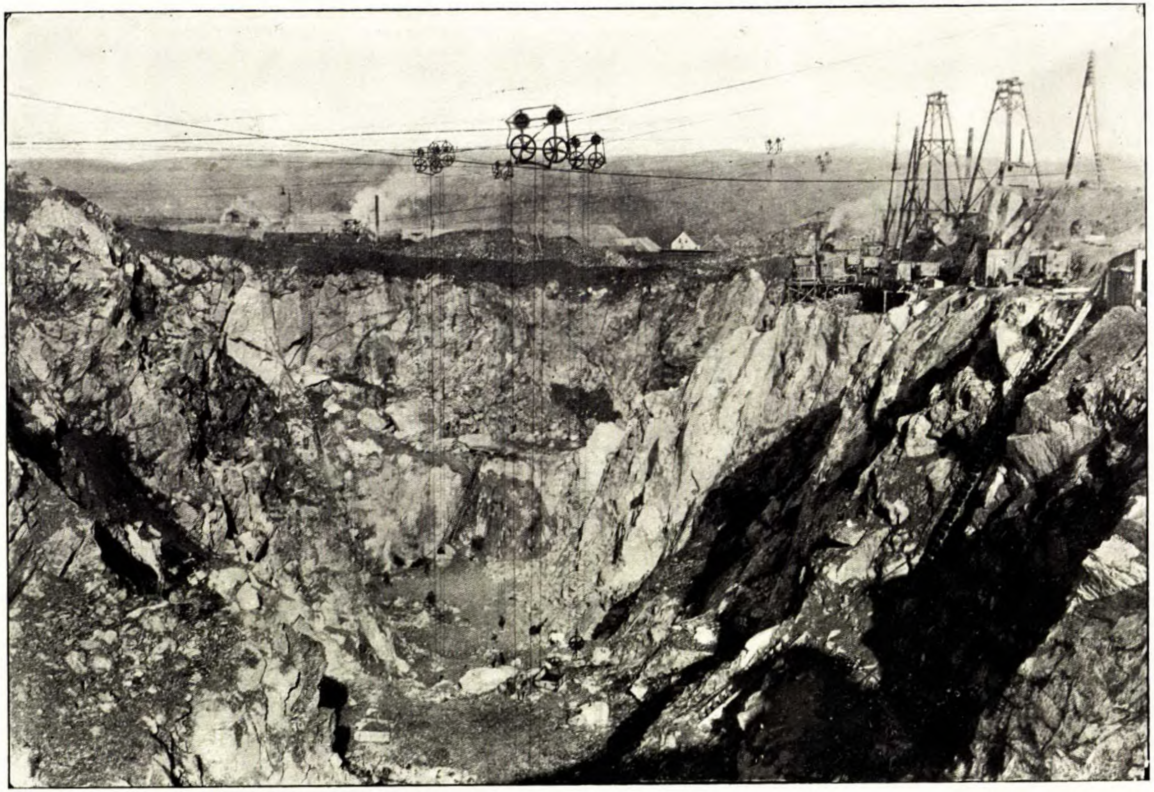
Asbestos Veins in the Quarry of the Standard Asbestos Co., Black Lake.

PLATE III.

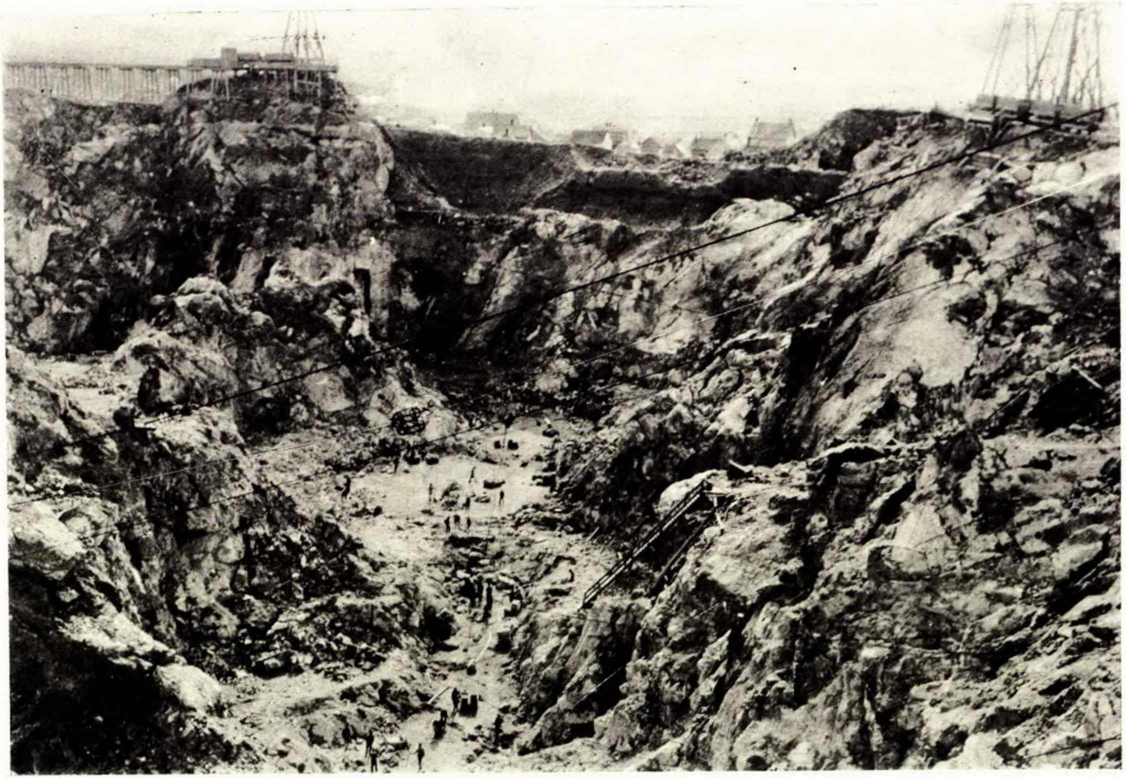


Seamy Partings Containing Asbestos Veins in the Union Mines, Black Lake.

PLATE IV.



Quarry of the King Bros.' Asbestos Mine, Thetford, looking North-west.

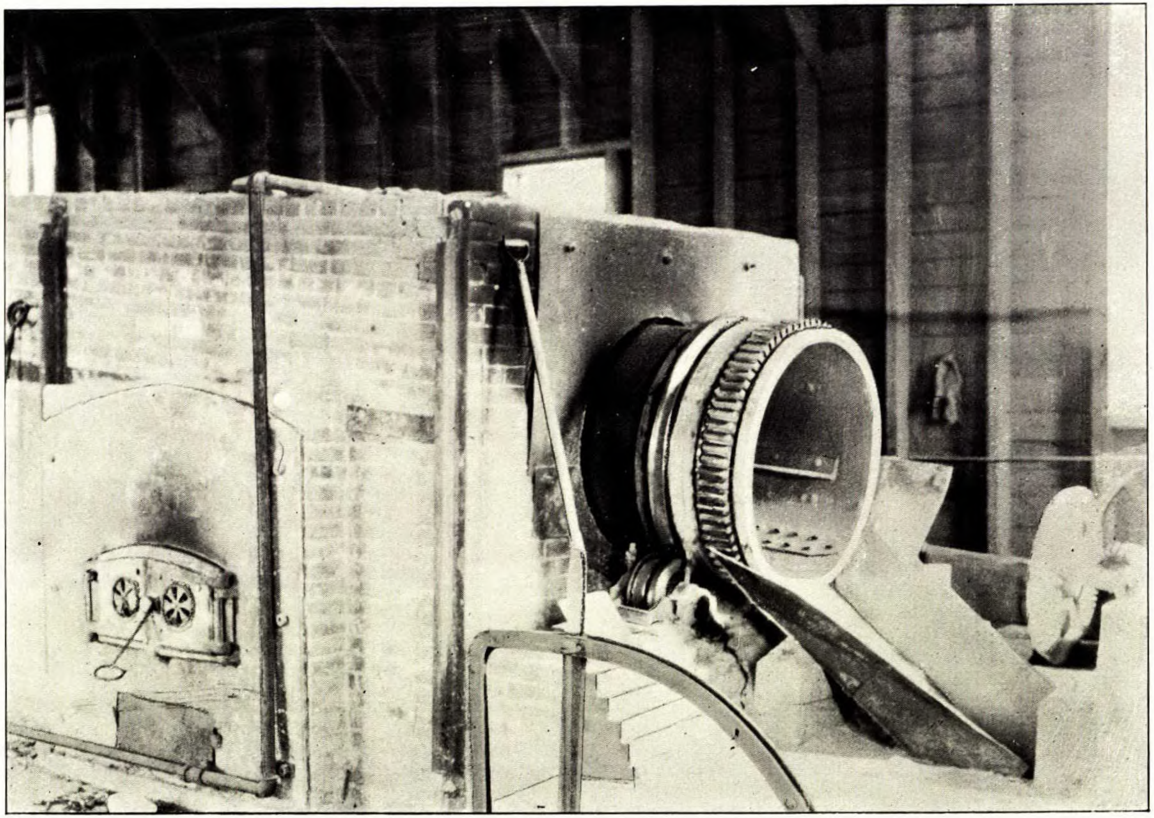


Quarry of the Bell's Asbestos Co., looking west. Thetford.

PLATE V.

Arrangement of Cable Derricks and Tracks near Border of Pit. King Bros.' Mine, Thetford.

PLATE VI.



Rotary Dryer at the Johnson's Asbestos Co., Thetford.

PLATE VII.

PLATE VIII.

A Bunch of Fiberized Asbestos, ready for the Market.

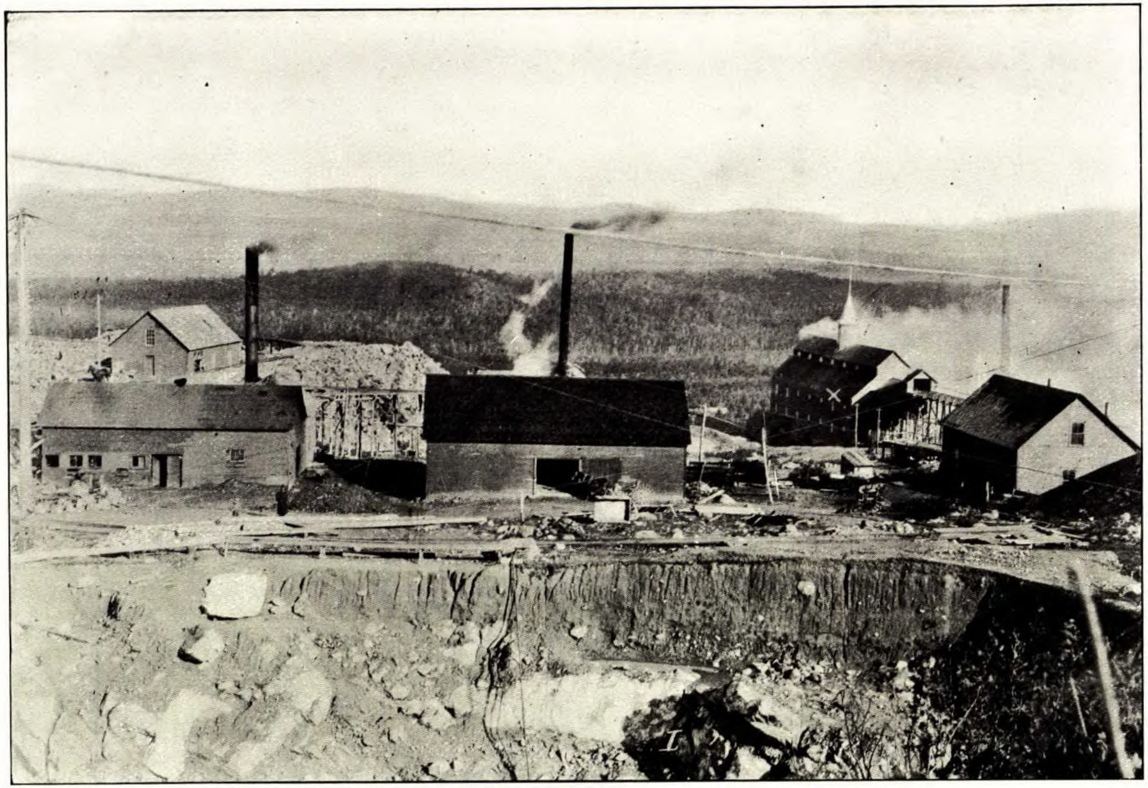
PLATE IX.

The Fiberizing Plant of the Bell's Asbestos Co., Thetford.

PLATE X.

New 500 tons Asbestos Separation Plant of King Bros.', Thetford. X Sand Shed. XX Sand Conveyor. XXX Mill.

PLATE XI.

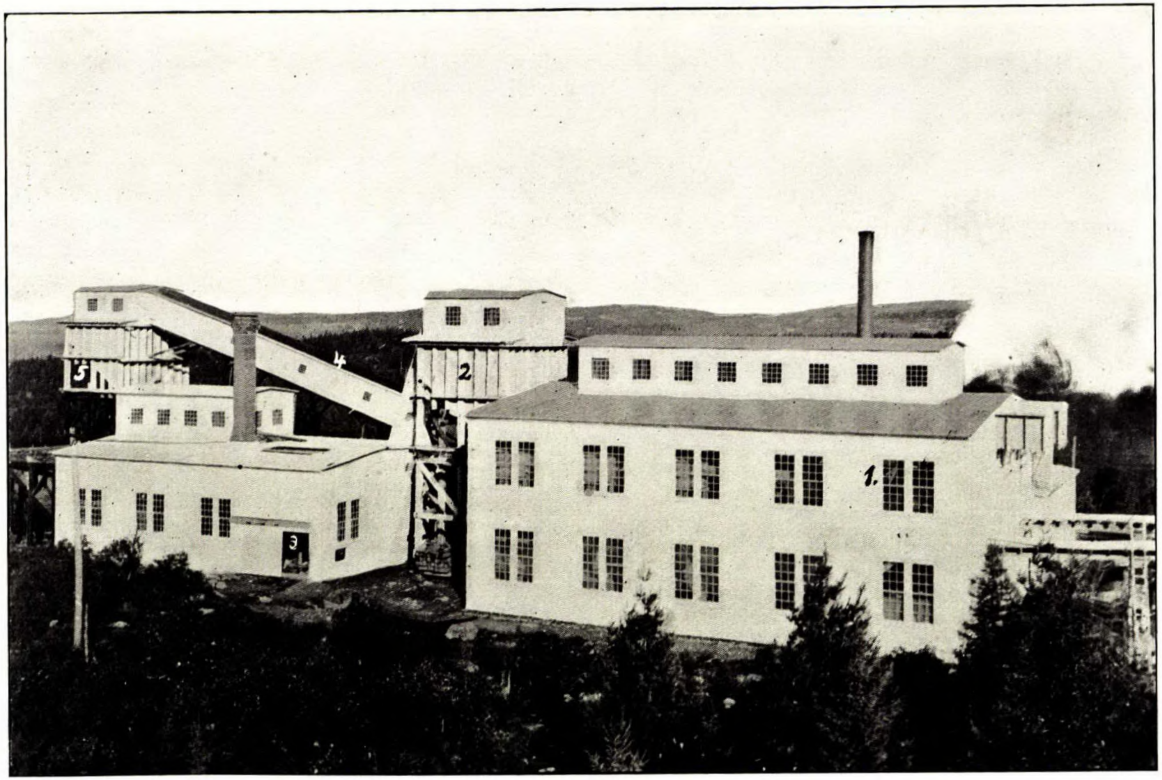


The Plant of the Johnson's Asbestos Co., Black Lake. X New Fiberizing Plant.

PLATE XII.

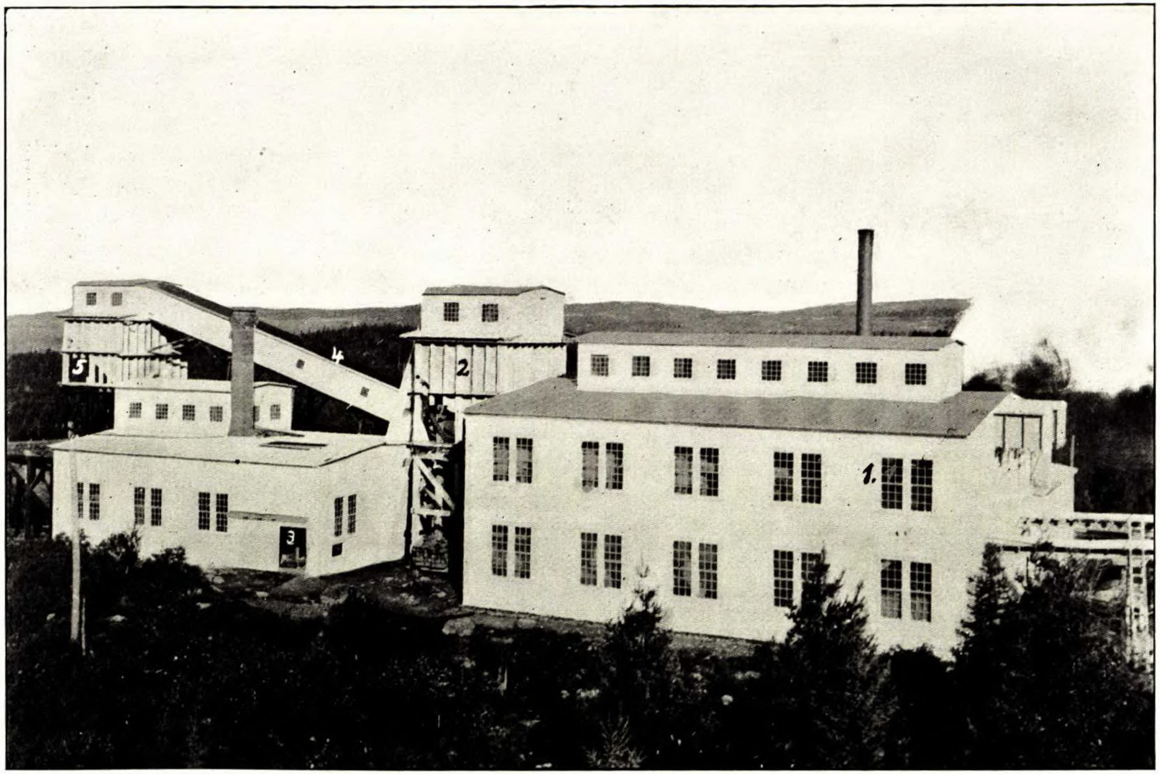
The Fiberizing Plant of the Standard Asbestos Co., Black Lake.

PLATE XIII.



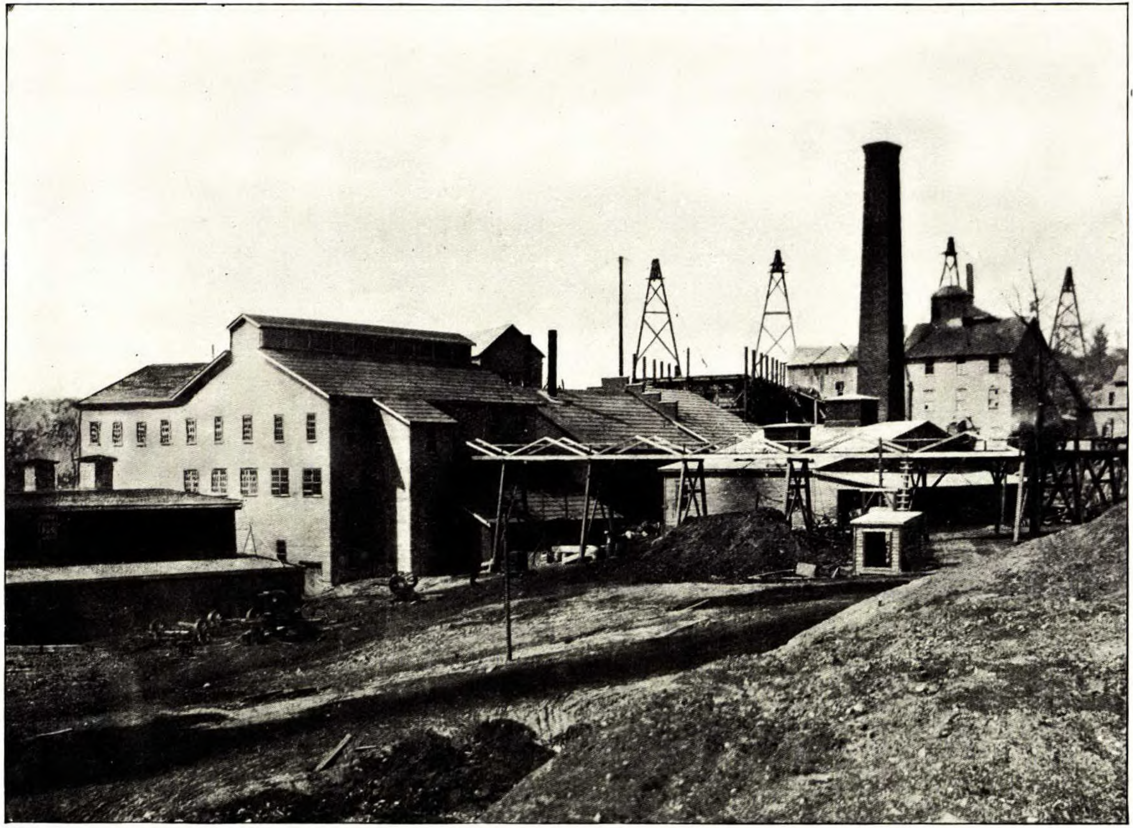
The new Fiberizing Plant of the American Asbestos Co., Black Lake. (1) Fiberizing Mill, (2) Ore Bin, (3) Tryer and Crusher House, (4) Sand Conveyor, (5) Sand Shed.

PLATE XIII.



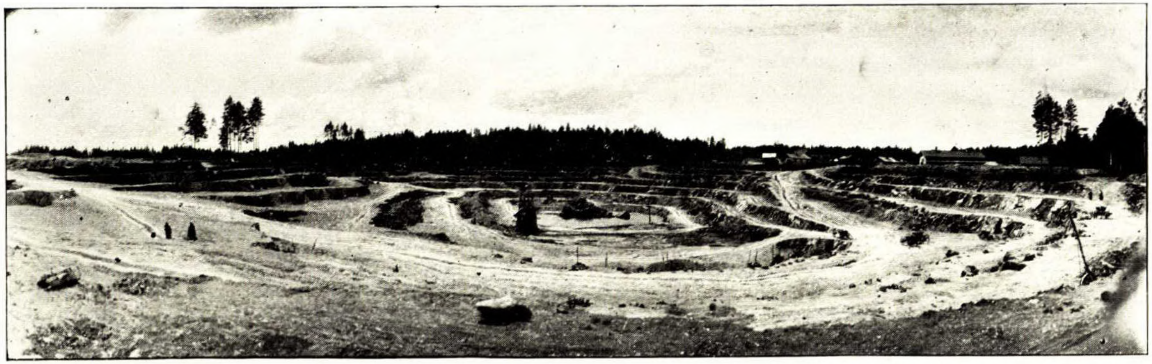
The new Fiberizing Plant of the American Asbestos Co., Black Lake. (1) Fiberizing Mill, (2) Ore Bin, (3) Tryer and Crusher House, (4) Sand Conveyor, (5) Sand Shed.

PLATE XIV.



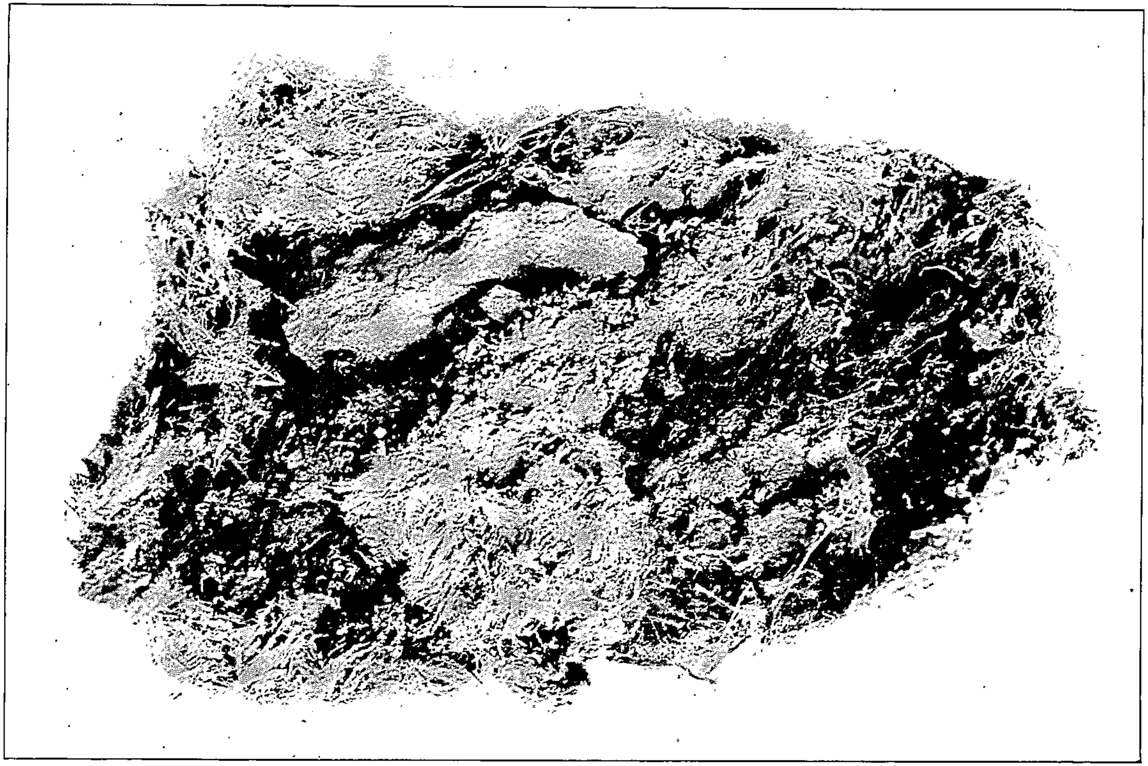
The Asbestos and Asbistic Company's Plant, Danville.

PLATE XV.



Baron Girar de Soukanton's Mines, Ural Asiatic Russia.

PLATE XVI.



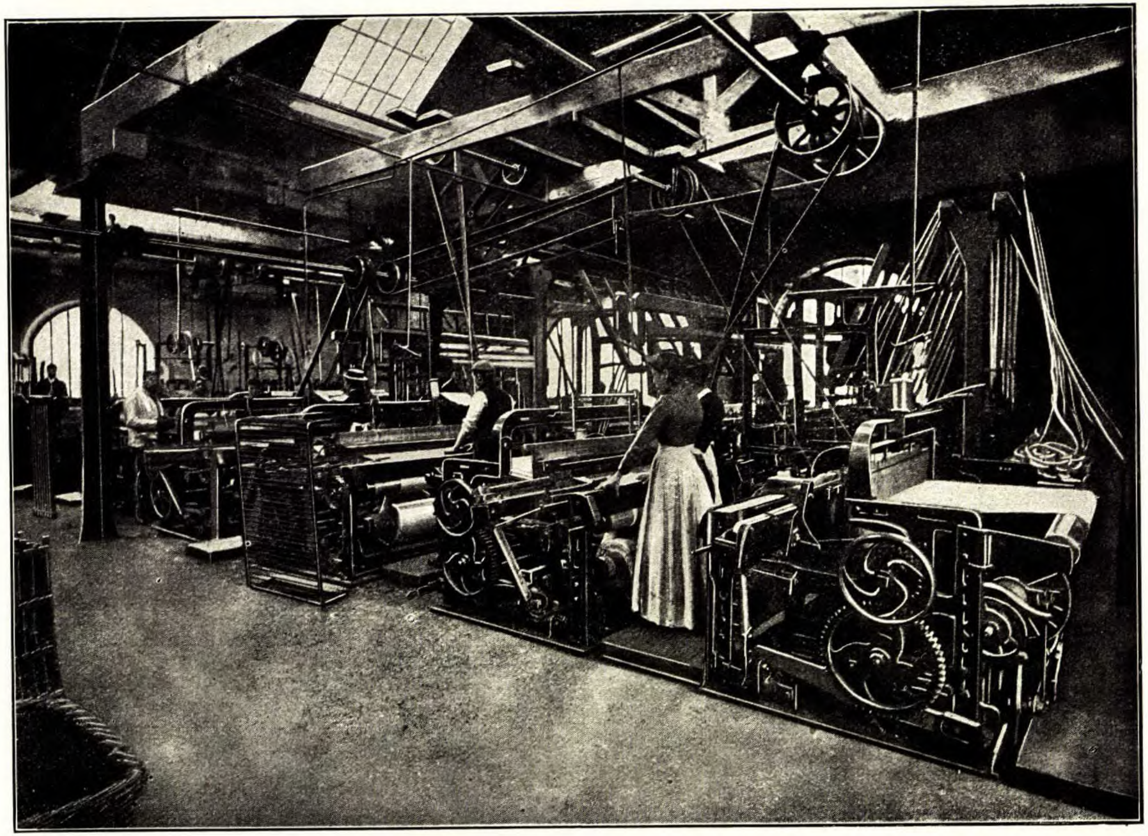
Specimen of Asbestos from the Uralit Mine near Bajencwa Station, Asiatic Russia. The specimen is a conglomerate of Asbestos, decomposed Serpentine, Roots and Fibre from the surface vegetation. This class of material is found in considerable quantity, and must be treated by wet process to prepare same for market.

PLATE XVII.

The United Asbestos Co's. Works, London, England. Spinning Department.

The United Asbestos Co.'s Works, London, England. Weaving Department.

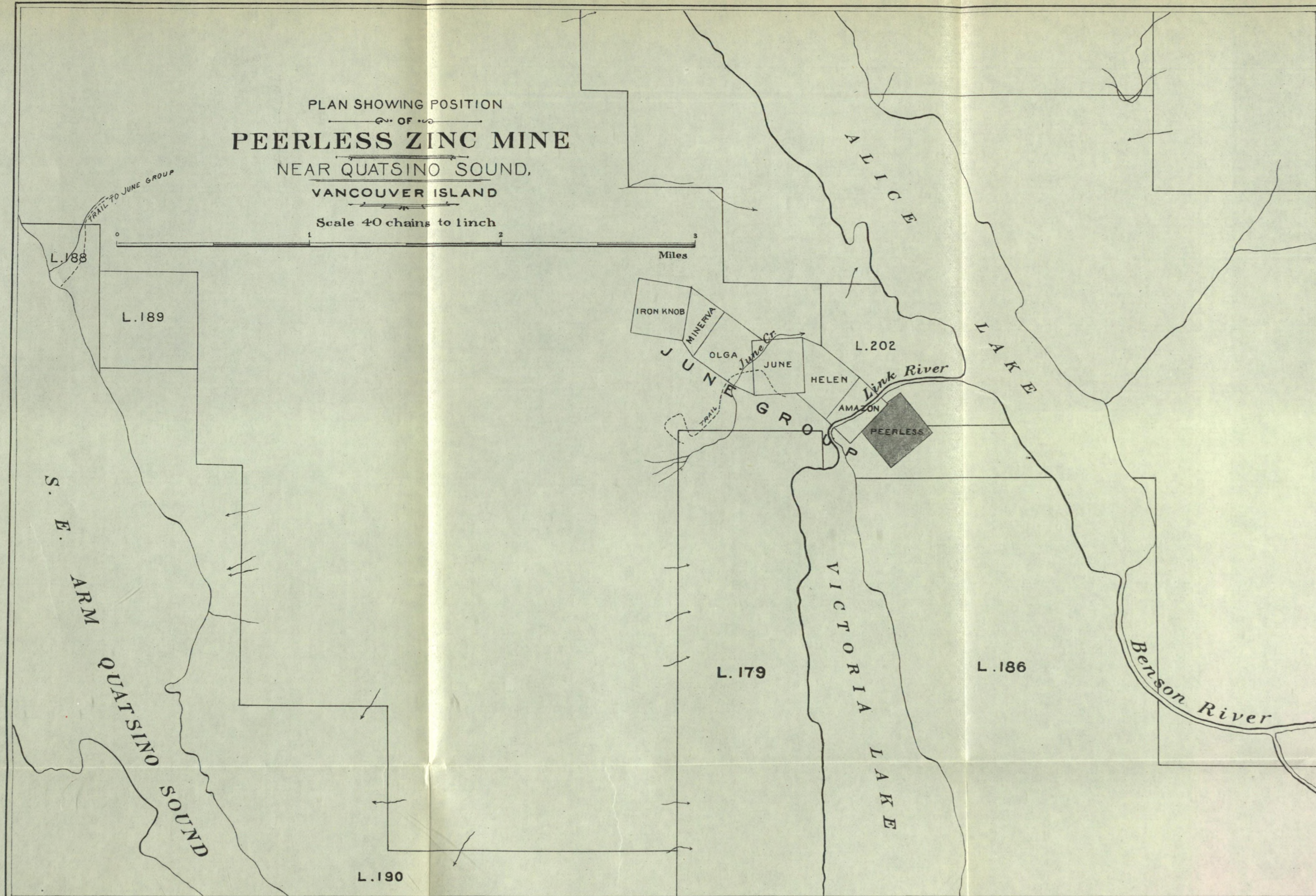
PLATE XVIII.



The United Asbestos Co's Works.—Weaving and Braiding Department, London, England.

PLATE XIX.

PLATE IV


PLAN SHOWING POSITION
OF
PEERLESS ZINC MINE
NEAR QUATSINO SOUND,
VANCOUVER ISLAND
Scale 40 chains to 1 inch
0
1
2
3
Miles
TRAIL TO JUNE GROUP
L.188
L.189
IRON KNOB
MINERVA
OLGA
JUNE
HELEN
AMAZON
PEERLESS
June Cr.
TRAIL
JUNE GROUP
L.202
Link River
ALICE LAKE
S. E. ARM QUATSINO SOUND
VICTORIA LAKE
L.179
L.186
Benson River
L.190