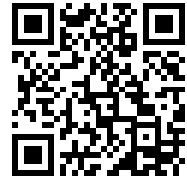
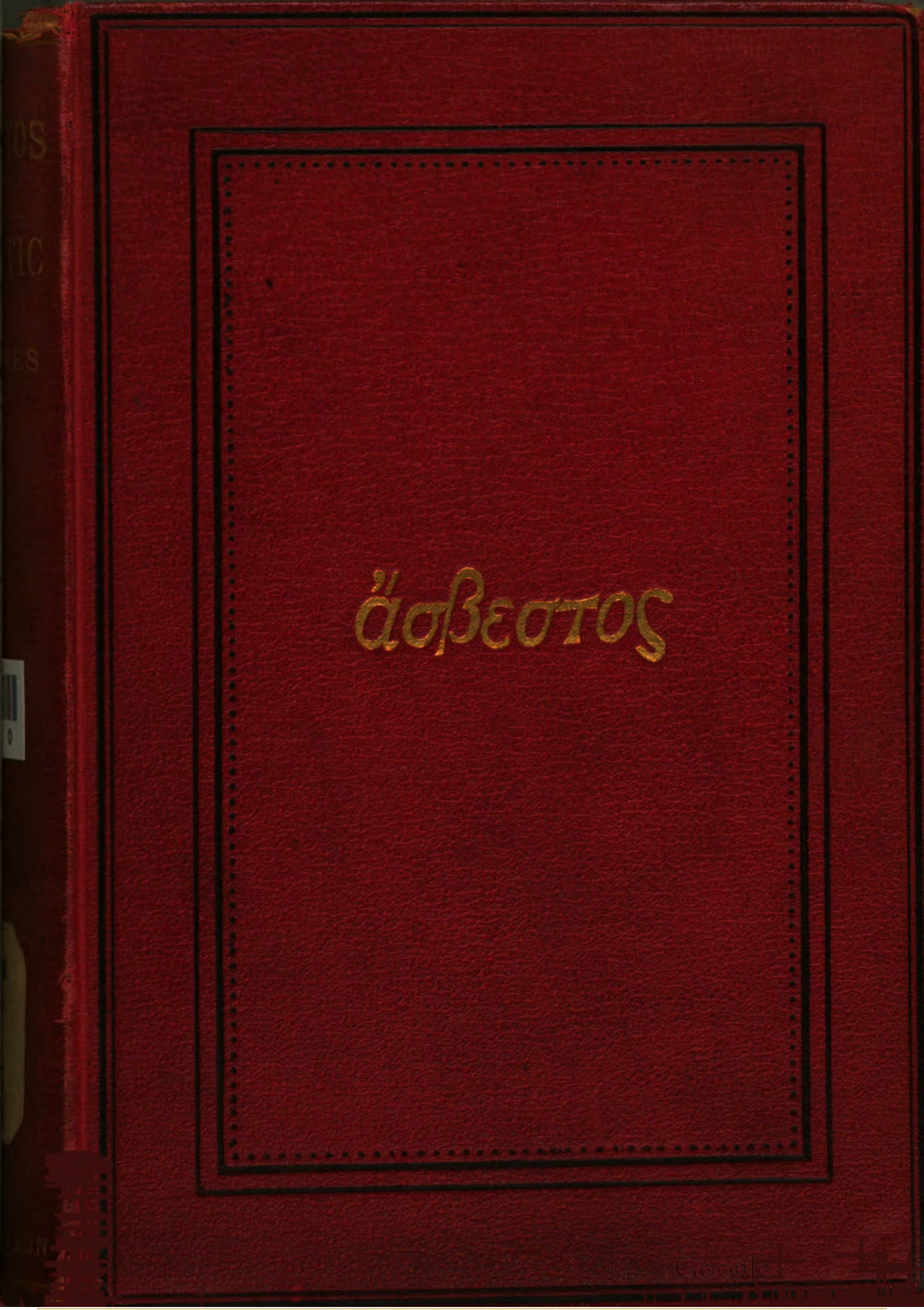
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ASBESTOS AND ASBESTIC

THEIR PROPERTIES, OCCURRENCE, AND USE

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"Of steely colour and of wondrous might
Arcadia's hills produce th' asbeston bright;
For kindled once it no extinction knows,
But with eternal flame unceasing glows:
Hence, with good cause, the Greeks asbeston name
Because, once kindled, naught can quench the flame."

—"LAPIDARIUM."

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ASBESTOS

AND

ASBESTIC:

THEIR PROPERTIES, OCCURRENCE, AND USE

BY

ROBERT H. JONES, F.S.A.

MINERALOGIST

HON. MEM. ASBESTOS CLUB, BLACK LAKE, CANADA.

With Ten Collotype Plates and other Illustrations



LONDON

CROSBY LOCKWOOD AND SON

7, STATIONERS' HALL COURT, LUDGATE HILL

1897

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PREFACE.

It is now barely seven years since I ventured to lay before the public a short sketch of some of the special properties of the new form of Asbestos, then recently found in Canada, with the rise and progress of the important industry, which sprang from it.

The first mine was not opened till 1879, but the fact of the existence of Chrysotile in the Province of Quebec, was known to scientists some years before, though regarded only as a mineralogical curiosity for preservation in the cabinets of the curious. Now its use is absolutely indispensable in every workshop where steam is employed; it is of incalculable value to the marine engineer, and is fast making its way in the domains of electricity.

On its introduction it was looked upon with some degree of suspicion, and only 300 tons were mined during the first year, which realised no more than $19,500. But in proportion as it became better known the rapidity of its progress was prodigious. By 1890, the output had grown to 9,860 tons, and its saleable value had reached $1,260,240.

This was a grand time for mine owners, when even by straining every nerve, under the stimulus of daily advancing prices, they were unable to supply the demands of the manufacturers; while these last daily found increasing difficulty in their endeavours to obtain adequate supplies of the raw material to meet their requirements. No forward contracts

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could be made, and it was impossible to foretell to how high a figure prices would eventually reach.

The immediate natural consequence was that new mines were being daily opened in the principal district, prospectors were hard at work all over Canada and the United States, while in every country in the world search was being made to find new sources of supply. In some cases, the minerals put forward, as being akin to asbestos, were of a singular character and, in a few instances, to the last degree remarkable.

Changes were everywhere incessant, and manufacturers, in self-defence, were beginning to acquire mines of their own, becoming thus producers as well as consumers; and this movement culminated in a combination of some of the most powerful among the last named, who formed themselves into a consolidated firm, under the style of the H. W. Johns' Manufacturing Company of New York.

Then, towards the close of 1896, came about the all-important discovery of Asbestic, by the enterprising Mr. Boas, of St. Hyacinthe, the immediate effect of which was to revolutionise the whole industry.

The time of the discovery coinciding with the exhaustion of the first edition of this book, a new and more complete edition was imperatively called for. Not only had the old methods of work become changed, but a new state of things had come about, and everything relating to the industry had become new. I took the first opportunity, therefore, of starting for Canada to take note of the new order of things, and immediately on my arrival became aware that the changes were everywhere radical, and the progress in machinery and general work so immense that former descriptions were quite inapplicable. Moreover, some account of the progress of the industry in other countries which I had visited, had to be recorded, with, more especially, an authentic account of the nature and effect of the important discovery at Danville.

In detailing all these matters in a new edition, I beg to express my acknowledgments to Mr. J. Alfred Fisher, the Secretary and Manager of the United Asbestos Company, for

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a description of the road to, and the proceedings at, the Italian Mines; and to the Proprietors of the various mines and works in Canada and the United States, who all, with one solitary exception of but little practical importance, gave me free access to their premises and every information about their progress and new methods of business.

In every case I have sought the highest and best authorities for the statements made, and have freely availed myself of the Government Reports, Maps, and Plans furnished by the Geological Surveys, of Ottawa and Ontario; and as in this new edition no time, trouble, or expense has been spared in any particular, I would fain hope that it may, at any rate, be as favourably received as its predecessor was.

ROBERT H. JONES.

ARDENHAM, THE GRANGE,
GUNNERSBURY, LONDON, W.
1st June, 1897.

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ASBESTOS.

CHAPTER I.

INTRODUCTORY.

NATURE AND PROPERTIES—Indestructibility — Fire Proofness — Supposed Vegetable Origin — Cremation Cloths—Shrouds—Salamander's Hair—Marco Polo—Sacred Fires in the Temples—Vestal Virgins' Lamps—Cere Cloths for Embalming—Charlemagne's Tablecloth—A Quebec Yarn — Roman Napkins — Difference in Nomenclature — Supposed Indian Dresses—Modern Appliances—Norwegian and Greenlanders' Lamp Wicks—Asbestos Paper described by Pontoppidan—Professor Bruckmann's Manufactures—Italian Experiments—Slow Recognition in Canada.

ASBESTOS is one of the most marvellous productions of inorganic nature. It is a physical paradox, a mineralogical vegetable,* both fibrous and crystalline, elastic and brittle ; a floating stone, as capable of being carded, spun, and woven, as wool, flax, or silk.

Occupying the apparent position of a connecting link between the mineral and vegetable kingdoms, it would appear to possess some of the characteristics of both, while being altogether different from either. In appearance, it is as light and feathery as thistle or eiderdown, while, in fact, it is as dense and heavy as the rock which carries it. Ostensibly as perishable as grass,

* "All stones, metals, and minerals are real vegetables, that is, grow organically from proper seeds, as well as plants."—Locke's "Elem. Nat. Hist.," c. viii.

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it is actually older than any animal or vegetable life on earth. So little, indeed, is it affected by the dissolving influences of time, that the action of unnumbered centuries, by which the hardest rocks are worn away, has had no perceptible effect on the asbestos found embedded in them. While some portion of its bulk is composed of the roughest and most gritty materials known, it is really as smooth to the touch as soap or oil. Apparently as combustible as tow, the fiercest heat cannot consume it, and no combination of acids will affect the strength of its fibre, even after days of exposure to their influence. Notwithstanding its extreme delicacy, a single strand of it can be spun to weigh less than an ounce to one hundred yards, and a cloth may be manufactured from its fibres which shall weigh less than eight ounces to the square yard.

Not the least remarkable of its many seeming inconsistencies, is that, while, in some form or other, it occurs in nearly every country in the world, it is never found, either in its fibrous state or in the rock which encloses the fibre, in any two countries precisely alike, or indeed in any two parts of the same country, or even the same district, which will be more particularly referred to when we come to speak of the Asbestos and Asbestic Company's Works at Danville.

In some few cases it is known to be applicable to a surprising number of often, seemingly, very dissimilar uses; but more frequently its coarseness, the ruggedness of its texture, or some defect in its general character, renders it, at present, useless in the arts and manufactures.

Its Indestructibility.—One of its best-known and most valuable properties is found in its indestructibility, which enables it to resist decay and destruction under almost every condition of heat and moisture, preserving it even from undergoing any deleterious change when brought into contact with superheated steam or grease. It is not even worn away, or rendered useless, by the severe treatment it undergoes in connection with marine, hydraulic, or other engines. So little influence of a chemical

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nature does it exert over any metal, with which it is brought in contact, that, if a joint be broken, the surfaces will be found entirely free from corrosion. Moreover, its incombustible nature and slow conduction of heat render it a complete protection from flames. In its crude state, therefore, it is keenly sought for, whilst, as a manufactured article, it must necessarily command a high price.

Fire-proof Quality.—Another of its most important qualities lies in its being absolutely fire-proof—a fact which was well known to, and properly appreciated by, the ancients. To us it is known also as a non-conductor of heat and electricity, as well as being practically insoluble in acids. But although, in its anhydrous form, it will withstand a temperature of from 2,000° to 3,000° Fahr., and even 5,000° will produce no visible effect on the best qualities, the hydrous variety loses much of its flexibility, and becomes brittle, at a temperature sufficiently high to affect, even partially, its dehydration. It is now so well known in the electrical, chemical, and mechanical arts, and is so unique in its fire and acid-proof qualities, that it has become of universal application, and is perfectly indispensable, in many trade and scientific appliances.

Supposed Vegetable Origin.—The Romans, who drew their supplies from the Italian Alps and from the Ural, believed it to be of vegetable origin, the silky appearance and unctuous feel of the fibre contributing to the idea that it was an organic substance; even silk itself, according to Herodotus (3, 106), was simply a kind of wool which grew on trees; and we are also told by him that they made a kind of

Cremation Cloth of asbestos, in which to enwrap the bodies to be consumed on the funeral pyre, in order that the ashes and unconsumed particles of bone might be kept separate from the remains of the fuel, in order to be preserved in vases or in the family urn. In this wrapping, apertures were of necessity left to allow of a free passage for the flames. It would not appear, however, that such a cloth as this could very frequently have been so used, on account of its expensiveness. Pliny speaks of it as a rare and costly cloth,

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the funeral dress of kings.* Assuming its vegetable origin, he calls it *linum vivum*,† the difficulty of weaving which, he says, was very great on account of the shortness of the fibre; which is a somewhat singular reason to give, seeing that he was not speaking of chrysotile, to which that remark might, with some justice, have applied, but to the Italian mineral, *amianthus*. Judging, however, from modern experience, it would seem that shortness of fibre could not have been the only, or indeed the main, cause of the difficulty, and it would be singularly interesting to know how that difficulty, whatever it was, was in those days surmounted. In all probability, it was accomplished by weaving some organic fibre, probably flax, with the inorganic, and then, aided by a liberal supply of oil, weaving both together, the oil and flax being afterwards got rid of by exposing the cloth to a red heat; which, in point of fact, was the mode actually adopted in modern times, until, after long-continued experiment, means were found of overcoming the refractory nature of the mineral fibre. In one of the asbestos cloths shown in the Vatican Museum, the vegetable matter woven with this mineral fibre can be very plainly seen.

Shrouds.—We are told by Sir E. J. Smith, that in the Library of the Vatican, he was shown a winding sheet made of amianthus, which, although coarsely spun, was as soft and pliant as silk. He also says that, when the attendant set fire to one corner of this cloth, it burned with great rapidity and brightness, without being injured in any way; which is sufficient to show the nature of the fibre which was woven in with the asbestos. This particular shroud is of considerable length, and was found, perfectly intact, with a quantity of ashes, in a sarcophagus in the Via Prænestina, in 1702; and by order of

* "Des suaires dans lesquelles on enveloppait le corps des grandes personnages."—Jagnaux, "Traité de Min." "Die Gewänder, deren man mehrere wieder abgefunden hat, waren aber so kostbar als Perlen."—Quenstedt.

† "Plinius handelte ihn als linum vivum bei den Pflanzen ab;—'nascitur in desertis adustisque sole Indiæ, ubi non cadunt imbres, inter diras serpentes, assuecitque vivere ardendo.'"—Quenstedt, "Handb. der Min." "Lana montana."—Agricola.

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Clement the Eleventh was deposited in the Library, where it is still to be seen by the curious.

Salamander's Hair.—The Pope is also said to have in his possession a cloth of Salamander's hair which was sent as a costly gift to one of his predecessors, by the Great Khan, in which cloth he keeps the Sudarium of our Lord.

Marco Polo.—That such a salamander, or asbestos, cloth was really manufactured in the country of that potentate is corroborated by Marco Polo, who tells us that when (about A.D. 1250) he was traversing the region then known as the Great Empire of Tartary, but which now forms part of Russian Siberia, where, as we know, asbestos exists in abundance, he was shown some cloth that withstood the action of fire, and which the people told him was made from the skin of the salamander.* But Marco was far too wary a traveller to be caught by any fable about a woolly lizard, so he very carefully examined the material, and then found it to be made of "a fibrous mineral called *amianto*." Following up his inquiries, he elicited the further information that when the ore, from the fibres of which the cloth was made, was first dug out from the mountain and broken up, it strung together, and formed a thread similar to wool. It was then dried and pounded in a mortar, when, after washing out the impurities, the clear thread remained behind. This thread was afterwards woven into cloth, which, at first, had a somewhat dingy appearance, but, after being subjected to the action of fire, became "white as snow, and without a stain."

When the mode adopted, at the present time, of extracting the Italian mineral from the rock, and preparing it for use, comes to be considered, we shall see with what singular accuracy the process has been described by him. It is matter of regret, therefore, that this painstaking traveller did not push his inquiry still further, or find an opportunity of witnessing the manufacture, so that he might have told us, in the same lucid manner, how the weaving of the fibre was accomplished. The dinginess of colour he refers to would

* *Vide* p. 22. "Earth-flax, or salamander's hair."

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naturally be accounted for by the handling. The process of weaving the cloth, as well by the ancients as by the Tartars, shows that they had both attained considerable skill in the textile arts, especially when we consider the difficulty experienced in modern times in accomplishing this object, by reason of the peculiar nature of the mineral fibre.

The variety of asbestos here spoken of, by Marco Polo, as amianto (amianthus) has always been regarded as the most valuable kind, on account of its beautifully long, white, flexible, and delicately arranged fibres. In whatever part of the world this occurs, it is always found embedded in the older crystalline rocks. It is seldom found in the United States, and never, so far as I know, in Canada.

Some very beautiful specimens of amianthus are brought occasionally from Savoy and Corsica. Indeed, so plentiful is it in the latter island, that, before its commercial value was known, it was often used, instead of tow, for packing. Dana says that Dolomieu, when there, made use of it for packing up the other minerals of his collection. There is also a fibrous kind of potstone* found there, which, like asbestos, is a silicate of magnesia, and for which considerable use is found.

The following extract from Marco Polo's travels will no doubt be read with interest. From its faithfulness and life-like truth it might have been written yesterday.

"Of the Voyages of Master M. Nicolo and M. Maffeo from Constantinople to the Great Can, and their coming home to Venice. In the Yeare of our Lord 1250.

"*After the Prouince of Camul, followeth the Prouince of Chinchuitalas, which on the North is bounded upon the Desart, and is sixteene dayes Journey in length, subiect to the Dominion of Great Cham. . . . In this prouince there is a Mountaine where are Mines of Steele and Andanicum, and also Salamanders, of which Cloth is made, which if it bee cast in the fire cannot be burned. But that Cloth is made of the Earth in this manner,* (*as one of my companions, a Turke, named Curcifar, a man*

See p. 48.

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endued with singular industrie, informed me), who had the charge of the Minerals in that Prouince. A certaine Minerall of Earth is found in that Mountayne, which yeeldeth threads not unlike to Wooll, which being dryed in the Sunne, are bruised, in a brazen Morter, and afterward washed, and whatsoeuer earthy substance cleaueth vnto them, is taken away; lastly, those threads so purged and made small, are spunne, like other Wooll, and wouen into cloth. And when they will whiten those Clothes, they cast them into the Fire for an houre, and then they are taken out of the flaming fire vnhurt, whiter than Snow. After the like manner they clense them, when they have taken any Spots; for no other washing is added to them besides the Fire. But touching the Salamander, the Serpent which is reported to liue in the fire, I could search out nothing in the East Countries. They say, there is a certayne Napkin at Rome, woven of the Salamander, wherein the handkerchiefe of the Lord is kept wrapped up, which a certayne King of the Tartars sent unto the Bishop of Rome."

Varro and others also make mention of these cloths, but none of them give us any information which can throw light on the point of manufacture.

Sacred Fires in the Temples.—The religious care, moreover, with which the ancients guarded from extinction the Sacred Fires in the Temples of the Gods, caused them to make use of asbestos as an auxiliary, the flame having been first started by means of a crystal sphere.*

Lamps of the Vestal Virgins.—The lamps, also, which were used by the Vestal Virgins are stated to have been

* Rock crystal, a pellucid quartz, pure silica. From κρύος, ice, κρύσταλλος, pure ice. This latter term was first applied to crystals of quartz only, which, by reason of its transparency, freedom from colour, and frequent enclosures, was thought to be water congealed by intense cold.—Pliny, 27, 9; Sen., "Nat. Quæst.," 3, 25. That it has once been liquid is proved by its enclosures. Boyle, however, showed it to be heavier than an equal bulk of water, by more than two to one, ice being bulk for bulk lighter than water. Pliny says that "the best cautery for the human body is a ball of crystal acted on by the sun" (37, 10); but

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furnished with asbestos* wicks, the fine fibres of which, by their contiguity, would form small tubes or channels, and so serve to draw up and feed the flame with oil, whilst themselves remaining unconsumed. Strabo† and Plutarch‡ both speak of these lamps, calling them ἄσβεστα (perpetual), because the wicks maintained a perpetual flame without being consumed. Pausanias§ also mentions them, specially alluding to one made of gold, for Minerva, by Callimachus, an Athenian artist, respecting which he says that, although it was kept ever burning, both by day and night, it was only supplied with oil once a year, which looks as if the oil was confounded by him with the wick. The wick, he moreover says, was made of Carpasian linen, "the only linen which is not consumed by fire," the name being derived from Carpasius, in Cyprus, where it was first manufactured; no doubt this was the same as that mentioned by Strabo, as being made of Carystian stone, an asbestos found at Carystus, in Eubœa.

Kircher, the German philosopher, had a wick made of amianthus, which he says he burned for two years without injury, it being at length destroyed by accident. But we shall see that, on the other hand, Pontoppidan says he used one for some time, but had to give it up, because he did not get so clear a light as with a cotton wick.

With reference to the use by the ancients of asbestos in lamps and fires, the mineral being abundant in Greenland,

the following extract from the "Lapidarium" indicates a still more singular virtue supposed to be inherent in rock crystal:—

> "Crystal is ice, through countless ages grown
> (So teach the wise) to hard, transparent stone;
> * * * * * *
> Dissolved in honey, let the luscious draught
> By mothers suckling their lov'd charge be quaffed,
> Then from their breasts, as sage physicians show,
> Shall milk abundant, in rich torrents flow."

* "Le mot asbeste vient de ce que dans l'antiquité on employait cette substance pour faire des mèches qui, alimentée *par une source de bitume*, fournissait des lampes perpetuelles."—Jagnaux, "Traité de Min.," 551.

† P. 396. ‡ "De Def. Orac.," v. 2, 410 B. § Lib. 1, 26.

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is there used at the present time, as also by the Labrador Esquimaux, as I have seen myself, for lamp wicks, and certain kinds of lamps which have asbestos wicks are made in England, for use in lighthouses; whilst the very common use of it in gas stoves, where the appearance of fire, so grateful to Englishmen, is desired, will at once be called to mind. These modern adaptations of the fibre, therefore, can only be looked on as so many exemplifications of the truth of Solomon's saying that "there is nothing new under the sun."*

Cere Cloths for Embalming.—Under the Pharaohs also a coarse kind of cloth was said to have been made as a cere cloth, to cover the relics of humanity, and so help to preserve them from the ravages of time; the body having been first embalmed, by the undertaker, with aloes and subtle essences, in order to prevent the survivors from suffering from the pestilential exhalations which would otherwise have emanated from them. But it is now greatly to be doubted, whether this cloth was ever made of asbestos at all. De Candolle† has shown that the cloths in which the mummies were enwrapped are invariably of linen and not cotton, according to Thompson and other observers familiar with the use of the microscope. Under the care of Professor Stewart, at the Museum of the Royal College of Surgeons, is the oldest mummy in the world, upwards of 6,000 years old. Professor Stewart helped to unwrap this mummy. He found it to be extremely dry and fragile, and there arose from

* "There is nothing more wonderful in the intellectual history of mankind than the skilful management (by the ancients) of many processes in the arts, the true nature of which was not understood till ages and ages afterwards. Thus, although zinc was scarcely known as a distinct metal until almost a century since, and almost within the same period, one of its commonest ores, calamine, was held in so little estimation in Great Britain, that it was frequently used as ballast for shipping, yet that same ore was used before the time of Aristotle for the purpose of making brass, and to that purpose it is principally applied at the present day."—*Second Bridgewater Treatise.* In regard to which it may be remarked that Pliny noticed that if copper was placed in close proximity to calamine, on being exposed to heat, it increased in weight by absorption of the calamine, thus anticipating the conversion of copper into brass by cementation.

† Alphonse de Candolle, "On the Origin of Cultivated Plants," 406.

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it a fine pungent dust which was extremely irritating, and the Professor told Mr. Fitzgerald, from whose account this is taken, that he found the brain remained, while the body was stuffed with handfuls of ancient cloth. It was wrapped in a gauze-like texture, which he took for papyrus, until he found by the microscope that it was linen. He at once suspended operations, and went to Bond Street, where, entering a linen warehouse, he asked for some of the finest linen it was possible to buy. A piece was brought to him, and he was informed that its like was rarely sold, and then only to the highest and wealthiest in the land. He hurried back with this, and compared it under the microscope with the ancient Egyptian texture woven more than 6,000 years ago; and Professor Stewart's microscopic photograph of the two linens is shown in *The Strand Magazine* for January, 1896, the finer of the two being the ancient Egyptian fabric, and the coarser the very best linen that Belfast or Bond Street can produce.

In former days also, cloth made of asbestos, as mentioned by Marco Polo, was cleansed by passing it through fire, by which, of course, asbestos and not chrysotile, and a charcoal, not a bituminous coal, fire must be understood.

Charlemagne's Tablecloth.—In later days we are told of Charlemagne, that having an amianthine cloth in his possession, one day after dinner he astonished his rude warrior guests by throwing it on to the fire, and afterwards withdrawing it cleansed and unconsumed.*

A Quebec Yarn.—As a modern pendent to this well-known legend, the following was told me in Quebec. A labouring man, who had left the old country to seek a better fortune in the Dominion, found employment on his arrival in one of the many lumber yards on the St. Lawrence, where his energy and activity, supplemented by great bodily strength, soon secured for him a good position. It so happened, however,

* "Amiantus alumini similis nihil igni deperdet."—Pliny, 36.

"Quod ignis adeo non inquinet ipsius splendorem, ut etiamsi in eum conjicitur sordidus, nihil deperdens, nitidus et splendens extrahatur."—Agricola, 609.

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that one evening, on returning from their daily toil, in the soft melting snow, to their common apartment, some of his fellow-workmen, who were crowding round the stove, saw him deliberately throw himself into a seat, kick off his boots, and then pull off his socks, and having opened the door of the stove, coolly fling them in, on to the mass of burning wood. Possibly no particular notice would have been taken of this, judged as an act of mere folly and waste on the part of the new-comer; but when, almost immediately afterwards, they saw him open the stove door again, take out the apparently blazing socks now cleansed to immaculate whiteness, and, after giving them a shake, proceed just as deliberately to draw them on to his feet again, as if such an act were nothing at all unusual, that was a trifle too much! Human nature could not stand that. Consequently, the horrified spectators, unaccustomed to witness such marvels, having for a moment looked on aghast, fled precipitately from the room. To them the facts were clear enough. This, they said, was no human being like themselves; such hellish practices could have but one origin. If not the devil himself, certainly the man could be no other than one of his emissaries. So off they went in a body to the manager and demanded his instant dismissal, loudly asseverating that they would no longer eat, drink, or work in company with such a monster. When, however, inquiry was set on foot, it turned out that some time before leaving England the man had worked in an asbestos factory, where he had learned to appreciate the valuable properties of the mineral; and being of an ingenious turn of mind, he had managed to procure some of the fibreized material and therewith knit himself a pair of socks, which he was accustomed to cleanse in the manner described. He was, as has been indicated, an unusually good workman, consequently his employers had no wish to part with him; but explanation and expostulation were altogether in vain. Nothing could remove the horrible impression which his conduct had made upon the minds of his fellow-workmen. Go he must, and did, nor could the tumult be in any way allayed until he had been dismissed from his work and had left the yard.

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Ancient Napkins, etc.—In regard to the so-called napkins, which are often mentioned, there can be no doubt that these, as well as some articles of dress, were, in ancient days, when wood was the principal fuel used, occasionally made of asbestos, and cleansed in the manner described. Pliny, referring to this practice (19, 1), avers that thereby "such things were returned far fairer and whiter than they could possibly be rendered by the air or water." Some of these napkins, supposed to have been used by the Emperors, are still to be seen in the Vatican Library, and in the Museums at Naples. And some of the cloth of which these were made is so identical in appearance with that manufactured at the present day that only an experienced eye can detect the difference.

With one more instance of its use by the ancients, we may leave this part of the subject. We are told, by Gibbon,* that, at the Siege of Auximum, the Roman General, in order to poison the waters, and thereby tame the stubborn spirit of the defenders of the place, cast into the stream (among other noxious things) "quicklime, which is named, says Procopius,† *titanos* by the ancients, by the moderns *asbestos*, meaning by the moderns, the men of his own time, *i.e.*, the sixth century." But what Procopius here calls asbestos was most certainly not amianthus. It might have been a variety of gypsum, which occasionally assumes an asbestiform appearance, though it may easily be distinguished from that mineral, not only by its softness, but by its becoming an opaque white powder immediately and without fusion, before the blowpipe. When dealing, however, with such statements as these, we must bear in mind that mineralogy, as we understand it, was only very imperfectly known to the ancients; and things quite distinct from one another were often comprehended by them under one generic term, not merely because of some similarity in their appearance, or because they might possibly agree in some striking quality, or even on account of their place of origin, but also, in a few special cases, because the uses to which they were applied were somewhat similar. It

* "Decline and Fall," c. 42. † Lib. 2, c. 29.

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has always, therefore, been a matter of extreme difficulty to identify the names of minerals as formerly employed with those they were intended to indicate. To give one instance, chalk, quicklime, and the sulphate of lime, were one and all occasionally called gypsum, although that word was used generally to signify sulphate of lime only. "Calci res gypsum est," Pliny says; but Theophrastus,* who was a far better mineralogist than Pliny, uses the term with a more general signification, as of an earth prepared by fire, in doing which, however, he seems to confound it with quicklime, as in the paragraph where he says: "Its heat, on being moistened, is surprising; and, when used for building purposes, the builders break it up, pour water on it, and stir it about with sticks, its heat being such that they cannot touch it with their hands." In another place he compares amianthus to rotten wood,† and even such dissimilar minerals as iron ore, quartz, emery, and the diamond were occasionally comprehended under the single term *adamas*.

Indian Dresses.—Professor Ansted, in his "Rambles in Search of Minerals," also tells us that certain tribes of Indians make dresses of asbestos, which they cleanse by throwing them into fire. But, unfortunately, he says nothing of the whereabouts of these unknown tribes. When speaking of "tribes of Indians" generally, one's thoughts first of all turn to the Red Men, dwellers on the American Continent; but it is absolutely certain that they could have been none of these; and even the bare supposition that any tribe of savages could have accomplished the feat of spinning and weaving this refractory mineral fibre into a cloth, is just as wildly improbable as to imagine that any human being could have used it as a covering for his bare skin. There is probably no production of inorganic nature about which there has been so much mystery and misconception. In ancient days, there were current many romantic stories, chiefly of magic and magical performances, in which asbestos undoubtedly played a leading part. It has even been suggested that the three who survived the ordeal of Nebuchadnezzar's fiery furnace were nothing more than three magi,

* περὶ λίθων, c. 29. † ἀμίανθος λίθος, v. 155.

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or magicians, of the period, clad in asbestos dresses,* and it would seem that some of these so-called mythical tales were by no means confined to byegone, or mediæval, times.

Modern Uses of the Mineral.—In considering the general application of asbestos, in modern times, to the several branches of practical mechanics and industrial manufactures, we must remember that the difference between the manners and customs of the present time and those of ancient days, may cause this and many other things to be very differently appreciated by us. It is often alleged that what was done in former times might very well be undertaken to suit modern requirements. But we must remember that the long domination of priestcraft and the perpetual crises by which, in the middle ages, the whole of Europe was kept in a state of perpetual ferment and disquietude, altogether prevented the development of the arts and manufactures, and caused very many of the ancient arts to be lost sight of, if not absolutely forgotten.

Professor Bruckmann.—Although we hear of asbestos wicks and even paper having been manufactured in Norway in the early part of 1700, and also that some time in the last century Professor Bruckmann, of Brunswick, was so successful in the manufacture of asbestos paper, that he caused to be printed on some of his manufacture an account of the natural history of the mineral, some copies of which are said to be still preserved in the Museum at Wolfenbuttel, yet the modern history of asbestos cannot be said to have commenced before the present century.

Madame Perpenti.—Early in this century, Madame Perpenti, of Cône, also successfully employed asbestos, not only in the manufacture of paper, but of cloth also, as well as of a kind of coarse lace, with many other articles of a similarly useful character. And it is especially worthy of note, that in her make of cloth, she made no use of any other fibrous ingredient as an admixture. Her process simply consisted of softening the asbestos in water, beating and rubbing it, and finally separating the fibres by means of a comb furnished with fine steel points, which mode of manufacture would only be consistent with the fact of its being Italian asbestos.

* See *post*, p. 261. (M. Pouchet's experience under the head of fire-protection.)

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Chevalier Aldini.—The matter, however, does not seem to have been seriously taken in hand until 1850, when the Chevalier Aldini and others joined in conducting a series of experiments, in which they were, to a great degree, successful, with the object principally of turning its fire-resisting properties to account for the protection of firemen. Soon after which a highly cultured and intelligent Florentine priest, one Giuseppe della Corona, brought to a successful issue his experiments for the manufacture of asbestos millboard.

Signor Albonico.—And later still, Signor Albonico, having given some attention to this product of the mountains of his native province, joined himself with the priest Corona and the Marquis di Baviero, a distinguished Roman nobleman, in the manufacture not only of asbestos cloth, but asbestos paper also. Having to some extent succeeded in this, they were unsuccessful in their endeavours to secure a contract with the Italian Government for the supply of paper for the use of banknotes and other securities ; any prospect they might have had in other directions being effectually destroyed by the outbreak of the Franco-German War of 1870.

Apart, however, from these and other isolated cases, which no doubt pointed out the way for later experimenters, the important industrial capabilities of asbestos were neglected until quite recently.

When, however, we turn to Canada, which seems to be the natural home of chrysotile, we find that, although the valuable variety of asbestos, which occurs in the Dominion, was well known to geologists for many years prior to 1877, yet, for all practical purposes, its true economic importance remained unrecognised until shortly before that date ; and even so recently as 1882 its value may be said to have been generally unknown. In Rand and Macnally's Great Atlas of the World we do not find asbestos even mentioned, in the copious dissertation to be found there on the trade and manufactures of the Province of Quebec ; iron and copper alone being named as the chief mineral productions of that part of the Dominion. And when, in 1886, a little book was prepared, with great care and at considerable expense,

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for gratuitous distribution in the Canadian section of the Inter-Colonial Exhibition of that year, in order to enlighten the world on the capabilities, productions, and mineral resources of Canada, no mention whatever was made of asbestos among the mineral productions of the country, although some good specimens were to be seen there, notably an especially fine exhibit by the well-known Johnson Company of Thetford.

From the foregoing it would seem that, even at so recent a date as 1886, no very great importance was attached to this mineral in the country of its production. Now, however, all this is changed: land on the serpentine belt (where the mineral alone is found) has been continually increasing in value, and new mines are being constantly sought for and opened; whilst, as the demand for the raw material increases, fresh capital is furnished, and improved machinery is invented and being continually brought into use, for increasing the production; greater care being, at the same time, used in the cobbing and preparation for market of the raw material.

The uses of asbestos, in the arts and manufactures, are, therefore, now of so important and varied a character that the main features of these must be treated of in a separate chapter, as even a mere enumeration of the principal among them would run to too great a length. Indeed, now that it has been demonstrated that a fairly abundant supply of the raw material can, with tolerable certainty, be relied on at a more reasonable cost than was recently believed to be possible, there would seem to be no limit to the growing demand, especially as new uses for the mineral are being daily found. This demand will, of course, still more rapidly increase, as the value and almost universal utility of the fibre becomes, by its increasingly extended use, more clearly known and more generally appreciated. At the present day, it is found and used, in one form or another, in every workshop where steam is employed, to a far greater extent in the United States and Canada than it is in England, where the uses of new things are of much slower growth, even though the fact of their great utility be generally admitted.

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CHAPTER II.

VARIETIES AND QUALITIES OF THE MINERAL.

Derivation of the Name—Varieties—Asbestos and Chrysotile—Asbestos and Actinolite—Intermediate Forms—Mountain Wood, Leather, Paper, and Cork—Earth Flax—Salamanders' Hair—Actinolite—Kymatine—Tremolite—Chrysotile—Blue Asbestos—Crocidolite—Picrolite—Baltimorite—Metaxite—Marmolite—Breislakite—Byssolite—Pyroxene—Hornblende—The Fibrous Structure—Crystallization—Molten Lake—Metallic Veins—Essentialities as a Commercial Product—General Use.

Called by mineralogists asbes*tus*, the name in its Greek form, as commonly used, ἄσβεστος,* signifies unquenchable, inextinguishable,† inconsumable, "*qui peut dure un temps infini.*" In Spain and Portugal it is called *asbesto*, whence asbestino (asbestine), a name applied to asbestos cloth, also to asbestic, a remarkable production of the Danville Mines, specially adapted for building purposes and the manufacture of paper. The French, using the same derivation, call it *asbeste* and describe it as *minéral filamenteux et incombustible.* In Germany, it is termed *Steinflachs* (stone-flax); and in Italy, *amianto* (amianthus, from ἀμίαντος,‡ pure, incorruptible), so named because of the simplicity of the means of restoring it, when soiled, to its original purity, by the agency of fire; and in the local vernacular of the French-Canadian miners it is *pierre-à-coton* (cotton-stone),

* "ἀγάπη ἄσβεστος," eternal affection.—Archbishop Benson, *Daily Graphic*, 4th April, 1890.

† "The stone called Asbestos is not more inextinguishable than the thirst of my paternity."—Rabelais, "Propos des buveurs."

‡ ἀμίαντος λίθος—Dioscor., v. 155. Not ἄσβεστος, quicklime. *Ibid.*, v. 133.

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perhaps as expressive a non-scientific designation as can be found, the fibre itself being commonly spoken of by them as cotton.

The varieties of asbestos are very numerous; but what is technically known by that name belongs to the pyroxene or hornblende group of minerals, and is classed among such igneous rocks as syenite, granite, porphyry, &c. It is, however, really a term used to denote a peculiar fibrous form assumed by several distinct minerals, rather than to designate any particular species. Tremolite, actinolite, and other forms of hornblende and serpentine, passing into fibrous varieties, assume the name of asbestos. These minerals are all silicates of lime and magnesia, or alumina, compounds of silica (silicic acid) with an earthy base, and the greater part of them hydrated. The bases, lime and magnesia, with the protoxides of lime and magnesia, are in many of the magnesian silicates mutually replaceable; these latter also are subject to great variations in colour, density, and other special characteristics. Nearly all the forms are distinguished by having a crystalline fibrous structure, and most of them possess both flexibility and elasticity. In some of them, the whole mass is flexible and elastic, in many others, the fibres only are so, while in some few of the remainder, neither the one nor the other have, to any great extent, either flexibility or elasticity.

There are two main varieties of this mineral, which are very commonly spoken of, and distinguished in a commercial sense, as Italian and Canadian Asbestos. Both are found in altered crystalline rocks, and each of them have their own special associates. In appearance and mineralogical character, the two are as widely different as possible; while, in chemical composition and general applicability to the arts and manufactures, they are almost identical. The former, asbestos properly so called, is anhydrous. It occurs in metamorphic rocks rich in hornblende; while the latter, which, like mica, belongs to the talc, or serpentine, group of minerals, is technically termed chrysotile. It is found in distinct veins in masses of serpentine, and both the rock and its contained fibre, being serpentine, are

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hydrous, its average amount of contained water being from 12 to 14 per cent. Chrysotile was hitherto supposed to be exclusively obtained from the Cambrian rocks; but indications have recently very abundantly shown that the great Laurentian series, to the north of the St. Lawrence, may yet prove to be a rich and fertile source of chrysotile. The fibre found in the Laurentian is widely different from that found in the Cambrian rocks, being so much lighter in colour as to be nearly transparent, on account of its non-association with iron. The Cambrian asbestos, when freshly fractured, is generally of a pleasant tint or some shade of green, often bottle-green.

Asbestos and actinolite are much alike, both in outward appearance and in chemical composition; so much so, indeed, 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 by the fingers, it is named asbestos. Neither of the two contain more than the very slightest proportion of alumina. Both indeed have so nearly the same combinations, and are in many other respects, so similar, that less diversity is to be found between the two, than between individual specimens of each other. In the protoxides of iron and manganese only, the differences between them are found to be more than 1 per cent., actinolite having 1·16 more ferrous oxide than asbestos, and asbestos containing 1·20 more oxide of manganese than actinolite.

Both minerals contain lime and manganese oxide, neither of which are to be found in chrysotile; yet notwithstanding that they are so strangely alike in their form and constituents, as well as in their use and application, by far the greater part of what is commonly sold and used as asbestos, is really, not asbestos properly so called at all, but chrysotile. A special feature to be noted, is that none of the anhydrous silicates of magnesia have much of the unctuous feel, which is so common a characteristic of the hydrous species.

In many places, instead of fibrous veins, an asbestiform substance of a white colour is met with, which not only has an unctuous feel, but shows a gradual change to the fibrous form.

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Asbestos and Asbestic: Their Properties, Occurrence, and Use (1897)
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The sub-varieties known as mountain wood, mountain leather and paper, and mountain cork, differ in many ways from the more valuable kinds, one of the principal peculiarities of these being that the fibres, instead of lying parallel across the vein, are so matted and interlaced, that the fibrous structure is not, at all times, readily apparent. The three first-named are so called, from the similarity of their appearance to the substances after which they are named, and the latter from its extreme lightness, which enables it to float on water, as if it were really cork; its lightness being caused by the loose interlacement of the fibres, which, by their peculiar arrangement, form multitudinous air cells, which, in this case, would seem to indicate its special use.

Mountain Wood (*Ligniform asbestos*, *Bergholz*, *Holzasbest*, *Xylotil*) is not only hard and close grained, but capable of taking a high polish. It is generally of a brownish colour, and often bears so exact a resemblance to petrified wood, that, at first sight, it might be readily mistaken for it, especially when sufficient iron is present to give it the tawny tinge of decayed wood or bark. Under the microscope, however, the crystal fibre is readily detected, as is also the absence of the vegetable cells, which are always to be found in petrified wood. The fibres of this variety, though varying much in texture, are generally long, curved, and compact, and will melt to a black slag. Rammelsberg thinks it may be an altered chrysotile.*

In some of the Canadian mines very curious specimens are occasionally found. Some of these, of the nature of mountain wood, as they lie on the ground, after blasting, have so much the appearance of a wood-cutter's choppings that, if placed side by side with actual chippings from rough timber exposed to the weather in the woods, the one could not be readily distinguished from the other, except by handling, when naturally the weight and stony feel of the asbestos would make the difference at once perceptible.

Mountain Leather (*Bergleder*, *Bergfleisch*) contains little or no alumina, and originates in cases where the fibres "felt"

* Quenstedt, 332.

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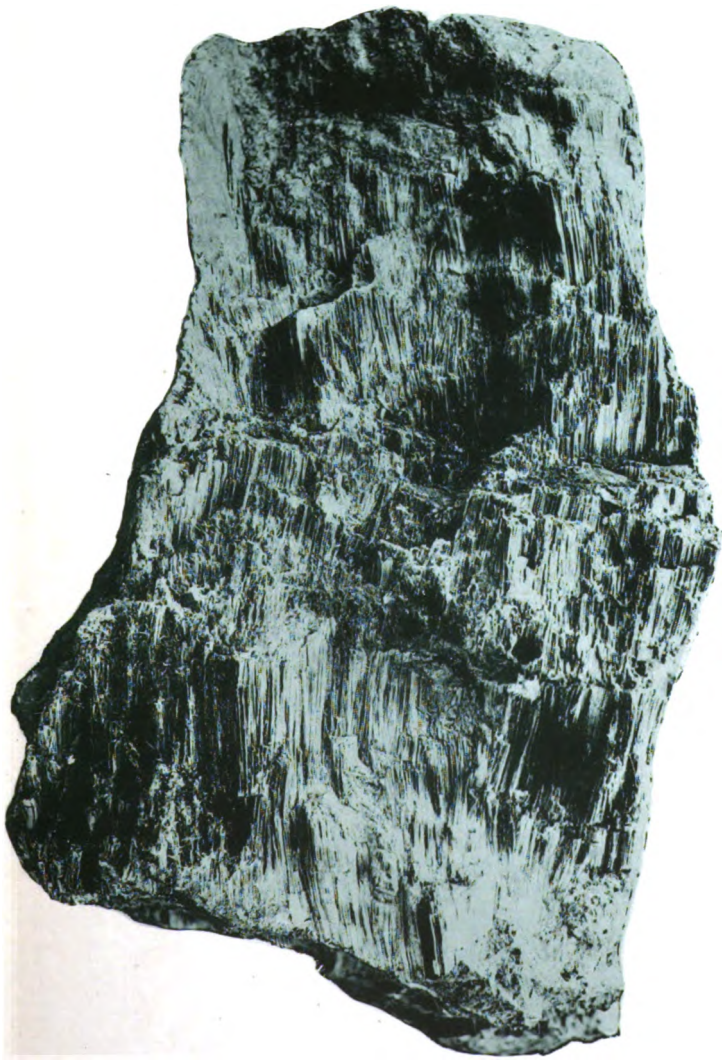
WOOD. NORWAY.

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MOUNTAIN WOOD, NORWAY.

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by interlacement, instead of lying parallel. This usually looks and feels very much like kid leather. Those varieties, which feel greasy and cold, contain a mixture of talc, and are called Bergfleisch, but when they are poor and warm, they become light enough to float on water, and may then sometimes be mistaken for meerschaum.* Mountain leather is found in considerable quantity at Buckingham, on the Ottawa, and at the Beaver Mine, Thunder Bay, Ontario.

Mountain Paper is merely a finer and thinner variety of the last named. It is a papery-looking sub-variety, sometimes called fossil paper.

Mountain Cork (*Rock-cork*, *Bergkork*), is a spongy, elastic form of asbestos, which has a texture like felt. It does not readily separate into fibres, and is unsuitable for most of the purposes to which asbestos is applied. It is something similar to mountain leather, but more elastic and thicker. It possesses the lightness and elasticity of cork, is usually of a dingy-white colour, and of a more massive form. Its specific gravity ranges from 0·68 to 0·99. The contained water, both in mountain cork and mountain leather, is occasionally 23, and sometimes a great deal more. The composition of mountain cork, according to Quenstedt, is—

Silica	57·20
Peroxide of iron	4·37
Magnesia	22·85
Lime	13·39
Water	2·43
	100·24

Professor Heddle includes both these last under the name of pilolite (πίλος λίθος, feltstone). He procured seven specimens, from as many different localities in Scotland, and, having analysed them, found they were essentially hydrated silicates of alumina, magnesia, protoxides of iron and manganese, with some lime, for which the calculated formula is given as $Mg_4(Al_2)\ Si_{10}O_{27}\ 15\ H_2O$. These seven specimens were all found in granular limestone, and in veins in granite, sandstones,

* Quenstedt, 332.

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and slates. The chemical composition of these varieties varies considerably, but they are mostly silicates of alumina and magnesia, with varying proportions of lime, iron, and water.

Mountain-flax (*Berg-flachs*, fossil-flax). This is merely another name for amianthus, which is sometimes called Earth-flax, Salamanders' hair, or fibrous talc.*

Actinolite (from *ἀκτιν*, *ἀκτινος*, a ray of light, "*trait de lumière*," the crystals of the mineral being arranged in the form of rays†).—A radiated stone; Fr. *actinote;* Ger. *Strahlstein*. This is a variety of amphibole, its similarity to asbestos having been previously noted. Its general affinity and composition is sufficiently indicated by Dana's compound name for it—"Magnesia-lime-iron-amphibole." It is usually green, or greyish-green, but often reddish, the colour being imparted by the contained iron. It occurs in several forms—crystallised, columnar, fibrous, or massive. Its sub-varieties are—glassy actinolité, which occurs in long, bright, green crystals; asbestiform actinolite, which much resembles the radiated, except that its fibres are more delicate; and radiated actinolite, when its coarse fibres are radiated or divergent. Its composition may be taken as:—

Silica	57·13
Alumina	1·15
Ferrous oxide	6·39
Manganese oxide	·65
Magnesia	20·66
Lime.	13·28
Water	1·57
	100·83

It never has the fibrous texture of amianthus, but is often spoken of as non-fibrous asbestos. It occurs in the greatest

* "The coarser sort of English talc is called plaister or parget; the finer sort is Earth-flax, or Salamanders' hair."—Woodward.

† The actinic rays are violet and blue. "To nourish the vegetation of this earth, the *actinic* and luminous rays of the sun must penetrate our atmosphere."—Tyndall. The German word, Strahl, signifies a stream, as well as a ray.

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profusion in talcose rocks ; and is found in the State of Maine and many other places in America, at Arendal in Norway, and elsewhere ; also in a radiated form (radiated actinolite) in Central Ontario, notably at North Hastings, where it is worked and used for a special form of roofing. It is found in magnesian rocks, such as talc, steatite, or serpentine, and is used for one or two purposes, especially for weighting paper and various forms of adulteration.

It occurs in special profusion in the Laurentian rocks of Ontario, especially in the townships of Elzevir, Lake, and Tweed. Mr. James, of Bridgewater, Ontario, on whose land there is a considerable deposit, commenced in 1881 the manufacture of a "patent actinolite cement roof," which seems to have met with considerable success. The roofing material, prepared from this actinolite having, for some time, withstood the test of the Canadian climate, with its extremes of heat and cold, may be deemed fit for use in any part of the world.

In order to prepare it for use, the mineral is pulverized in attrition mills, in such a way as to preserve the fibres as nearly intact as possible. It is then put up in bags, which each contain sufficient material, when mixed with a proper proportion of coal tar, to produce the quantity of cement required for a square of roofing, the fibre preventing any cracking or running in the composition. It is entirely fireproof, the coal tar being so effectually absorbed that there is nothing left to burn. It is obvious, therefore, that the material can be used for a variety of other purposes equally valuable, and there can be little doubt that should the price of chrysotile rise to prohibitive proportions, these forms of actinolite, as well as the tremolite of the New York State, will be more sought after, and will increase in value in proportion as attempts are made to find a substitute for the higher-priced mineral. The specific gravity of actinolite is 3 to 3·2.

Kymatine (*κῦμα, κῦματος*, a wave). — An indurated form of asbestos, its composition indicating a passage from actinolite to tremolite. Found, amongst other places, at Kuhnsdorf, in Saxony.

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Schweitzerite.—An indurated form of chrysotile, frequently found in Switzerland, in Ireland, and elsewhere.

Tremolite,* or *Grammatite*, is a magnesia-lime variety of hornblende, so called from Tremola in Mont St. Gothard, where it was first found. It usually occurs in the old Laurentian rocks, especially in connection with limestone, either magnesian or dolomitic. It consists of long prismatic crystals of white, grey, and green colours, but has none of the fibrous texture of amianthus. It frequently graduates into actinolite.

The compact tremolite, called *nephrite*, is found in talcose rocks and schists, while actinolite, the magnesia-lime-iron variety, occurs in steatitic rocks, and brown, dark green, and black hornblende in chloritic schists, mica schists, gneiss, and some other rocks.

Tremolite, and those varieties of hornblende which contain no iron, easily fuse to a glass from nearly transparent to a milk-white, while the lighter-coloured varieties, which contain no iron, fuse to a dark yellowish glass.

Chrysotile (*Schillernder asbest*), the form mostly found in Canada, differs materially from some of the other varieties, and is of so important a character that it will be separately described, when we come to speak of Canada and the Canadian mines, as will also the Italian variety, in its proper place, which is distinguished as true asbestos.

Blue Asbestos (*crocidolite, krokidolit, Blaueisenstein*) is a totally distinct variety, being an alkali-ferro silicate, iron in this case replacing magnesia, in the same way as alumina, or clay, does in the Natal species. It occurs in micaceous porphyry in the Vosges; and very abundantly, in association with beds of iron ore, in the Asbestos Mountains, Great Orange River, South Africa, about 700 miles from the Cape. It is found also at Brevig and Stavern, in Norway. It occurs in a fibrous as well as in an earthy form. In the former it is of a

* "La tremolite lorsqu'elle s'altère et devient hydratée manifeste une tendance marquée à se deviser en fibres flexibles, à éclat soyeux, capable de former par leur enchevêtrement de veritables tissus minéraux."—De Lapparent, 376.

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peculiar lavender-blue or leek-green colour, in texture much like chrysotile, possessing long fibres, which are somewhat elastic, and easily separable by the fingers. The colour is caused by the large proportion of oxide of iron contained in it. The enclosing rock is a dark brown-purplish shale. As compared with chrysotile, it possesses remarkable tensile strength; but, from its nature, is quite deficient in the fire-resisting quality. A good deal of diopside also occurs in the same formation. The technical description of crocidolite is as follows: "Silicate of iron, sodium (magnesium and aluminium), 3 $R''O_1$ R''_2O_3. H = 4. Sp. gr., 3·2 to 3·6, lustre, silky." But, although described as silky, the fibres have rather the appearance of stocking-wool than silk, as would seem also to be indicated by its name, which is derived from κροκις (pro κροκὺς, Ger. *Flocke*), woof, in evident allusion to its wool-like fibres. The composition is given as:—

Silica	51·1
Protoxide of iron	35·8
Soda	6·9
Magnesia	2·3
Water	3·9
	100·0

De Lapparent,* in alluding to this form, says: "Masses souvent asbestiformes composées de fibres parallèles, très fines, faciles à separer, paraissent être à l'Arfvedsonite ce que l'asbeste est à l'actinote. Les fibres sont tendres, elastiques et flexibles. Bleu indigo ou bleu-gris; poussière bleu lavande. Les fibres très déliées fondent à la flamme d'une bougie en devenant rouges; au chalumeau elles fondent facilement en globule noir magnétique: dans le matras degage de l'eau. Se dissout facilement dans le borax en donnant un verre verte olive. Dans le sel de phosphore laisse un squelette de silice. N'est pas sensiblement attaquée par les acides. On peut la considerer comme un Arfvedsonite dont la chaux aurait disparu." His

* "Cours de Min.," 84.

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analysis does not differ in essential particulars from that given above :—

Silice	51·22
Oxide ferreux	34·08
Oxide manganeux	0·10
Magnesia	2·48
Chaux	0·03
Soude	7·07
Eau	4·50
	99·48

Crocidolite.—That singularly beautiful mineral termed *crocidolite*, which displays such delightful sheens and radiances of gold, bronze, and green, as almost to give it the appearance of satin changed into stone, is really nothing more than compressed asbestos. The derivation of its name is not a happy one. It is said to be from *κρόκος λίθος*, crocus-coloured or yellow stone, which is doubtless its general colour, but the finest crocidolite is anything but yellow.

It occurs, in both its forms, in Greenland, in association with sodalite, and at Stavern and Brevig, in Norway. Seams or masses of this variety make an angle of 106° with the opposite surfaces of the seam, according to Haussmann,* who states that a cylinder of it $\frac{4}{100}$ of an inch in diameter supported ninety-one Hanoverian pounds without breaking, whereas one of asbestos $\frac{7}{100}$ of an inch in diameter broke with a weight of 6 oz. This marvellous tensile strength, which is attributable to the large amount of iron in its composition, is neutralised (for present purposes) by a corresponding deficiency in fire-resisting qualities, occasioned by the want of lime or magnesia. It is difficult, therefore, to see how this variety is to be usefully employed, in competition with the light-coloured, elastic, but less tenacious, varieties, which usually contain, with a small proportion of iron, a correspondingly larger amount of lime and magnesia. Yet it is being employed, as it would appear successfully, in a diversity of useful ways.

Some other minerals possess this peculiar shining lustre,

* Haussmann, "Handb.," 1847, 734.

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though none in so fine a degree. Cat's-eye (*Katzenauge*), for instance, a chalcedonic quartz, when cut *en cabochon*, exhibits a like opalescence, or glaring internal reflection, like the pupil of a cat's eye, which is caused by the fibres of asbestos running through it. The same peculiarity, but in a lesser degree, is sometimes found in satin spar, when cut in the same way.

Having heard that there were some fine specimens of asbestos on view at the exhibition of the United States products at Earl's Court, I made a journey there specially to see them. In this, however, I was disappointed. There was but one small tray of so-called asbestos (amphibole) on view; and this was of a coarse woody character, very similar in appearance to a sample I had had sent to me recently from California. It was, moreover, of a very poor colour, and by no means of a kind that would readily find a market. One piece of unmistakable chrysotile was, however, grouped among the American minerals, and this the exhibitor was good enough to inform me, was not an American product at all, but "a vegetable matter found in Canada."

At the same place I found a fine display of crocidolite, the sight of which well repaid the visit. I secured a good specimen, but found, on inquiry, that like all the superior qualities of this mineral, it had been brought from Griqualand West (South Africa). The sample I secured, was of the kind called "Tiger-eye" in the States, as I presume, on account of its general tawny-coloured streaky brilliancy. The exhibitor described it as a silicate of iron occurring in asbestos-like fibres. It is of a densely compact nature; from its hardness difficult to work, but susceptible of a very high polish. A few years ago it was thought to be a precious stone, and commanded a high price, but recent discoveries of large deposits considerably reduced its value. It is used for a variety of ornamental purposes, for which, from its natural beauty, it is peculiarly adapted. The grain is very fine, and in its rough state the fibres are singularly distinct.

Breislakite is a capillary, or rather a woolly-looking, variety of aluminous pyroxene, named after Breislak, an Italian mineralo-

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gist, and is sometimes called Cyclopeite. It is found at Vesuvius and Cape di Bove: and occurs in single hair-like fibres, or in felted masses, in cavities in the older lavas. The fibres are flexible, and the colour reddish-brown. It contains silica and alumina, but does not appear to possess any commercial value.

Byssolite (from *βύσσος*, the linen made from fine white, or yellowish, flax) is an old name for asbestos, now seldom used. Des Cloizeau says: "On avait donné autrefois le nom de Byssolite à une asbeste gris-jaunâtre qui accompagne souvent les crystaux d'albite du Dauphiné." * And Bauer, speaking of it says: "Byssolit gleicht graue und blondfarbigen Menschen haaren, aber trotz deiser Feinheit bleibt er glasig spröde, weil er auf Feldspathgesteine mit Adular und Berg-crystals in den Hochalpen einbricht."† It is more compact in aggregation than asbestos, the colour is usually of a dark olive green, the fibres coarse, and not easily separated; its structure is stiffly fibrous, so as almost to resemble wood. It generally occurs associated with a black oxide of manganese.

In early days, the silky thread, or byssus of the *pinna nobilis* and other molluscs, by which their shell is attached to the rocks, was spun and woven into articles of dress. This byssus, after being cut off and cleansed from impurities, is dried in the shade, straightened with a large comb and then properly carded. A pound of byssus, as taken from the sea, is by this process reduced to about three ounces. In Sicily and Calabria it is manufactured (with a little silk to strengthen it) into stockings, gloves, caps, and other articles of extremely fine texture, all of them far more curious than useful.

Asbestoid, used as a substantive, is a mineral resembling asbestos in form, and is often applied to byssolite.

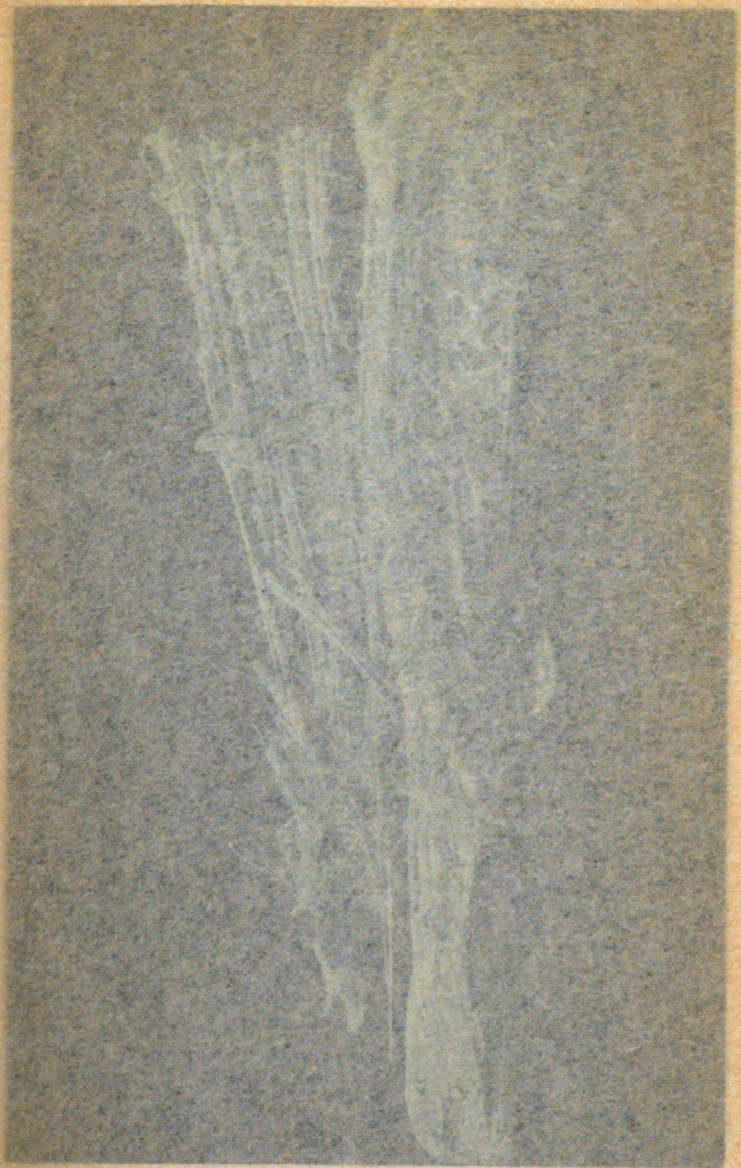
Asboline, from *ἄσβολος*, soot, though orthographically very near it, is an absolutely distinct word; chemically, it is a yellow, oily substance, acrid and bitter, obtained from soot, but, as a mineral, it is a kind of earthy cobalt.

Picrolite, or *Pikrite* as it is sometimes called, from *πικρος*, bitter, "*ou qui a une saveur désagréable*," caused by the amount

* "Manuel de Min.," 80. † Lehrbuch, 425.

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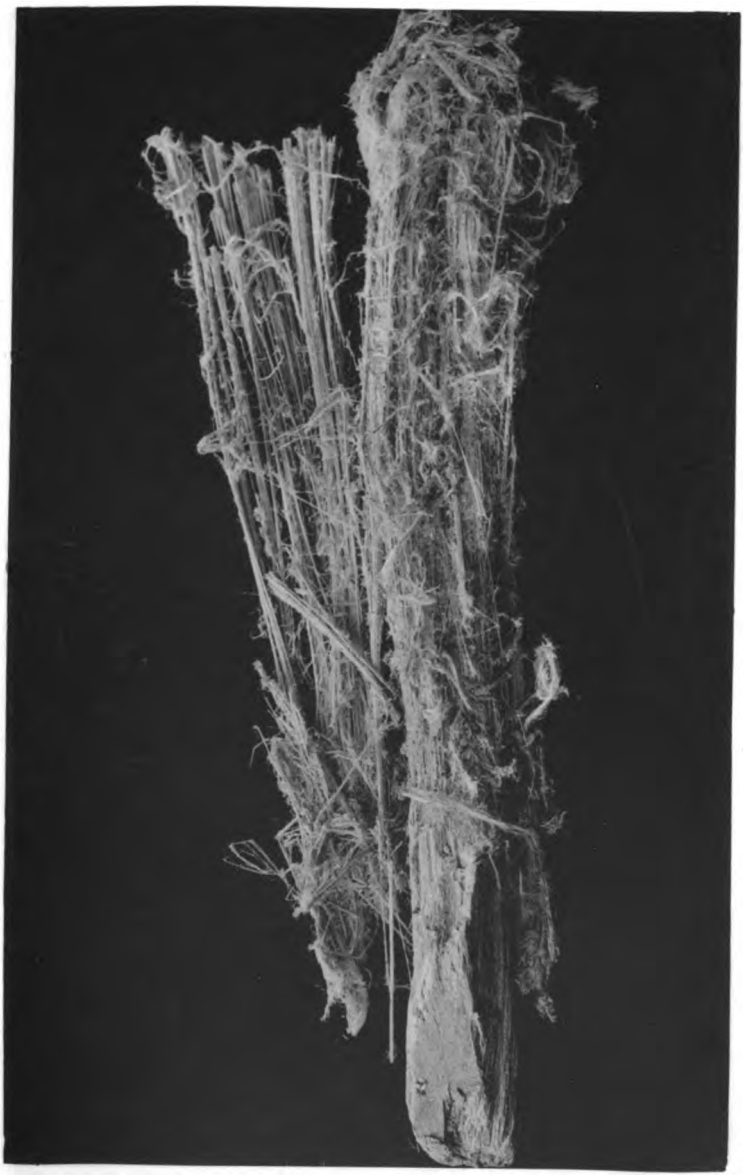


PICROLITE OR BASTARD ASBESTOS.

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PICROLITE OR BASTARD ASBESTOS.

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of magnesia, or *littererde* present in its composition, is like a coarse asbestos. It is a variety of serpentine, which occurs in masses of columnar fibres, somewhat rigid and not readily separable. A considerable quantity occurs in most chrysotile mines, and by the miners is called *Bastard Asbestos*. It is found largely in the mines of Canada, Newfoundland, Norway, South Africa, and New South Wales. It would seem to be as yet an unformed mineral, for which at present no use seems to have been found; large quantities being thrown away on the dumps as useless, though, judging from its composition, and the many new applications of the mineral now being introduced, there can be little doubt that this inferior article will presently command its price in the market, a use being found for it, in some of the many purposes, for which coarse pulverised asbestos is applicable. It has a specific gravity of 2·607 and the following composition :—

Silica	43·70
Magnesia	40·68
Ferrous oxide	3·51
Oxide of nickel	traces
,, chromium	,,
Water	12·45
	100·34

Professor Donald thinks it probable that movements of the rocks, with the resulting heat, may have been intimately connected with its formation.

Dana gives several analyses from various places, but most of them differ only slightly, according to locality, all of them being in practical accord with the above, and all showing important characteristics. It is mostly found along the lines of faults, and sometimes in very considerable quantities, especially at Bolton and Broughton, where large heaps, showing many curious forms are now thrown away, but will undoubtedly soon be found useful.

Baltimorite (named from the place where it was found) is a variety of serpentine, considered by Dana to be identical with *Picrolite*. It is composed of longitudinal fibres, which

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adhere to one another, and has a silky lustre. When thick, it is opaque, but on the thin edges, transparent.

Metaxite (*μέταξα*, silk).—An analogous variety, of a greenish-white colour, which also has a silky lustre. The following analyses were taken from two separate samples:—

Silica	42·97	35·10
Magnesia	44·14	42·20
Iron oxide	—	10·50
Water	12·89	12·20
	100·00	100·00

Marmolite (*μαρμαίρω*, to shine, or glisten), Ger. *marmolith*.—A variety of serpentine, which occurs in thin, brittle folia. Its specific gravity is 2·41, lustre pearly, and colour greenish or pale green. It is found at Hoboken, New Jersey, U.S.A., and was called by this name, before it was known to be serpentine.

Pyrallolite is very similar to Steatite, in chemical composition, softness and refractory properties. It is often met with in the Laurentian series of rocks. In colour it is mostly sea-green or greenish-white, and some varieties nearly white have the translucency of porcelain.

Hydrophite.—A translucent, massive variety of serpentine, sometimes, but only rarely, fibrous. It is of a mountain green colour, with a pale streak, and is found, with *picrolite*, at Taberg, in Småland.

Antigorite, *Schweitzer.*—A foliated variety of serpentine; the laminæ readily separable. Colour a brownish-green, or leek green. It occurs in the Antigoris Valley, to the northward of Duoma d'Ossola in Piedmont, where masses five inches long and over two inches thick can be obtained.

Porcellophite.—A porcelain-like serpentine, something like meerschaum, found at Taberg and Sala.

Bastite, *Schiller Spar, Schillerstein.*—An impure foliated variety of pyroxene or bronzite, nearly allied to serpentine.

Neolite, *Scheerer.*—Serpentine in silky fibres, stellately grouped. Colour green and lustre silky or earthy. This is

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a recent formation produced in one of the mines of Nâskill, through the agency of filtrating waters which have passed over rocks containing magnesia.

Pyroxene and Hornblende.—Both pyroxene* and hornblende† are sometimes called asbestos, the latter most frequently, the former rarely assuming an asbestiform character. The name, moreover, is frequently used with especial reference to certain amphibolic minerals, such as actinolite, tremolite, and marmolite, in which the long capillary crystals occur, forming a compact fibrous mass, the individual crystals generally lying side by side, in parallel lines, at right angles to the walls of the vein, *i.e.*, to the cooling surfaces. But it must be understood, that these conditions will be found in very varying degrees in different varieties of the mineral. In amianthus, for instance (the fibres of which are of a singularly

* "Pyroxene is one of the most common minerals. It is a constituent in almost all basic eruptive rocks, and is principally confined to such as are of crystalline and volcanic origin. In different localities it is associated with granite, granular limestone, serpentine, greenstone, basalt, or lavas. The name is derived from πυρ, fire, and ξένος, stranger, Haüy's idea being that this mineral, was a stranger in the domain of fire,' whereas in fact, it is, next to the feldspars, the most universal constituent of igneous rocks." —Dana, "Min. et Lith.," ed. 1879.

† "Hornblende is generally dark green, brown, or black in colour, and often occurs in stout or more slender prisms, or in irregular-shaped granules or patches. It is an essential constituent of syenite or diorite, and is met with likewise as an accessory mineral in many other igneous rocks. Its cleavage is more perfect than that of augite, and often gives it a platy-like structure, the angles between the cleavage planes being 124° 30′ and 56° 30′."—Geikie, "Geol.," 146.

"Pyroxene and hornblende have the same formula, and under this there is but one difference of any importance, viz., that lime is a prominent ingredient in all the varieties of pyroxene, while it is wanting, or nearly so, in some of those of hornblende. It is difficult to distinguish hornblendic asbestos from the pyroxenic, except by noting its association with known varieties of one or the other minerals."—Dana.

"La hornblende ne diffère de l'actinote que par une proportion plus forte de l'oxyde de fer ; à mesure que le fer augmente, la couleur verte de l'actinote devient de plus en plus foncée, passe au noir par degrès insensibles de telle sorte qu'il est impossible d'établir une ligne de démarcation bien nette entre ces deux substances."—Jagnaux, 554.

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delicate character and beautifully arranged), the crystals are very flexible and easily separated by the fingers; whereas, in the commoner varieties, the crystals are of a much coarser character, are more difficult to separate, are frequently interlaced or irregularly disposed, and possess but little flexibility. Many of these last are of such a brittle siliceous texture as to be of little or no economic value: they usually exhibit a dull green colour, are somewhat unctuous, and occasionally, but only rarely, display a pearly lustre. Sp. gr. usually about 2·7.

Arfvedsonite, a black hornblende containing both iron and soda; its lustre is vitreous, inclining to resinous.

Amphibole, Lat. amphibolus, from Gr. *ἀμφίβολος*, doubtful, ambiguous, *ἀμφίβαλλω*, to throw around as a garment, or to turn out uncertainly. The great mineral genus which the British Museum catalogue makes synonymous with hornblende. Dana considers that the term amphibole, proposed by Haüy, should have the preference, inasmuch as that distinguished scientist was the first rightly to appreciate the species, bringing together under it hornblende, actinolite and tremolite. It varies much in composition, and Dana classifies its constituent elements as follows:—

I. *Containing little or no Alumina.*

1. Magnesia—lime—amphibole = Tremolite.
2. Magnesia—lime—iron—amphibole = Actinolite.
3. Magnesia—iron—amphibole = Antholite.
4. Magnesia—lime—manganese = Richterite.
5. Iron—magnesia—amphibole = Cummingtonite.
6. Iron—manganese—amphibole = Dannemorite.
7. Iron—amphibole = Grünerite.
8. Asbestos.

II. *Aluminous.*

9. Aluminous magnesia—lime—amphibole = Edenite, Smaragdite.
10. Aluminous magnesia—lime—iron—amphibole = Pargasite, Hornblende.
11. Aluminous iron—lime—amphibole = Noralite.
12. Aluminous iron—manganese—amphibole = Cumsigradite.

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One of the most valuable properties of asbestos is its infusibility. Under the blowpipe, a single fibre will fuse into a white enamelled glass, or opaque globule, but in the mass some varieties have been known to resist the most intense heat without any visible effect. Chrysotile, however, if exposed for some time to long continued heat will lose somewhat of its tenacity and silkiness, and become rough and brittle, as is especially seen in the Black Lake Mines.

When of a light colour, or some light shade, it is usually found to be tremolite or actinolite. The ore found in the celebrated seam at East Broughton was, like the serpentine in which it was enclosed, of a singularly light (yellowish green) shade, but this was fully equal, if not superior, to any that has since been found in the darker rock, which usually carries the finest quality, the matrix in this case being common serpentine with an association of chromic iron ore.

There are many varieties besides the above, but these will no doubt be sufficient to show the diversity of form assumed by asbestos in various localities and in different regions, ranging from the silky flexibility of amianthus to the density of mountain-wood, and the extreme tenacity of crocidolite. But, in whatever part of the world it may be found, it will be seen that too much attention cannot be paid to its composition, or to its immediate surroundings or associates, so much depending on this for its usefulness in the arts and manufactures.

The Fibrous Form.—I learnt from the late Mr. Dana, whom I consulted on the subject, as the then highest living authority on geology and mineralogy, that he considered there was little to be said in regard to chrysotile that was special to this particular mineral; that it was an example of fibrous crystallisation due to crystallising across a fissure, but why it was so finely fibrous, or how it gained that form, could not at present be explained, except by stating that that was the way with serpentine. When first formed, the mineral was

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probably in a soft or pasty state* and contracted as it hardened in drying, and in thus contracting broke into thin, irregular, usually nearly parallel, plates, flat, incurving; and in the intervals between these plates, the serpentine crystallised in the fibrous form we call chrysotile. Sometimes there are many such layers to an inch, and in other cases the fibres are several inches long.

Dr. Ells has suggested that, when the rock was in this pasty state, it was exposed to such strains and twistings as would produce the fibrous form in certain portions of it, though it is somewhat difficult to understand how it is that the fibre, wherever found, is so compact as to be as dense and heavy as the solid rock in which it is embedded. Other mineralogists have suggested, that the cracks in the rock were formed by its cooling and shrinking. Subsequent to which, the cracks or fissures were gradually filled with some asbestiform matter, which often met at or near the centre, as would seem to have been the case by the presence of some mineral impurity which is too commonly seen occupying that portion of the centre of the vein, in which these mineral particles, often of iron, are frequently to be found of sufficient size to form a regular division of the fibre. As a theoretical description of the formation of the fibrous structure, the foregoing sounds very promising, but in the Danville Mine a mass of rock, weighing perhaps a hundredweight, was taken up and carried to the office by my direction, for examination after a blast, and in this specimen two broad veins crossed, cutting each other at right angles, so as to form a perfect cross. It seems, therefore, somewhat difficult to understand, how the internal twisting of the pasty matter could have been carried on in this position.

Professor Dana refers, but only in a general way, to this important point. In his chapter on Theoretical Crystallogeny,† he says:—"In aggregated crystallisations there is a

* Serpentine is very commonly found in a pasty state in asbestos localities. In this state, it is so soft, when first taken out, as to be compressible between the thumb and finger, but hardens on exposure to the atmosphere, and if then compressed and baked makes a capital firebrick.

† "System of Min.," 1850, 124.

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mass of material entering into the solid state together, and no opportunity exists for single crystals to perfect themselves. While a liquid mass is cooling, whenever the temperature of solidification is reached, at numberless points throughout the mass, crystallisation will begin, and together an aggregation of crowded crystals or grains is produced, with no external regularity of form; in other words the *granular structure*. The same will happen in a crystallising solution if the process goes on rapidly.

"When a solution is spread thinly over a large surface minute crystalline points encrust the whole, and if the solution be gradually supplied, as crystallisation goes on, it is obvious that the minute points may elongate into crowded prisms of fibres, producing a *fibrous structure*. Such a structure is common in narrow seams in rocks, and the fibres are usually elongated across the seam."

This latter paragraph would seem to refer to chrysotile rather than to asbestos; the crystals of the former being elongated across the seam in the precise mode described, whereas the capillary or filiform fibres of the latter are frequently tufted or bundled up in irregular masses, and are often so compactly cemented together, by some foreign substance, as to require treatment in the boiling tanks, and thorough beating and rubbing to rid it of the cementing material, before submission to the carding machine.

It is much to be regretted, that this interesting subject has not yet received more attention from scientists; we can only hope that ere long (in the words of Professor Dana) "the entrance to one of the innermost recesses of the works of nature will be thrown open, and that the qualities of atoms and molecules, their forms and peculiarities, will then be understood."

The phenomena of crystallisation are an intensely interesting study, not only on account of the great beauty of some of the forms, but also of the mathematical regularity and precision with which the process is accomplished.* Although ignorant of the

* "Here is a solution of common sulphate of soda or Glauber salt. Looking into it mentally we see the molecules of that liquid, like disciplined squadrons under a governing eye, arranging themselves into

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manner in which the majority of crystals are formed in the vast laboratory of nature, we can crystallise an immense number of substances, watch their numerous intricate modes of formation, and that even in the smallest appreciable quantities, when aided by the microscope. The formation of artificial crystal may be readily effected, and the process seen, by simply placing a drop of the saturated solution of any salt upon a previously warmed slip of glass.

Mr. Simmonds, when referring to fibrous minerals possessing the chemical composition of augite or amphibolite, says :—"In all these minerals, a portion of the magnesia is displaced by basic water, and it is exactly the presence of this water which appears to give to these minerals the fibrous structure, and in general causes the crystalline structure to be found with one long axis, obliterating all sideward aggregations of molecules."*

When the prismatic concretions become very narrow, the fibrous structure originates. Minerals may have either a parallel-fibrous structure, as is seen in gypsum, calc-spar, &c. ; an irregularly-fibrous structure, as in augite or hornblende ; matted, as in rock-cork, or radiated, as in actinolite, &c., where the fibres radiate from central points.

Such of them as present a fibrous structure are sometimes said to be the result of a disturbed crystallisation, although the systematic perfection of others would seem to be at variance with this idea. Possibly, the fibres of asbestos, like those of some other fibrous minerals, have been produced by the same process of crystallisation as has given rise to the long acicular crystals occasionally found in quartz ; and asbestos may perhaps be considered an extreme example of crystallisation in the fibrous form, the crystallisation having evidently taken place under conditions of high temperature and extreme pressure. This pressure may have been caused either by the weight of the superincumbent mass, or by the

battalions, gathering distinct centres, and forming themselves into solid masses, which, after a time, assume the visible shape of the crystal now held in my hand."—Tyndall's "Fragments of Science."

* "Undeveloped Substances," p. 467.

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action of gas, in the same way as liquid steel is compressed in hermetically-sealed ingot moulds, by carbonic acid introduced into the top of the mould, the heat of the molten metal, in that case, evaporating the acid when the confined gas exerts a very high pressure upon the metal. M. Gosselet, referring to crystalline minerals generally, says they owe their origin to the action of superheated water in the rock,* in this agreeing with Professor Dana, who says that the great promoter of metamorphic changes is subterranean heat, acting in conjunction with moisture and, usually if not always, under pressure. It is admitted that rapidity of cooling tends to produce the glassy condition of minerals, whilst slow cooling is the condition most favourable to crystallisation; it may, therefore, be that the more intense the previous heat, the more extreme the pressure, and the slower the process of cooling, the finer would be the resulting crystallisation. And this view seems to be supported by the fact that the heat, by which the production of the fibrous mass was generated, necessarily proceeded from below upwards, whilst it is a matter of daily observation, at the mines, that the deeper the fibrous veins are followed down into the rock, and the harder and more compact the rock becomes, the finer and purer the fibre is found to be. This is a matter of no slight importance to the miner, because the proportion of the inferior grades, which are of much less value, diminishes in a corresponding ratio; the inferiority of these mainly resulting from surface influences acting upon the shattered rock.

When Mr. Moseley was watching the molten lake at Kilauea,† he saw the smooth surface become cracked in all directions by contraction on cooling, whilst all below was glowing hot. It may be that cracks such as these, formed by contraction of the cooling crust of the earth, or by some primary convulsions by which the crust of the earth has been cracked, originated the fissures in which the asbestos lies, the cracks having a special relation to the direction of the forces which produced them; and that, when the molten mass below

* Report of Geol. Congress, 1888.

† "Notes by a Naturalist on board the *Challenger*," 501.

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had, by gaseous agency or the explosive power of steam, been forced upwards, so as to fill the fissures, the cooling process commenced. The walls of the vein, that is, the cooling surfaces, or rather the wall, for the fibres grow from one side only, would first become drusy, the point of the minute crystals thus formed on the inner cooling surface forming the poles of attraction; and these, becoming gradually elongated, would eventually reach, and then become stopped by the opposite wall of the vein, the result being layers of the filiform or capillary crystals constituting the asbestos mineral, compacted into a solid mass, as we find them, by the intense pressure. The difference in the quality of the asbestos would result from the component parts of the molten mass which had thus become crystallised; hence, the lower veins would of necessity be of finer quality and freer from impurities than those nearer the surface, where extraneous matters would be more likely to intrude, and where solutions of metallic oxides, resulting from surface exposure, could by infiltration through the shattered rock, or by the planes of cleavage, exercise a deleterious effect on the cooling mass.

In regard to metallic veins, M. Simonin remarks that metallic emanations reach the fissures in one of two ways. Either they are deposited in the fissures, which constitute the veins, in the state of vapour, which he calls *the dry method*, as in the craters of volcanoes, or the chimneys of smelting furnaces; or in a state of chemical precipitation, by *the wet method*, as in the solutions of our laboratories. The rich family of precious stones, he adds, seem to owe their perfection to the same cause. Volatilised in the clefts of the igneous rocks, these stones are there turned into brilliant crystallisations—"the tears of nature."*

Turning from theories of formation to the mineral itself, it may be remarked that, as a general rule, asbestos of good quality is only found in serpentine; sometimes, it is found disseminated in granular limestone, and in that case is often found to give an asbestiform appearance to large masses of the rock, or the gangue that contains it, and to give it also a

* "La Vie Souterraine," 406.

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clouded green colour. It occurs thus occasionally, as already mentioned, in a pasty state, and then hardens on exposure to the air. It is also found, in masses, in feldspathic and chloritic rocks.* One instance has been noted of its occurrence in quartz; but here, when six feet of the rock had been blasted away, the inevitable serpentine was found cropping through.† In the Coleraine and Black Lake district of the Eastern Townships of Quebec, it is occasionally found in contact with granite, which is not held to be a good sign. The same is also seen in the serpentine formation of the Vel Fjord, in Nordland, Norway; and in Newfoundland I have followed the chrysotile veins for some distance through a bed of chrome iron; the iron being solid and massive, and the fibrous serpentine being thrust into it. For some, as yet unexplained, reason (although granite, like porphyry, is one of the richest metalliferous rocks), the granite seems to detrimentally affect the quality of the fibre. Granulite, on the other hand, as will be seen later on, has the opposite effect. At East Broughton, the asbestos occurs along the contact between the serpentine and the black Cambrian slates; and here, although the asbestos is remarkably good, there is a striking difference in its appearance. Another divergence is that of a case cited by the State mineralogist for California, where the asbestos vein occurs in a belt of slate enclosed in granite; but there the asbestos, like most of that found in California, is brittle and wanting in elasticity. Many specimens have been sent me for trial from this part of the world, but none of them have as yet been found to possess much commercial value. The enclosing rocks must always claim the highest consideration of the explorer, because it is well known that, although some rocks are highly favourable to the formation of good fibre, others are just as much opposed to it. The serpentine, in which it generally occurs, is, in most cases, a product of the hydration of rocks containing olivine, augite, hornblende, and other intrusive or erupted igneous masses. It is essentially a hydrated

* Davies on "Earthy and Other Minerals."

† Boyd on "Italian Asbestos."

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silicate of magnesia, resulting from the alteration of magnesian rocks, infusible, and without distinct crystallisation. It occurs with eruptive rocks, and the general view entertained of it is that it is derived in many cases from peridotites, because it very often exhibits the characteristic form of crystals of peridotite, which is a name originally given to certain pre-tertiary rocks, the essential constituent of which is olivine. Containing some protoxide of iron and other impurities, these crystals of peridotite frequently cause a change in colour from a dull green to brownish or reddish-brown, often marked with red or purple. In olivine, under the action of carbonated waters, the iron is frequently carried off, instead of being peroxidized, some of the magnesia being removed at the same time ; hence comes serpentine, which frequently retains the crystalline form of chrysotile.

Commercial asbestos generally occurs in serpentine of some shade of green on fresh fracture, usually a greyish-green, in which are found numerous particles of iron ; but when it has a hard, dark, chippy look it does not promise well. This refers to the Cambrian asbestos only, and not to the Laurentian.

Most minerals, even when their general nature and component parts are very nearly identical, are found to vary very considerably in appearance and character, according to the different conditions of climate and locality ; sometimes, even in adjacent localities, they will vary with the nature and surroundings of the rock in which they occur. Asbestos forms a remarkable instance of this. It is widely disseminated over the globe, but the deposits are not found anywhere to repeat themselves in different regions, even in strata of the same age, but both in appearance and composition they are found to vary very greatly. This difference may occasionally be caused by variation of constituents, as in some of the South African varieties, but in others it may be the result of formation under different temperatures, or according to different rates of cooling.

To be of any economic value, the main essentialities of asbestos are length, fineness and elasticity of fibre, tensile strength, flexibility, and great power of fire resistance. Some of these qualities are often lacking, and the value of the mineral is

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consequently diminished, even when it has the most promising outward appearance, or the most desirable quality of tensile strength, as in that from West Griqualand.

The main point in which asbestos differs from other minerals, lies in its being both fibrous and textile, and impervious to the action of fire. Subject to what is stated above, its quality is determined by the greater or less proportion of siliceous matter with which the fibre is associated. When crushed out from the rock, and freed from all harsh or gritty particles, its fibres vie in delicacy with silk, and, after carding, are spun and woven in precisely the same way. For a long time they obstinately resisted all attempts in this direction, the difficulty arising, as will be explained subsequently, from the peculiar formation of the fibre, which, possessing a perfectly smooth surface, and being much less elastic than fibres of organic origin, would seem of necessity to require the admixture of some foreign material to enable it to be spun into a yarn, because when first it was attempted to twist these smooth, rod-like fibres together, it was found that instead of the fibres clinging together, they simply slipped past each other. This will be better understood when we come specially to deal with the question of fibre spinning. That difficulty, however, has now been so entirely overcome, that yarns capable of withstanding great tensile stress can be readily produced by machines constructed for the purpose. The difficulty of twisting it into a thread becomes at once apparent when its behaviour in the breakers and carding engines is seen, and this difficulty will be more fully explained presently. Instead of leaving these in a sheet or "lap," it drops out in separate fragments just as it entered, except that the fibres are combed out straight and laid side by side parallel with each other. A single thread can now be made which, while weighing no more than an ounce to a hundred yards of thread, has a fair tensile strength. The carding, is, however, ultimately accomplished in several successive machines, each set to a finer gauge than the preceding. The entire process consists of one long brushing and combing, in which cylinders, covered with teeth of gradually increasing

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fineness, pass the fibres from one to another, continually drawing them out, until all the knots and irregularities are eliminated, and they lie straight and parallel. This more especially refers to the manipulation of the Italian fibre.

Regarding the general use of asbestos, Germany is a large consumer. In France, the consumption is not so great, though some very good qualities of paper were some time ago made there. The industry is, however, apparently reviving in France, an energetic attempt having recently been made by a company, calling itself *La Société Française des Amiantes*, at Tarascon-sur-Rhône, for the production of the usual qualities of asbestos goods, accompanied by some others of a novel character. Paris was the first to set an example, by following out Aldini's idea of protecting firemen by a dress of asbestos cloth, which has since been followed up in London, after conclusive proof of its practical utility in Paris. But the United States are as far away ahead of any other country as consumers of asbestos, as they are also in their manifold applications of it. A good deal is used in England in the manufacture of some valuable kinds of packing for engineering work, millboards, felts, lubricants, paint, and the like; but in England we lack in some degree the readiness which is found on the other side of the Atlantic, in the adaptation of new materials, and the adoption of new methods of working up those already in use.

Whether it be that Englishmen are influenced by climatic or other causes, certain it is that they are slow to adopt new systems, to cultivate novel ideas, or to move out of old grooves. Consequently, when new materials, or even novel applications of those long used, are suggested, they ponder over them, hesitate, and weigh the chances, and, in so doing, not infrequently let slip valuable opportunities; whilst the keener and more enterprising American, once he sees the drift of the new matter, will, to use his own expression, "catch hold" at once. It by no means follows, however, that in England this is the fault of the manufacturers alone; they have naturally to gauge the requirements of their customers, and prefer to limit their make to what they know they can sell.

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CHAPTER III.

PRESENT SOURCES OF SUPPLY.

Universal Diffusion of the Mineral—Its many Varieties—The United Kingdom—Italy and Canada—Savoy and Corsica—The United States—British Columbia—Yukon—Alaska—Newfoundland—Scandinavia—Norway—Pontoppidan—The Vel Fjord—Lapland and Finland—Russia—Siberia—Ekaterinburg—China—Australasia—Tasmania—South Australia—New South Wales—Africa—The Cape Asbestos Company—The General Asbestos Company—Importance of the recent Discovery at Danville.

As already mentioned, asbestos, in one form or another, and in more or less abundance, is pretty well diffused over the whole surface of the globe. It occurs in many parts of England, at Aberdeenshire in Scotland, in the North and on the West Coast of Ireland. In the north, Kinahan, the Government geologist, reported some time back, the finding of good specimens at Bloomfield, near Enniscorthy, and on the west coast, about Mayo, the writer found many small veins, or stringers, of chrysotile of fairly good quality, but nowhere in sufficient abundance to encourage a hope of successful work. Like most of the Irish minerals, asbestos is singularly deceptive and tantalising. You may follow a vein, or indication, until you are almost sure of success, when suddenly, heigh, presto! the whole thing vanishes away. I found there a good deal of an indurated form of chrysotile, which proved to be *Schweitzerite*, which is found plentifully in Switzerland. It does not occur in either France or Germany in sufficient abundance to make either country independent of foreign supply; but is found more plentifully in the Pyrenees, Spain, Portugal, the Italian Alps, and Savoy, especially near the boundary between Italy and Switzerland. It occurs in

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CHAPTER III.

PRESENT SOURCES OF SUPPLY.

Universal Diffusion of the Mineral—Its many Varieties—The United Kingdom—Italy and Canada—Savoy and Corsica—The United States—British Columbia—Yukon—Alaska—Newfoundland—Labrador—Scandinavia—Norway—Pontoppidan—The Vel Fjord—Sweden—Lapland and Finland—Russia—Siberia—Ekaterinburg—Persia—China—Australasia—Tasmania—South Australia—New South Wales—Africa—The Cape Asbestos Company—The General Outlook—Importance of the recent Discovery at Danville.

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profusion, as well as in singular purity and fineness, in the Island of Corsica; where, however, the conditions of land tenure seem to form an obstacle to the successful working of the deposits, some of which are of great beauty, although there is considerable abundance also, of the coarser varieties. In South Norway it occurs in association with the apatite-bearing rocks; and in Nordland, on the Vel Fjord, near the enormous deposits of marble, it is found abundantly, but the fibre approaches very nearly to *Arfvedsonite*. In many parts of Scandinavia, it is harsh and rugged, and frequently takes the form of mountain wood. It is found also in Greece, Turkey, Asia Minor,* Servia, and Hungary; in the two last of a dark brownish colour and very unpleasant to handle; also in many parts of Greenland and Iceland. In Newfoundland it occurs in various parts of the untrodden interior, as well as on the west coast, but no encouragement is there given for the introduction of any trade which might interfere with the fisheries; selfishness and exclusiveness being, as heretofore, the ruling principle of that much neglected island, just as it was in the old days of the Star Chamber. In North America, it is frequent, often abundant, but little of what is found there is adapted for commercial purposes. It is found in many parts of South America, notably in Brazil; also in Persia, China, and Japan. It occurs also in many parts of Africa, especially in the country bordering on the Great Orange River. It is also found in Tasmania, South Australia, and New South Wales, but has never yet, so far as I know, been discovered in New Zealand.

Interesting specimens from all these places are to be found in England, in the museums, or preserved as curiosities in private collections; but, in by far the larger number of cases, their brittleness, coarseness, or want of flexibility deprive them,

* On one occasion the writer was shown some unmistakably good fibre from this part of the world, and negotiations were entered into to arrange for his going out to report on the best method of working, and its conveyance to England. But on inquiry, we found that the country was in too disturbed a state to render it practicable for working. Unquestionably many parts of the country show ample evidence of rich mineral lands, which anywhere else would be the scene of active industry. This has been confirmed by many who have traversed the country.

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for present purposes, of any commercial value, so that, in only too many instances, they are found to be but of little use to the manufacturer. Where the quality is good, the quantity available is often not sufficiently abundant to pay for working. The seams vary very greatly in different regions, not only in length of fibre, colour, and general appearance; but whilst they have, almost universally, the same dip and inclination, they differ very greatly in composition.

Some varieties, the product of different lands, are not only singular, but, in many instances, singularly beautiful, the asbestos of different climes being occasionally as varied in colour, form, and texture, as the special foliage of the countries in which they are found. What, for instance, can be more remarkable than the peculiar bluish-green appearance of some of the Australian gum trees, when contrasted with the soft refreshing verdure of the English woodland scenery, as it luxuriates in the luscious beauty of the moist atmosphere of early summer? Australian specimens often reproduce the characteristic shade of the eucalyptus, though some of them have the usual light-coloured tints.

How different this from the gorgeous display of the autumnal hues of the Canadian maple, which can be likened to nothing but a succession of gigantic bouquets of tropical flowers, often thrown prominently into relief by a deep background of pine—a never-ending source of delight to the traveller, forming such enchanting displays of colour as can be found nowhere else in the floral world. The irresistible glory of this leaf was naturally chosen by the Canadian as a distinguishing mark on his flag. Where, also, can you see more lovely specimens of pure silky chrysotile fibre than in the province of Quebec? Contrast also the smooth and white, easily pulverised form of asbestos from the Pyrenees, with the harsh and brittle tremolite of Servia, unpleasant to handle, its fine needle points insidiously penetrating the skin, just like the particles of slag wool; and this again, with the long, soft silkiness of the Corsican variety, the hanks of which look like skeins newly wound from a cocoon, the resemblance being all the more perfect from some

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of them being of a silvery white, and others of a pale amber or golden colour. Then, turn to some of the strange African forms, many of which are of a coarse brownish texture, and others wool-like and of an indigo blue. Again, give attention to some of the Scandinavian textures, many of which exhibit fibres as rough and rugged, in appearance, as the country which produces them.

The mineral being thus so widely distributed, it would not seem to be unreasonable to suppose that it could be had in unlimited quantity. Such, however, is so far from being the case, that in very many instances, the quantity obtainable is much too small to pay for working; in some others the quality is only suitable for special purposes of manufacture; in many more, difficulty of access or local surroundings preclude any attempt at profitable mining, at any rate for the present. Indeed, there are surprisingly few places where it can be advantageously obtained, and we will now point out some of the localities where asbestos can be had, and endeavour to describe its quality and value.

THE UNITED KINGDOM.—The British Isles seem to be entirely shut out from the list of asbestos producers. We have indicated one or two places where it can be found, but in none of these does it occur in sufficient quantity to be of any economic value.

Great hopes were, some time ago, held out that it would be found in the long ophitic range which runs through Mayo, on the west coast of Ireland, from a rugged, outlying pile of massive storm-swept, water-worn, boulder-like rocks at Old Head, near Louisburg, through the villages of Leckanvy and Murrisk, to a point at some distance beyond Westport. The Government geologist, and many persons of influence, took an interest in the matter, and, as a preliminary, the writer was sent over to test the ground; but although he found the serpentines were often very beautiful and eminently adapted for indoor ornamental work, it was abundantly clear, from the nature of the rock, that none of them were sufficiently fertile in fibre to lead to the remotest expectation that asbestos would anywhere, in that

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district, be found in quantity sufficient to pay for working. The likeliest place for work was in the rugged out-crop at Lug-na-demon, on the shoulder beneath the towering summit of Croagh Patrick, where innumerable small veins were found, as we gradually uncovered them, shewing up in a most tantalising manner. We give here a view of the spot, showing where the



first blast took place. Here we found such abundant indications as proved ample justification for the expectations which had been raised, but nowhere, unfortunately for the inhabitants of that poverty-stricken district, could one be justified in recommending any great outlay to be incurred in the hope of attaining any favourable result.

ITALY AND CANADA.—The two countries which at present furnish the bulk of the world's supply are Italy and Canada. In these two, the appearance, formation, and associates of the mineral are as widely different as the climate, the manners of the people, or the natural features of the lands themselves. Naturally, therefore, these being the chief producers, the

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mineral itself, as well as the mode of mining, being so entirely different, both are deemed of such importance that it will be necessary to deal with them in separate chapters.

CORSICA AND SAVOY.—Some charmingly beautiful specimens are brought from Corsica and Savoy; and so plentiful is it in the latter island, that formerly (its mercantile value being unknown), it was often used instead of tow for packing. There is also a fibrous kind of potstone* found there, which, like asbestos, is a silicate of magnesia,† with which the inhabitants manufacture certain kinds of pottery by mixing it with the ordinary potter's clay, obtaining thereby a lighter and more durable vessel than they could get by the use of clay alone, and one more capable of withstanding sudden alterations of heat and cold than ordinary earthenware.

UNITED STATES.—That neither asbestos nor chrysotile of good quality can be found in the United States, in sufficient quantity for working, is shown by the fact that, whilst America is by far the largest consumer of the mineral, her supplies of crude ore are almost entirely derived from Canada. Out of a total export from the Dominion of 3,936 tons in 1888, no less than 3,612 tons were taken by America. It may certainly be that some portion of this large quantity was bought by dealers in New York, who afterwards exported it at enhanced prices; but as to this we have no data. In 1889, under the stimulus of the high prices then ruling, the exportation from Canada was much larger; but for that year, the proportion of the amount exported will work out very differently, as four of the

* Ollite (*lapis ollaris*) from *olla*, a dish. An impure soapstone of a greyish-green or dark-green colour, and usually of a slaty structure. It is found abundantly at Potton in the Eastern Townships of Quebec. And see *post*, p. 330.

† So called from a city in Thessaly. There was another city, also of the same name, where, Pliny says, the mineral called magnet was found, which he describes as being of a whitish colour, somewhat resembling pumice and not attracting iron. A purer form of magnesia was no doubt meant by Hippocrates (της μαγνησιης λιθον) which he mentions as being prescribed as a cathartic, possibly native carbonate of magnesia.

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mines have been purchased, and are now worked, by English and German manufacturers, who require the produce of them for their own special use; so that the output of these mines is practically withdrawn from the general market.

The announcement of the discovery of the mineral in Newfoundland in 1893, and, quite recently, on the shores of Hudson Bay and the Straits, gave a keen impetus to the mining for asbestos on the North American continent, but this soon fell off, on the uselessness of the latter and the neglect by the owners of the former being proved.

The best known asbestos land in the States lies in a narrow belt, which extends over the Piedmont region of the Appalachians, stretching from New York through Pennsylvania, Maryland, Virginia, and the two Carolinas, into Georgia. Asbestos is also found in Staten Island, in New Jersey, in Texas, Montana, and many other places; but, wherever found in the United States, its hornblendic character gives it much the appearance of fossil wood. The veins may range from an inch or two to several feet in length, but the fibre is generally of the same quality, short, coarse, woody, brittle, and of but little tensile strength. It can be split off like chunks of soft wood, but, when separated, is found to have no cohesion. It can neither be spun nor pulped, and is practically of no commercial value. Chrysotile is chiefly remarkable for its absence. Large deposits of magnificent fibre are frequently announced, as having been just discovered under peculiar circumstances, but, in almost every case, the printed description has some indication of *caveat emptor*. Most of these Munchausenisms appear in some local paper, and are merely meant to attract the attention of incautious buyers; but if none such comes forward, the rich mine, with its splendid fibre, soon disappears and is never heard of more. Quite recently, an extensive deposit of unusual character was announced to have been discovered in Southern Montana, in the West Gallatin basin, and a company was stated to have been formed to work the claims, the asbestos being said to be nearly pure white and of long fibre; but whether the mineral was chrysotile or asbestos there was nothing to show,

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Another announcement was of the uncovering of a vein near Hamilton (?) for a distance of over seventy-five feet, the "ledge" in which it was said to have been found having been proved for eight feet in width, so that after the surface soil had been removed, "the pure asbestos ore, as white as chalk, was seen, as "fine as silk, the feathery fibre being as long as the pieces of "rock from which the fibres were pulled, in some cases reaching "the entire length of *eighteen feet*."

Numerous samples have been forwarded to me from various parts of the States—from Wyoming, for instance, where it was said that great deposits had been found; at Caspar Mountain a deposit was stated to have become developed into such extraordinary richness that numerous claims had been taken up; and at Montana also. But in none of the cases where samples were sent me, by the owners of the property, to obtain advice as to the best methods of turning the mineral to account, have I found them to be of much use. It is at any rate suggestive, that in no case has any sample been sent me of any one on those miraculous fibres, the praises of which have been so loudly chanted in the local papers.

During an exploration for steatite, some time ago in Pennsylvania, about 300 lbs. weight of fibre was got out, but this fetched no more than nine cents. per pound, which was a sufficient indication of its value. And even if it could be said that the quality of the ore usually found in America was good, the deficiency in quantity is shown by the official returns. The figures for recent years also show a continual falling off if production, in precise accord with the rise in price of Canadian, which can only be attributed to the growing appreciation of the merits of Canadian ore for manufacturing purposes.

In "Rothwell's Mineral Industry of the United States," the production for 1892 was given as just 100 short tons, the value of which was stated to be $5,000, and that for 1893 was given as 120 tons, value $6,000. There seems to be some discrepancy in both these years, but the matter is practically immaterial. From another source we give what we believe to be the correct figures for each year from 1880 to 1894. These

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clearly show that mining for asbestos in the States is an industry which virtually has no existence. In most cases the trifling output seems to have come from California.

Year.	Tons.	Value.
1880	150	$4,312
1881	200	7,000
1882	1,200	36,000
1883	1,000	30,000
1884	1,000	30,000
1885	300	9,000
1886	200	6,000
1887	150	4,500
1888	100	3,000
1889	30	1,800
1890	71	4,560
1891	66	3,960
1892	104	6,416
1893	50	2,514
1894	325	4,463

The above figures show clearly enough that, American manufacturers do not rely on home production, and as they make no use of Italian ore, their dependence at present is necessarily on that of Canada to meet their rapidly increasing requirements. In a statement published by the Geological Survey of the United States, the total production for 1894 amounted to no more than 325 short tons, valued at $4,463, while the imports (from Canada) amounted to $256,018.

In 1887, there was an exhibition at Earl's Court of the economic minerals of the United States, but, so far as asbestos was concerned, my visit to it was fruitless. There was but one small tray of amphibole* in the whole collection, and this was of no value for manufacturing purposes. I saw there one unmistakable fragment of chrysotile, but on asking the proprietor about it, he was good enough to inform me that "he did not believe it was a mineral at all, certainly it was not

* "On attribué généralement à l'amphibole les mineraux fibreux, et plus ou moins flexibles, que l'on a désigné sous le nom d'asbeste ou d'amiante."—Jagnaux, 550.

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from America; he believed it was some vegetable substance from Canada."

In the Washington State, there is some coarse thread-like fibre to be found in considerable quantity, but the sample sent me from that State, was not sufficient for a determination of its quality or value. It was of the hornblende character, similar to much of that generally found in Norway, especially in Nordland, but much superior to anything hitherto found in Montana or Wyoming, and although its existence has been known for more than ten years, no one has yet ventured to work it, with a view to any profitable return.

CALIFORNIA.—In that rich storehouse of the economic minerals, California, asbestos occurs in many places, and sometimes the deposits are of considerable extent, but out of numerous samples forwarded to me from that State, none have yet been found that, with our present limited knowledge of the capabilities of the mineral, would pay for working. In San Diego County, asbestos of a coarsely fibrous kind, occurs in a belt of slate enclosed in granite, an unusual formation. Here the strike is north 70° west magnetic, and the dip nearly vertical; the ore is exposed in an open cut fifteen to twenty feet long, by six or eight feet deep.

In the mountains to the south-west of Warner's Valley, within three miles of the hot springs, asbestos was recently said to have been found, with a seven-inch width of fibre. The description, both of the locality and the mine, was of a very circumstantial character, but the probabilities are decidedly against it.

There are deposits also in Placerville, El Dorado, and Lake Counties. Some of them possess sufficiently good fire-resisting qualities, all of a hornblendic character, but nearly all of them are deficient in tenacity. It is not to be said that these forms are worthless—their value will no doubt presently be discovered—but at this moment, when the practical uses of the mineral are so far undeveloped, it is only the more silky and tenacious fibres that are in especial demand. For grinding, the manufacture of cement, boiler and pipe coverings, roofing

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materials, and similar purposes, these Californian varieties may be useful; but, in a general way, the supply of refractory minerals, for such uses as these, is sufficient to meet the demand.

BRITISH COLUMBIA.—Chrysotile has been found on the Stewart River, British Columbia, where the occurrence of large masses of serpentine tends to justify the expectation that workable deposits will presently be found.*

YUKON.—In the district of Lake Temagami, to the north of Lake Nipissing, asbestos has been found from half an inch to nine inches long. One of the veins here shows about a foot wide, running in trap, in the same direction as the quartz.†

ALASKA.—It has also been found in Alaska, but there amongst other things, difficulty of communication blocks the way.

NEWFOUNDLAND.—So rapid has been the development of many of the English colonies, that it remains a constant matter of wonderment how it comes about that this, the oldest of them all, should form such a striking instance to the contrary. And this wonderment will remain, until the traveller shall visit the island and mix with the people, when he will soon cease to wonder, except at the apathy of the inhabitants, and the total indifference shown by the local authorities, to all that can affect the prosperity of the island, or conduce to the welfare of the people under their charge. The picture here given of *Quidi-Vidi*, near St. John's, strikes the key note of the whole business. It is a characteristic bit of the country; all fish and fish alone. Newfoundland is as rich a mineral country as Norway; many parts of the west coast are astonishingly fertile; the forests are extensive, but practically untouched, and the greater part of the country, even to this day, is unexplored and utterly unknown; while thousands of the people are periodically in a state of semi-starvation, in order that a handful of the inhabitants may grow rich; and the better to secure this end, any alternative employment to that of fishing is studiously discouraged. The one hope of salvation for the

* Report on the Yukon District, N.W.T., by G. M. Dawson, 1888.

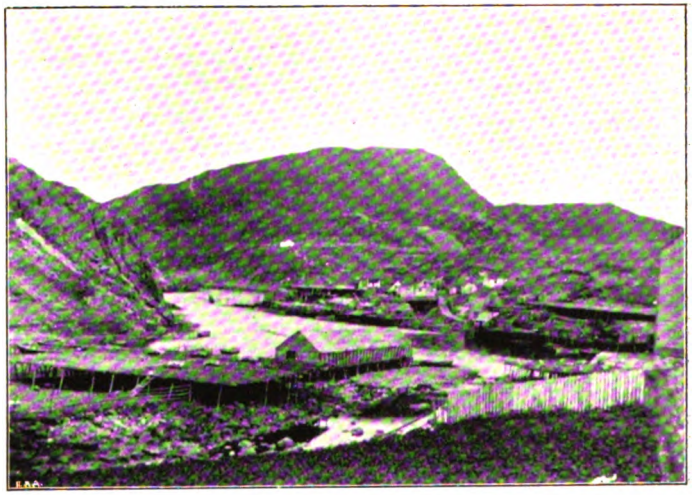
† Report of the Royal Commission on the Mineral Resources of Ontario, 1890, p. 57.

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island, lies in the progress of the railway across the country, and the energy of the Canadian builders of it, Messrs. R. G. Reid & Sons, who, by the infusion of new blood into the place, and their untiring energy, will sooner or later wake up the inhabitants from their torpid state and their present total indifference to any matters, except such as relate to the catching, curing, and trade in fish.

So great a resemblance exists, in a physical sense, between some part of the geological formation of Newfoundland and



that of the Gaspé Peninsula, with portions of the Eastern Townships of Quebec, of which the former is doubtless a continuation, that it is naturally to be expected the same minerals would be found in both countries, including asbestos. The Quebec group, a continuation of the Appalachian chain, is part of the great metalliferous formation of North America. In the great section of country included in this formation are to be found gold, silver, copper, asbestos, magnetic and chromic iron, cobalt, nickel, and some other minerals; all which are everywhere associated with the ophiolites and other magnesian

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rocks of the Lower Silurian, whilst many of them are apparently wanting in those of the same age in the Laurentian series.

The rocks, with which the asbestos-bearing serpentines are most commonly associated in the Province of Quebec, form a considerable belt along the west coast of Newfoundland, where are to be found the same series of slates, sandstones, diorites and tremolites. In these, wherever the rock is laid bare, asbestos-bearing serpentines also are to be seen in abundance. Although the chrysotile veins, near the surface, are short, they are otherwise seen to be of a quality like that of Thetford.

During my stay of the best part of two years in the island, I spent considerable time on the summit of Bluff Head, Port-au-Port, which varies in height, above the sea level, from 1,800 to 2,000 feet. Our landing-place was, as shown on the next page, startlingly rugged, and storm beaten, piled up everywhere with masses of rock and huge boulders, except immediately under the bluff, where there is not an inch of foothold, deep water running close up to the precipitous escarpment, as in the fjords of Norway. We were often unable either to land or embark for many days together, and several times had our boats smashed under us, as we were flung on to the rocks. No landing is anywhere possible, except in remarkably fine weather, and in particular states of the wind. Near the summit of the Bluff, about 1,600 feet up, we erected our shanty on a shelf of land near the wood, and surrounded by some delightful birch and mountain ash (the rowan tree of Scotland), where we could overlook a wide expanse of the stormy bay, with Fox Island and Long Point to the front of us.

The underlying rocks, about the former place, are famous for the size and abundance of the lobsters caught there; and at the extremity of Long Point, petroleum can be seen exuding from the rock, from which it is afterwards washed into the sea. Near the Tail of the Fox, the rocks are of a hard, dark green sandstone, enclosing massive lumps of jasper, "the mother of gold," but containing here only a profusion of particles of gold-like pyrites. On the opposite side of the bay, where Bluff Head

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looms up in a purple haze, we see the long range of serpentine hills, trending far away beyond Coal River towards the Bay of Islands, beyond which it runs farther north than Bonne Bay. This is the commencement of the Lauzun Division of the Quebec group of the Lower Silurian, which, as already mentioned, is the great metalliferous zone of North America, and especially rich in the precious metals, and in the ores of copper, which chiefly lie in the interstratified cupriferous slates, and are nearly always



productive both of silver and gold, with nickel, chromium and cobalt. All five of these minerals are to be had on the summit of the Bluff, awaiting some more intelligent occupation than that of the syndicate which now, unfortunately, has possession of the land.

Here I uncovered many veins of good fibre, some of them ranging from an inch and a half to two inches, the prospects of which were unusually encouraging, but unfortunately the company which owns the property has no one connected with it who has the remotest pretensions to any knowledge of

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asbestos, or its mode of mining, and being far too parsimonious to employ competent assistance, it at once stopped work when discovery was made that asbestos could not be got with the same ease as potatoes or parsnips are dug from a field. Another company, the Halifax Asbestos Company, started work on some adjoining land, also with good prospects of success; but unfortunately their capital was deposited with the Union Bank at St. John's during the late financial crash, so it came about that



this company also had to cease work, a want of funds in their case bringing about the same result as the want of ordinary intelligence in the other. The nature of the ground, moreover, is such as to entirely preclude any successful issue of efforts of a parsimonious or spasmodic character.

This part of the west coast is entirely uninhabited, but the climate is delightful and pleasant in every sense. A photo of our shanty is here given, which we built close to the asbestos deposit. Here I spent, with my men, a charming sojourn of several months, with no one to disturb our work, our solitary

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visitor being a huge bear, which used to prowl about the camp at night, attracted, doubtless, by the savour of our pork-barrel and molasses-tub, his nightly pleasure being to knock our tubs and tools about, in search of something good. In the day-time we had no leisure to look for him, so his skin, which was worth $20, fell into the hands of a roving sportsman, to my great chagrin.

In addition to the good fibre, we found here many curious samples of wet and decomposed serpentine. One specimen, when got out, proved to be short chrysotile mixed with fragmentary particles of serpentine, so saturated with wet that it was very easily pulled out by the hands; but, on exposure, it gradually came to look like a pure carbonate of magnesia, at first almost of the consistency of putty. On longer exposure it dried and became a pure white, not unlike gypsum, and then could be easily pulverised by the fingers. A sample of decomposed serpentine was found near by, in the bed of a mountain stream, which had the appearance and consistency of an unctuous plastic clay. Some of this I rounded up in my hand, making it into a smooth ball, moulding another lump of it into brick shape. These, I left on the rock to dry, and then placed in the centre of a furnace, where a fierce fire was kept up for over twelve hours. When taken out, they were glowing at a red heat, and were then left to cool gradually, after which they were found to be without crack, or flaw of any kind, or in the slightest degree harmed by the intense heat to which they had been exposed. I naturally concluded, therefore, that the material would be admirably suited for the manufacture of fire-bricks, furnace-backings, or hearths.

Close on the same part of the property, I discovered also a deposit of chrome iron, not in a pocket, like so much of that which is found in Canada, especially in the neighbourhood of Black Lake, as to which a professor from Yale College, who came over to inspect it, stated it to be the second largest chrome deposit in the world, and at that time, more than a year ago, it was believed to be worth something like £50,000. This was at once snapped up for the price of an old song. In these cases, of iron deposits, the amount of ore may be calculated by stating

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that, in a mile, every five feet in depth will yield a million tons of pure iron.* On various parts of this unique mineral property, gold has since been found, the first sample tested yielding 1 oz. to the ton of quartz, besides black oxide of silver, grey copper ore, pyrites and hematite iron; and, at a mile distant, also on the same property, another valuable deposit of chrome iron and a vein of nickel silver has been discovered, the last a hundred feet wide.

In many other parts of the island there are important developments of fertile serpentine, especially in the interior, and on the northern side of Hare Bay, and between that place and Pistolet Bay, but the total absence of roads, the supineness of the authorities, and the opposition of the merchants and priests, render any development of this self-neglected island, except on the merest fraction of coast-line, as useless for all but fishing, as if it lay at the bottom of the sea. Some extent of asbestos-bearing serpentine occurs also in the Bay of Islands, extending from the north arm of the Humber to Bonne Bay; but none of this is proved to be of much value.

On the west side of Tickle Harbour, north of Long Reach, is a group of altered rocks consisting of purple and variegated slates, associated with serpentine and steatite, the veins of asbestos being intersected with layers of yellowish quartzite.

At Tilt Cove, in the neighbourhood of the copper and pyrites mines, great masses of serpentine and steatite occur, the magnesian rocks in that district being permeated throughout by magnetic and chromic iron in grains and crystals. In front of this, and overlying the mineralised lands, are masses of a hard, grey diorite, containing epidote in strings and patches. This is succeeded on the north-west by the great body of serpentine of the Castle Rock depression, where a very soft and shaly serpentine containing asbestos is found, the veins at the surface averaging about a quarter of an inch in width.

There is also a large development of *picrolite* towards the top of Sitdown Hill, which runs through the rocks and breaks out in long fibrous crystals, the surfaces of which are sometimes

* Government Geologist (Ontario) Report, 1892, p. 31.

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opalescent. Seams of asbestos are also frequent here, and in several other places; indeed, it is manifest that there is abundance of mineral and material wealth on the island, which it is to be hoped may some day be considered ripe for exploration, but which at present is entirely useless, no alternative being wanted to compete with the all-important fishing interests. The only two asbestos companies formed here, one of which, the Newfoundland Mineral Syndicate, which formerly worked half-heartedly at Bluff Head, possesses two miles of rich mineral land, now so utterly wasted, that it is to be hoped it will soon get into other and more competent hands; and the other is the Halifax Asbestos Company, incorporated under the Nova Scotia Companies Act, in 1893, with a capital of $15,000, in shares of $1 each. The work of this company was stopped, as before mentioned, by the locking-up of their funds in the defunct Union Bank.

The news of the discovery of the existence of asbestos in the island, caused for the moment considerable excitement in the asbestos world, one Canadian writer not hesitating to say that here would, in the future, be found Canada's greatest competitor in this material; but, however, that may be in years to come, although the fibre found in many parts of the island, besides those mentioned, is good enough, there are sufficient reasons for the contrary view, some of which we have already indicated, for any fear of this being the case till the country is more carefully explored. At present any such idea is totally without foundation.

SCANDINAVIA.—Turning to Scandinavia, the physical features of which are of so eminently striking a character, we find a chain of mountains running throughout almost the entire length of the peninsula, in such a way as to form a practical divide between the countries of Sweden and Norway. Nine-tenths of the last-named country, are of a bold, mountainous character, the valleys being mere rents or chasms, sometimes not more than a hundred feet wide, at the bottom of which generally runs a fjord, or occasionally a river rushes in a tortuous course down to the sea, the enclosing mountains, picturesque, wild, bold and grand, rising up in grim and bare sterility, to a height

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it may be, of about 4,000 feet. So strange, indeed, is the general conformation of the country that Victor Hugo could liken it only to the skeleton of a great fish. Such a country as this is specially favourable for deposits of the economic minerals, amongst which asbestos and other magnesian varieties naturally find a place. In many parts of this lapidious region, as Pontoppidan calls Norway, serpentine abounds, as well as in many other parts of Scandinavia. It occurs in massive form at Fahlun, in Sweden, and crystalline massive at Snarum and other parts of Norway, especially near the apatite districts of the southern portion of the country. At Fahlun and Gulsjo precious serpentine is found, and a soft, earthy variety called porcellophite, which much resembles meerschaum in appearance, is also found, in abundance, at Sala, in addition to great quantities of picrolite.

Amphibole, which is an essential constituent of such rocks as syenite, diorite and greenstone, is there also found, as well as asbestos, in association with the greenish apatite rocks about Arundel, Snarum and several other places, where actinolite, rutile, chlorite and epidote also abound. Pontoppidan mentions its occurrence at Sundmoer, where Victor Hugo also speaks of it, in his weird novel of "Hans d'Islande." A pseudo-chrysotile is also found at the same place, which has the following composition :—

Silica	42·92
Alumina	87
Ferric oxide	2·28
Magnesia	41·66
Water	12·02
	99·75

There can be no doubt of the valuable character of this mineral, but I have not yet heard of its being worked. And there is just as little doubt that chrysotile is generally wanting, most of the asbestos found in Norway, especially about the north, being hornblendic, hard, rough and coarse, and too

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often closely resembling mountain-wood, mountain-cork and leather. It more especially partakes of this character in the limestone and hornblendic regions about the Vel Fjord. A photo of the spot where the asbestos was found is here given, showing the pleasant locality, the rugged nature of the mountains being charmingly and picturesquely relieved by the delightful waters of the fjord, which are studded at this point with numerous small but exquisitely verdant islands. The general face of the country is indicative of having undergone a mighty upheaval of the primitive rocks, granite, gneiss and



syenite, especially near the coast-line, none of these being, as a rule, intimately associated with the more silky fibres of asbestos. Near the shore, and adjoining some of the fjords, these minerals are brought into close proximity with them, by mile-long patches of serpentine and hornblende. The crocidolite form of blue asbestos, such as is brought from the Cape, is also not unknown in the country, being found, somewhat sparingly, in the region about Snarum and Arundel.

The shattered nature of the rock is shown by the following

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cut, which represents one of the asbestos openings, up to which we had to climb on stepping from the boat on to the lower part of the rock.

The whole country, which, geologists tell us, is one of the oldest portions of Europe, bears ample evidence of having been raised above the ocean level at a very remote age. Comparatively speaking, there is no country in the world which exhibits such extensive areas of those primary, or palæozoic rocks, which



are of such supreme interest to the geologist, as forming so large a part of the oldest crust of the earth, and presenting nearly the same form as when originally solidified, their features being of the most hoar antiquity.

Pontoppidan, Bishop of Bergen, a translation of whose very interesting "Natural History of Norway" was published in London in 1750, says, "*That the amianthus, or asbestos, which makes an incombustible linnen or paper, is to be found in the parish of Waldens, I can affirm from my own experience. I had sent for some samples* of *that wood, which was said to be petrified by a certain water above mentioned. Accordingly, a large parcel*

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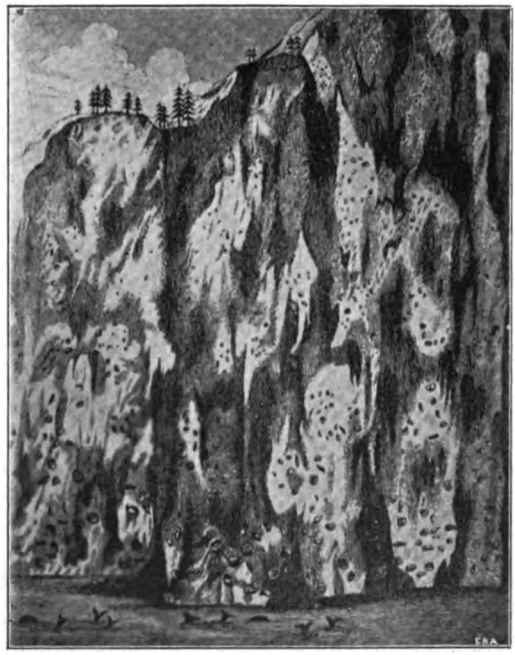
of it was sent to me, and at first I could have compared it only to hazle, which had lain a long time in the water, but upon a narrower inspection and drawing out some of the filaments, I found it was no petrified substance, but an amianthus, and far finer than the Greenland stone-flax, which the Reverend Mr. Egede, in his account of his mission, relates to be there used as wicks in the lamps, without being in the least wasted whilst supplied with oil or fat. This Sundmoer amianthus, which is produced in a mountain in Birkdalswamp, deserves, like that of Siberia, and even better, to be called stone-silk, *rather than* stone-flax, *its fibres being softer and finer. I also made a wick for a lamp from it, and it was not consumed, but its light being much dimmer than that of cotton, I laid it aside. I have also in my possession a piece of paper of this asbestos, which when thrown into a fierce fire is not in the least wasted, excepting only that what was written on it totally disappears. The manner of preparing this stone-silk or stone-flax is briefly this. The stone, after being softened in water, is beaten with a moderate force till the fibres or long threads separate from each other; afterwards, they are carefully and repeatedly washed till cleansed of all terrene particles: then the fibre is dried in a sieve, that the water may run off the sooner. All that now remains to be done is to spin their fine filaments, wherein great care is required, besides which the fingers must be softened with oil that they may be the more supple and pliant. That Kircher and others should have mistaken this stone for the* alumen plumosum* *and imagined it to be an allum fire-proof appears hardly probable, especially as allum has a very acrimonious and peculiar taste, which this stone is so far from having, that it is as void of taste as any other stone can possibly be.*"

* Pontoppidan's note on this is, "Dico itaque hunc lapidem esse compositum ex certa aluminis seu talci specie, ut proinde eum multi alumen scissile, aut alumen plumæ nominandum putarint est enim multo mollioribus filamentis, &c." Mund. subterran, Lib. VIII. sec. 3, cap. 1. p. 67. The mineral here referred to is *Halotrichite*, ἅλς, ἅλος, salt, and θριξ, τριχος, hair; a yellowish-white mineral, with silky fibres and an astringent taste, much like alum, which is often found efflorescent or in feathery masses, especially in Natal. See p. 75.

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And in reference to the petrified wood spoken of, he says, he "*had learned from an old book that the water of Birkdalswamp* "*in Sundmoer has a petrifying quality and that within three years* "*it turns hazle into stone, but not elder, which grows near it.*" Yet although he had many specimens of such petrifactions,



he suspended his judgment until he could visit the place, and then he found that there was no such thing as petrifying water in that place, "*but that on one side of it, there is a piece of an* "*amianthus, or asbestos rock, which being divisible into long pliant* "*threads, like flax, and being more like wood than stone, has been* "*given out for petrified wood.*"

I venture to give here another quotation from his interesting work, in which the rock spoken of may be serpentine, once in

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a pasty state, near to which he gives a sort of fancy picture of a fossiliferous mountain near Stene Sund, not a great way from Bergen, "*where*," he says, "*the mountain for half a quarter of a league, abounds with such petrified bodies as are sought for in the cabinets of virtuosos. All these figures appear as if they had been impressed into a paste, or dough, and no rational enquirer can entertain any doubt that the rock was as soft as dough, or paste, when first these bodies were intermixed with it.*" The photo of his drawing of this rock (shown on p. 65) is taken from the folio edition of the book in the British Museum. Unfortunately, in travelling over this part of the country, I did not pass this wonderful rock of Stene Sund, so had no opportunity of inspecting the miraculous size of the fossils displayed there, or the multiplicity of what are presumably whales. I, however, came across a "prodigious beast," as the man called it, who had just killed it, by smashing in its skull with his boat-hook. This proved to be a gigantic specimen of the great horned owl, which I should have much liked to carry home to the British Museum. It was by far the largest and heaviest specimen of this bird I had ever seen. The plumage of this nocturnal raptorial bird (*Bubo maximus*) was of a partridge brown colour, with a tinge of rusty red. Its wings stretched upwards of six feet, and its enormous black horns and its ferocious looking head gave it such a demoniac appearance that I should not much have liked to meet it in the gloaming. I cut off its huge claws, one of which I now carry at my watch chain, as a memento of my visit to the arctic regions. This bird's powerful foot has three toes or claws in front and one behind. The centre toe was no less than four and a half inches in length, and the sharply-curved talon, with which it was armed, two inches and three quarters.

In inserting here a view of the rocks in which the hornblendic serpentine is found the writer believes that no apology will be needed for introducing the foregoing quotations and drawing on account of their general interest, nor can any one acquainted with the Norwegian mineral for which Pontoppidan claims the name of *stone-silk*, wonder at his saying that the wick he made

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from it gives only an indifferent light. But chrysotile wicks are very different, and the subject of asbestos wicks, generally and as now used, will be referred to hereafter. Perhaps even a more important matter than this, is his reference to asbestos paper, made so long before the Italian experiments, previously referred to, though doubtless the cause of them, and which are now becoming such important articles of manufacture.

At Nævernæs, of which the entrance to the harbour is here



shewn, and the Holmen, on the Vel Fjord, to reach which you must pass Torghatten and the Seven Sisters, the serpentine, varied by masses of hornblende, runs for something like three miles in a heaped-up mammillated form, until suddenly cut off by a great upheaval of granite. Here, there is abundance of asbestos, which is all of the usual Norske character.

In the Report of the Royal Commission on the Mineral Resources of Ontario (1890), it is mentioned that Mr. Willimott has enumerated sixty-one species of minerals as distributed in the Upper Laurentian rocks of that province ; and these almost without exception, are to be found in rocks of a similar

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character in Norway. Among them, granite is everywhere conspicuous, in association with syenite, which abounds in zircon ; pegmatite or graphic granite occurring also in veins. In the north, gabbro, greenstone, and granite are found among the eruptive rocks, whilst in central Norway the formation is mostly overlaid with clay slates and quartz.



SWEDEN, LAPLAND, AND FINLAND.—Asbestos is also found at Jemtland, in Sweden ; at Tornea, Pitea, Kemi, and Uleaborg, in Lappmark ; and at Nyland, in Finland.

RUSSIA.—Asbestos also occurs abundantly in various parts of Russia, especially in East Russia, and beyond the Urals, as well as in Russian Siberia ; but although much of this, notwithstanding its unattractive colour, looked well worth a trial, in practical experiment it was not found satisfactory. Indeed, up to the present time little use has been made of it in Russia, on account of the prevailing ignorance respecting its peculiar properties An amusing instance of this occurred, some time ago, at some ironworks in the interior, with which I was at the time concerned.

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The iron ore, in the district referred to (Vyksa, below Nijni-Novgorod), is found in nodular bunches, near the surface of the ground; and in order to get at it, the peasants dig out pits about seven or eight feet in depth, and then burrow, rabbit-like, into the surrounding sandy earth, in all directions, below. When all the ore is got out from one spot, they dig another pit further afield, and so they go on, until the particular patch of ground they are working on is exhausted, the moujiks having an extreme aversion to going to any depth below. On the occasion referred to, some of our men, in their burrowing, threw out a considerable quantity of coarse asbestos. They had not the slightest idea what it was. In fact, they knew nothing at all about it, except that it was not what they were in search of; and, consequently, as it obstructed their work, they threw it all out in a heap, near the piles of ore. Presently, one of the foremen, or overlookers, saw it, and wanted to know what that rubbish had been put there for. "Here," said he, to some of the men, "just clear up all that mess at once, and fling it into the furnace, and get rid of it." And this was immediately done, that is, the asbestos was thrown into the furnace, with what result may be easily imagined.

At the present time, St. Petersburg possesses the only manufactory for the use of asbestos in Russia. Enormous deposits have been notified in one or two places, of which the reports that have reached us, as is generally the case, have told us they were of the finest and most silky character, but of many samples sent me, none are likely as yet to meet with the approval of the manufacturers.

Its value commercially would naturally be dependent, first, on the quality, and then on the nearness of the mines to an available market, transport being necessarily an important factor in the element of cost. But as a matter of fact, the specimens of the mineral, sent from Russia hitherto, have not been up to the mark. They are generally of poor quality, but mixed with Canadian for paper-making, and for some of those purposes for which an inferior grade can be utilised, may possibly be made available in Russia, though I know but of the one asbestos factory mentioned as existing in the country. There is some reason,

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however, for believing that more recent discoveries are of a different character from those previously made.

SIBERIA.—Siberia, being so well known for its rich mineral treasures, and the formation of some parts of the country giving indications of the whereabouts of asbestos, the recent discoveries there are by no means surprising. It seems, moreover, that the inhabitants are now beginning to realise the value of the discovery, for the protectionist papers, as is usually the case in Russia, are loudly clamouring for the imposition of a prohibitive duty on imported asbestos, the better to encourage local industry. For many reasons, not the least of which is difficulty of communication, the rich mineral treasures of Siberia have not yet attracted much attention from European capitalists. The important question of communication is, however, being gradually overcome, and means of establishing a trade will soon be found by the German merchants, who overrun the country in every direction.

EKATERINBURG.—Some little while ago, the Technical Society of Moscow announced the fact of its having received some unusually fine specimens of asbestos from Ekaterinburg, accompanied by scientific reports which seem clearly to establish the existence of large deposits of the mineral. From Orenberg to Ekaterinburg, the whole country is reported to be traversed by rocks containing deposits of asbestos, which culminate near the Verkin Tagil Ironworks, in the vicinity of which there is a hill, called by the peasants, Sholkovaya Gora (hill of silk), *which is said to be entirely composed of asbestos*, a not unusual specimen of Russian exaggeration. The principal of these deposits lie close to the railway, the facilities afforded by which, aided by those of the Volga River system, will materially assist in opening up an export trade, as soon as these deposits are properly worked, and found to be commercially valuable. Further veins have also been disclosed in the Gorobtagsdat and Neujansk districts of Perm. Similar announcements were, some short time back, made of discoveries in South Russia, but the local excitement soon died away when it was found that the quality was not such as was represented.

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Immediately adjoining the graphite works on the Oka, a mountain of green talc is to be seen, of remarkably beautiful appearance, and *lapis lazuli* can also be found in some of the neighbouring streams.

PERSIA.—Amianthus is stated to have been recently found here, and the report is, that it is about to be worked on property belonging to the Persian Bank Mining Corporation, Limited, at Kirwan, but of its quality we, as yet, know nothing.

CHINA.—In China also asbestos occurs; but, apart from the manufacture of a coarse kind of cloth, we know little of any purpose to which it is there applied. One singular use of it which Dr. Hobson, of the London Medical Mission, brings to our notice, may, however, be mentioned. He says that it is used by the Chinese as a medicine, and figures in their pharmacopœia, in company with such uncanny things as "dried spotted lizard, silkworm moth, human milk, the parasite of the mulberry tree, asses' glue," &c.; and this being so, we are quite prepared to take Cobbold* at his word, when he tells us that the native practice of medicine in China is not easy for a foreigner to understand. Before, however, we smile, or turn with disgust from the medical practice of the "heathen Chinee," it will be well to call to mind, that it is less than 200 years ago since such horrible things as "toads, vipers, centipedes and worms, found a place in the official pharmacopœia of the London College of Physicians."† Hippocrates prescribed asbestos as a cathartic, but it is probable that, under this name, he referred to a native carbonate of magnesia.

Only quite recently a good quality of fibre was reported to have been discovered at Lanzechan, in the Province of Chefoo; but no samples, nor any particulars, have come to hand up to date.

AUSTRALASIA.—Chrysotile has been found in Tasmania, in South Australia, and in New South Wales.

TASMANIA.—Its existence in Tasmania has been known for many years, but for a long time the gold discoveries prevented any attention being given to it. At Ilfracombe, it is said to have the appearance of "solidified silkworms' produce, and

* "Pictures of the Chinese, Painted by Themselves."

† "English Folk Lore," by the Rev. F. T. Thiselton Dyer.

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"exists there in large bunches petrified. In mining it," we are told, "it can be taken out of its bed in a similar way, and "almost as rapidly, as we take out a particular layer of chalk "or coal in this country," that is, in Tasmania, presumably.

SOUTH AUSTRALIA.—Asbestos also occurs, in long white silky fibres, at Jones Creek, Gundagai, where it is being worked by the Australian Asbestos Manufacturing Company. Some fine specimens of pyrophillite are also found there; meerschaum (so called) at Bingara, Murchison County, and picrolite at Kelly's Creek, Gwydir River. At Broken Hill, there is said to be a good market for this last, where it is manufactured into a covering for steam pipes; the "asbestos clay" found at the same place is also said to be very valuable for the manufacture of firebricks. If this should prove to be anything like what I have described as "decomposed serpentine," which was found by me in a mountain stream in Newfoundland, there is no doubt it would be admirably adapted for that purpose and many others. In a local paper, it was recently stated that at the office of Messrs. Johnson Messent there was advertised to be seen a number of splendid samples of asbestos, of a quality superior to anything yet recorded in Australia. The locality of the discovery is Red Hill, about nine miles easterly from Broken Hill, in the Rockwell paddock, where for a long time past a Mr. R. Hinspeter had been prospecting on the side of the hill, in which asbestiform rock was known to exist, and lately he is said to have struck a large vein of true amianthus of the Italian variety. The specimens on view are said to be of great length, one being as much as "twenty-eight inches, the staple "of which ranges from a striated salmon-tinted variety, known "as picrolite, from near the surface, to a beautiful snow-white "flossy fibre of a considerable length and good tensile strength, "taken from the shallow depth of twenty feet, while the material "is improving rapidly every foot." 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. This is a most unlikely statement, as it is extremely improbable that the two varieties should appear in the same place; and perhaps

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still more wonderful that we have not yet been favoured with a sight of this glorified mineral. Lower down a strong vein has been opened, while to the eastward is the deposit of amianthus, which seems to be of considerable extent. Stains of green carbonate of copper are plentiful, and both silver and gold, in small quantities, have been found on the property, an unfrequent occurrence in the asbestos countries of Europe.

Jagnaux gives the following analysis of the picrolite :—

Silica	55·19
Magnesia	31·58
Chaux	—
Oxide ferreux	1·70
,, manganeux	—
Alumine	1·40
Eau	10·62
	100·49

Laurentian asbestos, similar to that found in the Ottawa Valley, also occurs in abundance, near the copper and bismuth mines of Port Lincoln, South Australia. I have seen specimens of the ore from these mines, which seem to carry gold as well as copper, both of which must naturally be detrimentally affected by the bismuth.

NEW SOUTH WALES.—Near the Cow Flat Copper Mines here, a dark green-coloured asbestiform mineral (unnamed) is reported by Liversedge to be found, but from its having the following composition, it may be considered to be, for the present, unworkable :—

Hygroscopic water	1·084
Combined water by difference . .	1·941
Silica	49·447
Alumina	9·688
Iron sesquioxide	16·330
,, protoxide	5·151
Manganese protoxide . . .	4·389
Magnesia	traces
Lime	11·970
	100·000*

* "Minerals of New South Wales," by A. Liversedge, F.R.S. 1888, p. 180.

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The value of the asbestos raised in 1885 and preceding years, however, amounted only to £3,216. The serpentines in which the asbestos is found, in Australia as elsewhere, are in close association with deposits of chrome iron and other minerals. Those with which the asbestos deposits are most commonly associated are soapstone, magnetic or chromic iron, and occasionally mica and enstatite; chromite is less frequently met with, but generally all iron, found in the workings, is called by the miners chromic. The colour of Australian asbestos is usually white, or of a light dingy greenish-blue, the form densely compacted, but the fibres easily separable. This peculiar colour is sometimes seen in other minerals, notably in Azurite. The Native Asbestos Company, established for working up the Australian ores, is located in Flinders Street, Melbourne, Victoria.

AFRICA.—Now if we turn to Africa, "the land of sparkling gems," which, in all ages, has been celebrated for its mineral wealth, and which now, as in the days of Aristotle, has always something new to show, "Ex Africâ semper aliquid novi," we shall find her true to her reputation, and showing several new, or rather unfamiliar, varieties of asbestos. Africa has (perhaps in some moment of despondency) been stigmatised as "a country of samples," but when we remember that she has furnished the world with *six tons* weight of diamonds, a thousand tons of ostrich feathers,* with gold, and other produce, in equally fabulous quantity, it must be admitted that her samples are of rather a portentous character. This was written many years ago, but since the first discovery of diamonds in South Africa, from 1867 to 1893, it was stated in a paper, read by Mr. Brough before the Society of Arts, that more than 50,000,000 carats, representing £70,000,000 sterling, and weighing more than *ten tons*, have been exported. These, if piled up in a heap, would form a pyramid six feet high, with a base nine feet square. And since that date even these figures have been immensely increased.

And even now, whilst her wealth of gold and gems is being

* "The Land of Gold, Diamonds, and Ivory," by J. F. Ingram, F.R.G.S.

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distributed in such lavish abundance, news is flashed home that she again "has something new to show," asbestos being said to have been discovered, according to the report, of a quality and in such abundance, as has never before been seen. There is little doubt, however, that this is only another of those mythical statements of which we hear so many, unless, perchance, it refers to the Orange River crocidolite, which is certainly unlike any that has ever before been seen, and doubtless is to be there obtained in great quantity.

Crocidolite (blue asbestos) has long been known to exist in the neighbourhood of the Great Orange River; both crocidolite and soapstone were among the mineralogical specimens brought home from the Kalahari Desert by Mr. Farini; and a special variety of asbestos, of a highly aluminous character, occurs in Natal.* This last is imported into England for use in the potteries as a refractory material for lining furnaces and kilns, and for the making of crucibles, for which it seems to be well adapted, alumina being both insoluble and infusible.† Asbestos is also found in abundance in the Somali fields, about a hundred miles beyond Kimberley; and yet another discovery was announced in September, 1889, of a "gigantic asbestos farm" (whatever such an expression may be taken to mean), on the property of the Griqualand West Copper and Mineral Syndicate. The find here was, with the usual exultation, announced to be "amianthus of the finest quality, beautifully white in colour, and many feet in length." The first samples sent over, however, by no means bore out this description, being comparatively

* In many parts of Africa, notably in Lagos Bay, alum occurs in fine crystallisations like asbestos with a silky lustre; in a cave near the Bosjesmans River it is said to cover the floor to a depth of six inches. Sapphire is pure alumina crystallised; but the sapphire of the ancients was *lapis lazuli*, as appears from Isidorus: "Sapphirus cærnleus est cum purpurâ, habens pulveres aureos sparsos," that is, particles of iron pyrites disseminated through it and looking like gold, something similar to the jasper found in Newfoundland.

† "The magnesian silicates are only fusible at very high temperatures, but the silicates of alumina are probably quite infusible."—Pickett's "Useful Metals and their Alloys," 624.

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short and brittle. The produce of deeper workings soon followed; some of these in my possession are very beautiful in appearance, in fineness of colour and length of fibre not to be surpassed by the best Italian, but, at the same time, they are so deficient in tensile strength as to be practically useless for any present purpose. Although for this particular kind there is no demand now, it must not be forgotten, that every year brings to light new mineral combinations, or new varieties of those with which we are already acquainted, and usually the practical application of them soon follows.

No one can yet know the value of the mineral resources of the western range, though both gold and silver are known to be generally abundant. Along the eastern mountain ridge runs the best seam of coal to be found in Africa, south of the Zambesi.

When the African discoveries were first announced, simultaneously with those in Russia, and those anticipated, with considerably less probability of realisation, from Servia, fears were expressed lest the markets would be glutted and prices so reduced, as to make it scarcely worth while to work the mines; but it must never be forgotten that

> "Le globe est un vaisseau frété pour l'avenir
> Et richement chargé . . . . ,"

and that as new scientific discoveries are made, so the great mineral reserves which year after year are brought to light, readily find their place, without much disturbance, in the great economical relations of the world.

The important question of transport from these regions, will be one of the first difficulties to present itself, but granted a practical acquaintance with the mineral, no great difficulty need be apprehended on this head.

Bearing in mind the great number of places, in the neighbourhood of the gold mines, especially on the north side of the Great Orange River, where both asbestos and crocidolite abound, it would not appear at all unlikely that, in the near future, a fine quality of asbestos will be discovered, and that Africa may

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again have something new to show, and become one of the main sources of supply. The elevation of Griqualand West, where the crocidolite and blue asbestos is found, is about 4,000 feet above the sea level, a not unimportant factor in the case.

In addition to the African localities already indicated as the whereabouts of the mineral, travellers seem to have been frequently on the verge of discovery. Anderson* found in the Kuruman range, at Blaaw Klip, a soft stone, which the natives dug out from the hillside and formed into pipes, plates, etc., no doubt a kind of ollite, or potstone, which would seem to indicate a probable locality for asbestos. And Dr. J. W. Matthews,† who spent a considerable time in that region, reports that the calcite, which runs through the blue ground in all directions, in the diamond district, was covered with a coating of a "greyish-white substance, very soapy to the touch, and resembling steatite."

The importance of the subject, in view of the probability of the South African asbestos mines coming prominently to the front at an early date, will perhaps justify the insertion here of an extract from Dr. Schenk's report on the formation at Barberton. The doctor, an eminent geologist, who has paid several visits to the goldfields, says that "the formation there consists of very old, and, in most instances, highly metamorphosed rocks, composed of slate and sandstone, with interposed eruptive rocks of greenstone (diorite, serpentine, etc.). These rocks are highly erected, dipping invariably at great angles, often perpendicular, and run from east to west. It is in this formation that the gold-bearing reefs are situated, and these, with few exceptions, run in the same direction, nearly always accompanying the eruptive rocks." The gold, in his opinion, came with the eruptive rocks from the interior of the earth to the surface, and there became concentrated in reefs, which consist of quartz, and often contain iron with the gold. There is no young formation overlying these rocks at Barberton, but,

* "Twenty-five years in a Wagon," vol. 1.
† "Ingwadi Yama," 148.

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in the Drakensburg and Witwatersrand, a younger formation lies unconformably over the older rocks, which he concludes to be of Devonian age. The younger formation has subsequently been folded in the same way as the Barberton rocks, though it is not so highly erected.*

On an examination of the adamantiferous rock, as well as of the ore free from diamonds (of Kimberley), Mr. Lewis states, that "both are dark, heavy, basic rocks, composed essentially of olivine, belonging to the group of peridotites. Both are similar in structure and construction, differing only in the presence or absence of inclusions. The rock consists mainly of olivine crystals lying porphyritically in a serpentine ground mass."

In a country where the hitherto usually recognised feature of the mineral seem to be so diversified in colour, texture, and component parts, we should not, perhaps, be surprised at any further distinctive feature; yet it seems somewhat strange to be told of an "asbestos farm;" and, again, to find it stated, on the authority of "an eminent engineer, late Surveyor of Lands to the German Government," that, on part of the ground where some of the new discoveries have been made, he traced four distinct "*asbestos reefs, three feet wide, and running parallel to each other at regular distances for many miles*,"† a description calculated to make an asbestos expert open his eyes in wonderment.

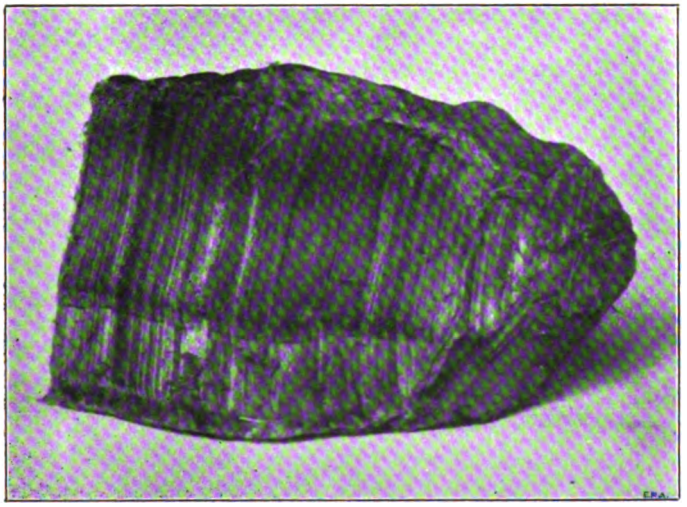
The Cape Asbestos Company, Limited.—Notwithstanding its undesirable analysis, a company bearing the above title has been formed to work the blue asbestos (crocidolite), with a capital of £55,000, in 55,000 shares of £1 each. It is said, in the prospectus, that inexhaustible quantities of this peculiar fibre are to be found on some extensive farms in Griqualand West, on the Orange River. The fibre, when first brought over to England, was by no means well received, but the undertaking met with success in the diamond district, the shares being there well taken up, three of the directors of the De Beers

* "Science," 8, 860.

† *The Diamond Fields Advertiser*, quoted in the *Weekly Bulletin*, September 7th, 1889.

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Company joined the board, and the other directors were all well-known men; while most of the shares were taken up by shipowners and others who could influence business. The company claims to have secured important contracts for boiler and steampipe coverings in the dockyards of the French and Italian Navies, and that already about forty of the one hundred steamers owned by the *Navigazione Generale Italiana* have been so protected.



The company was formed to acquire and work a property of 30,000 acres, having a frontage of sixteen miles on the Orange River. The species of asbestos is said by its friends to be the "now famous blue fibre," which is comparatively new to commerce, and although when first introduced to the London market, it met with much opposition from the existing companies, it has steadily won its way to a good position; and although Canada and Italy formerly had a monopoly of the trade, the rise of the Cape asbestos is said to have done much already to break down the monopoly. The company claims also that the

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blue fibre can be so well opened and carded as to "produce wool "of quite half the specific gravity of the finest wool obtainable "from other asbestos;" and that although the property is only partially prospected, it is estimated that there are some 4,000 tons in sight.

The particular speciality of the company is the manufacture of a kind of asbestos cushion, technically known as a mattress, to be used as a boiler covering, and is said by them to be much superior to the cement system, for the following reasons: "It can be applied and fitted to boilers before leaving the "makers' works, so that thus a perfect fit is ensured; it has a "great advantage in being fitted entirely around the boiler, thus "avoiding leakage; it will also prove a valuable protection "to the tank tops in double-bottomed vessels, which, owing to "the heat from the bottom of the boiler, invariably give trouble "by rusting away quickly; and it can be fitted to a cold surface, "thus avoiding the necessity of getting up steam, and avoiding "also the mess and dirt of ordinary cement." The asbestos is prepared for commerce at the company's works at Turin, where it has a large plant and machinery.

In the preparation of these mattresses, or jackets, they also claim that their pure well-carded asbestos fibre is packed dry in asbestos cloth, which is sewn round it and stitched through, at frequent intervals, to keep the material from shifting. "It thus forms "a mattress or jacket, made to any size or shape, to fit the boiler "or object to be covered, to which it is secured by bands of hoop "iron, or similar means, in such a way that it can be removed "and replaced with the greatest ease. The outside when painted "or tarred has a surface which will resist any amount of friction; "it can be walked upon without injury, and requires no protective "casing." They also weave a hollow rope which "filled with our "pure carded asbestos fibre," forms, they say, "the best heat "insulator and the simplest, lightest, cheapest and most durable "covering extant."

The company also make a specialty of a "Blue Cape Asbestos Bedding," which is said to be "fireproof, insect and germ proof, rot proof, and hygienic," and they have introduced many other

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useful articles made from it, but its cost delivered in London, £10 per ton, must militate considerably against its use.

A light blue asbestos of a fine silky character is to be found in Bosnia, Mexico, and South Australia, but whether in any quantity or what may be its analysis is as yet unknown. But to show how small a proportion of iron oxide is to be found in the Cape blue (crocidolite), the following analysis of it has been handed to me :—

Magnesia	38
Silica	42
Oxide of Iron	3

General Outlook.—As to the more immediate outlook, it must be remembered that although, for their own special productions, Italy and Canada are, for the present, the undoubted masters of the field, it is scarcely probable, in view of what is now taking place in many other parts of the world, that they will permanently remain so. As far as Italian produce is concerned, the company, which practically monopolises this, requires all the asbestos it can get from its mines for its own special use, and in order to supplement the produce of its Italian mines, has recently bought a mine in Canada, so that there also it will, in future, be a producer as well as a consumer. Indeed, the large consumers of the Canadian mineral, feeling the pinch of continually increasing prices, (in consequence of supply not keeping pace with demand), are gradually buying up all the present best-known mines, and turning miners themselves, the natural effect of which is that the produce of the mines so bought is practically withdrawn from the general market. It therefore becomes increasingly difficult for those consumers who are not also mine owners to obtain the supplies they want. A natural consequence of this state of things is further increased price, and greater exertions to find fresh sources of supply. It is only, therefore, to be expected that new discoveries will continue to be made, and it may turn out that Italy and Canada will presently find both Russia and Africa formidable competitors. Dealings with the former country may, from many causes, remain somewhat

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difficult for the present, but with Africa the case is somewhat different from that of Russia. Given the requisite quality, the question of transport can be easily overcome, and it is only fair to assume, from what we have seen, that the right quality will presently be found there, and when that is the case, if the mines are only intelligently handled, methods, which almost indicate themselves, will speedily be adopted to settle the transport question.

The statement with which this chapter commenced, that asbestos is very generally distributed all over the world, has, we submit, now been sufficiently demonstrated by the wide geographical distribution here shown.

But here comes in the important development which has burst into light, since the foregoing was written. The discoveries at Danville are so important, and so far-reaching in their effects, that I prefer not to speak of them, until the time arrives for me to describe the result of what I saw and actually experienced in a personal investigation.

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CHAPTER IV.

ITALIAN ASBESTOS AND THE ITALIAN MINES.

The Italian Mineral a Distinct Variety—Difference between Asbestos and Chrysotile—Analyses of four Magnesian Minerals—The United Asbestos Company—Italian Exhibits in London—Difference between Italian and Canadian Fibres—The Italian Valleys and the different Classes of Ore found in them—The Susa—The Aosta—The Valtellina—Level of the Mines—Association of Italian Ore with other Minerals—Operations of the Company—Long and Short Fibre—Millboard—Paper—Yarn—Cloth—Salting Mines—The Industry in France.

The asbestos found in Italy is asbestos properly so called. It is a fibrous form of tremolite,* or hornblende, mineralogically distinct and totally different, both in form and appearance, from the Canadian variety, the technical name for which, as already mentioned, is chrysotile. The most important distinguishing feature of asbestos is its anhydrous character. Chrysotile, on the other hand, is simply a fibrous form of serpentine, and consequently hydrous. Notwithstanding, that in form and general appearance, the two minerals are so strikingly different, in chemical composition they are very similar, and in many of the uses, to which they are put, are absolutely identical. Indeed, chrysotile, from many points of view, is so like asbestos, that the greater part of what is described, sold, and used, as asbestos, as well in the arts as in commerce, is really chrysotile, which in very many cases is undoubtedly preferred to it.

In considering asbestos itself, there are four magnesian

* "La tremolite, lorsq'elle s'altère et devient hydratée, manifeste une tendence marquée à se deviser en fibres flexibles, à l'eclat soyeux, capables de former par leur enchevêtrement de veritables tissus mineraux."—De Lapparent, "Cours de Min.," 376.

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minerals, which so closely resemble one another in a chemical sense, that a table is here given of their average constituents (as computed from Dana), so that the fact may be readily seen :—

	Actinolite.	Asbestos.	Chrysotile	Talc.
Silica . . .	57·13	57·82	43·56	61·95
Alumina . . .	1·15	·43	·52	·98
Ferrous Oxide . .	6·39	5·23	1·60	1·91
Manganese Oxide .	·65	·66	—	—
Magnesia . .	20·66	21·86	41·36	30·87
Lime . . .	13·28	13·98	—	—
Water . . .	1·57	·77	13·79	4·08
	100·83	100·75	100·83	99·79

In order to be sure of the correctness of these figures, it may be stated, that the composition here given of actinolite is the average of eleven analyses, asbestos of six, chrysotile of five, and talc of forty. Their constituents, therefore, may fairly be taken as standard. Actinolite and asbestos, it will be seen, contain two minerals which are wanting in chrysotile and talc, namely, lime and manganese oxide, the former of which is nearly fourteen per cent. of the whole, and the latter only a little over half of one per cent. Between actinolite and asbestos, the average combinations are so nearly similar that less diversity occurs between them, than between individual specimens of each other. It is only in the protoxides of iron and manganese that the differences are more than one per cent.; actinolite having 1·16 more of the ferrous oxide than asbestos, and asbestos 1·20 more of the manganese oxide than actinolite. In point of fact, these two are nothing more than different forms of amphibole or hornblende, or that variety of it which contains little or no alumina. When the crystals appear in radiating masses, or long slender prisms, the mineral is called actinolite, but when in long, fine, flexible fibres, easily separable by the fingers, it is termed asbestos.* Another important point is, the great difference to be remarked between the two forms of asbestos in the amount of magnesia respectively

* Third Report Bureau of Mines, Ontario, 1893.

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contained in them, chrysotile having double the amount of that important constituent to what asbestos contains.

It is now a good many years ago, since asbestos first began to be talked about in England, and attempts were very soon afterwards made to turn its peculiar properties to useful account. The time was getting ripe for such a business. Steam pressures had, for some time, been gradually rising. Although 30 lbs. to the square inch at sea, and 50 lbs. on land had hitherto been the average, these pressures were then beginning to be doubled, and consequently the old forms of packing for joints and glands were, under these new conditions, found to be incapable of withstanding the strain put upon them. Gasket rings and hemp gland packings had both to be superseded by more durable appliances, yet these were so far from being perfect, that it was felt to be certain that trouble would occur with them when exposed to the higher temperatures which were evidently coming. Just about the same time, asbestos millboard was being successfully made in Florence, and a good piston packing was made in America; soon after which a "Patent Asbestos Manufacturing Company" was established in Glasgow, for making piston packings after this American invention, as well as millboard after the Italian method. The peculiarity of the packing, introduced by this Scotch company, consisted in its being formed of a core of asbestos fibre, consolidated by machinery, and braided over with cotton to keep it together; and although this first attempt was rather crude, some wonderfully good results were said to have been obtained from it.

In 1879, about a year after the opening of the first chrysotile mine in Canada, three firms which had made asbestos mining in Italy and the manufacture of asbestos goods a speciality, became amalgamated, as "The United Asbestos Company, Limited," of London; and this new company, having secured about 180 mining properties, in the region of the Italian Alps, covering eighty square miles, being nearly all the Italian mines then known, thereby at once, for the time being, obtained a practical monopoly of the trade.

The United Company was registered on 1st November, 1880,

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its capital being stated as £9,970 in fully paid ten per cent. non-cumulative preference shares of £10 each; £30,000, in 6 per cent. cumulative preference shares; £49,875, in fully paid ordinary (A) shares of £5 each, and £50,000, in fully paid deferred (B) shares of £5 each. The "B" shares being issued as fully paid up to the subscribers of the "A" shares; but at the end of 1883 it was decided to write off £5 per share from the ordinary and deferred capital (the preference shares not having been issued).

It would serve no useful purpose now, to revive the vexed question of the relative trade merits of the Italian and Canadian varieties. Experience has shown that both of them possess undeniably good qualities, as also that there is an ample field for both. Indeed, it is now clear, that the very qualities which may render one of them less suitable for some special purpose are precisely those which best adapt it for another. Moreover, it is tolerably certain, that for some particular forms of marine packing, for instance, a mixture of the two fibres is superior to the best quality of either one of them used separately.

Some fine specimens of Italian asbestos are occasionally to be seen in London, at the various exhibitions, and perhaps the finest ever yet shown is a sample of grey ore, brought from one of this company's mines in the Valtellina Valley.* This natural curiosity can be seen in the window of the company's branch establishment, in the Charing Cross Road, London.

Some of the specimens shown occasionally are very curious. For instance, at the recent Italian Exhibition in London, one of the exhibits was of a very unusual character, described in the catalogue as a "*Collezione d'amianti italiani in 70 vasetti*," sent from Rome by the "*Impresa mineraria italiana*" of that city, which company had an office at that time in Leadenhall Street, London. Many of this large number of specimens were curious, both in structure and colour, but it must not be supposed that they were so many distinct varieties; indeed, except as curiosities, their exhibition could scarcely be said to answer

* A fine quality of alabaster (gypsum) is also found in this valley, so delicate as almost to resemble white wax.

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ITALIAN ASBESTOS. "THE GREY."

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any really useful purpose, as there were no analyses given, nor any facilities for their examination by experts.

On regarding the mineral with a view to determining its economic value, too much importance cannot be given to its analysis. It is evident, however, that, when dealing with asbestos, accurate agreement between any two operations must not be looked for, unless the samples analysed are not only from the same mine, but even from the same part of the same mine; because, although the constituents may be practically the same, the proportions may be different, arising from a difference in the associations and surroundings of the mineral analysed.

To be of any commercial value, asbestos needs length and fineness of fibre combined with infusibility, toughness and flexibility; some of these qualities being often wanting in a specimen of very promising appearance. The qualities of length and silkiness can, of course, be determined by the eye, but some of those from South Africa, for instance, are wanting in such essentialities as infusibility, tenacity, or elasticity, which can only be determined by an accurate knowledge of the proportions of the constituent parts.

Disregarding all such analyses as carry on their face a suspicion of having been prepared for a specific purpose, I submit the following perfectly independent analyses, of Italian and three Canadian fibres, made by J. T. Donald, Esq., Professor of Chemistry, Bishop's College, Montreal, who kindly furnished me with copies of them, when in that city. The Professor is well known, and his analyses can unquestionably be taken as correct.

	Italian Fibre.			
		Canadian Fibre.		
		Thetford		
Silica	40·30	39·05		
Magnesia	43·37	40·07		
Ferrous Oxide	·87	2·41		
Alumina	2·27	3·67		
Water	13·72	14·48		
	100·53	99·68	99·63	

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ITALIAN ASBESTOS.

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	Italian Fibre.	Canadian Fibre.		
		Cambrian Chrysotile.		Laurentian.
		Thetford.	Broughton.	Templeton.
Silica . . .	40·30	39·05	40·87	40·52
Magnesia . .	43·37	40·07	41·50	42·05
Ferrous Oxide .	·87	2·41	2·81	1·97
Alumina . .	2·27	3·67	·90	2·10
Water . . .	13·72	14·48	13·55	13·47
	100·53	99·68	99·63	100·10

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These analyses clearly show that, notwithstanding the remarkable difference in the form and appearance of Italian asbestos and Canadian chrysotile, there is almost a complete identity in their chemical composition.

Prior to 1880, nearly all the fine fibre, of that quality most suitable for spinning, was obtained from Italy and Corsica, and consequently Italian asbestos was supreme in the market. And this, owing to its exceptionally fine quality, and the difficulty with which it was mined, naturally commanded a high price in the market. But the subsequent discovery of the chrysotile deposits in Canada, which lay close to the line of railway, and within convenient distance from a shipping port, made a great difference in its commercial estimation. A good deal of the produce of the Italian mines is nearly identical with that found in several parts of Norway, and some parts also of the United States, which is only adapted to those special purposes for which pulverised asbestos is suitable. And, moreover, Italian asbestos is mined and worked with much more difficulty than Canadian chrysotile. In the first place, because hand labour is compulsory, on account of the nature of the ground in which it is obtained, and secondly, the supply also is far more uncertain. Then the fibre is much more difficult to deal with, requiring the use of special machinery, nothing like which is requisite for chrysotile. For these particular reasons, amongst others, a higher price is necessarily demanded for it. As much as $250 or $300 per ton could at one time be obtained for it, and although no such price can now be had, it is still much more expensive than Canadian No. 1. Moreover, we are informed that the best grades are becoming extremely rare, and consequently the supply is in some measure falling off.

Many parts of the mountains and valleys in which the mineral here occurs are as beautiful as any to be found in the Alpine region. Indeed, there are not many places which will so amply repay the naturalist for the time spent in their exploration, which would further be much enhanced by the healthy enjoyment of the most exhilarating atmosphere.

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Three of the main valleys in which the company's mines are located are the Susa, the Aosta, and the Valtellina. The Susa Valley is approached from France, through the famous Mont Cenis tunnel. On emerging from which, on the Italian side, the line follows the southern mountain slope, with a gradual descent, overlooking the town of Susa, at the head of the plain, which at times widening, and at others narrowing, for a distance of about forty miles, finally opens out on the great plain of Piedmont. At a point in the centre of this valley, and on the northern mountain slope, are the places from which the floss fibre, the appearance of which in gas stoves is familiar to us all, is obtained. It occurs on the northern slope of the Susa, where it is found dry, with a smooth, silky fibre. It is somewhat like some of the Corsican fibres, but has not so much strength. It usually occurs in thick horizontal seams, which have a rapid dip when once the rock is opened. The "silky" is not much unlike the flossy, but has a smoother texture, is longer in the fibre and of greater tenacity.

In the same locality also is found the "powdery," and in the centre of the powdery mass are often found lumps of quartz and other substances, which are apparently of vegetable origin. This powdery variety is chiefly used in the manufacture of asbestos paint, and some other special purposes of a cognate kind.

Although the powdery is found in the same range of mountains as the flossy, it is generally obtained at a much lower level. Like a good deal of the mineral found in various parts of the world, it exhibits a pasty appearance when first opened up, but rapidly dries and pulverises on exposure to the atmosphere. *La Société Française des Amiantes* claims that this powdery material is of great value, to agriculturists, as a manure, and, to viticulturists, for application to the vine stocks, as a powder for a preventive of mildew, and a destroyer of the phylloxera. It has been tried in England, with a similar object in view, in the hop gardens of Kent, but with no marked success; indeed, it is somewhat difficult to understand what there is in its composition to give it any efficacy for either of the purposes named.

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The ground from which these materials are got in the Susa Valley 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 done on foot, from four to five hours being required for the journey from the plain, where the railway and the high road are situate. 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 sort 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 a load of 8 cwt. of asbestos in three hours.

Continuing along the valley, there is hardly a spot that is not replete with historic interest. A ruined castle marks the epoch at which the peasantry revolted against the exercise of the infamous "seignorial right," and having stormed the walls, led by a brave and youthful bridegroom, overthrew the brutal tyrant, who from this stronghold domineered over his enslaved vassals. A narrow gorge, through which there appears to be hardly space enough for the railway line, is the scene of many a hard fight between invaders, of one nationality or another, and the Piedmontese, or between rival nobles; and a stupendous building perched on a lofty eminence is the ancient burial-place of the war-like and illustrious Dukes of Savoy and Princes of Piedmont. Nor are places of modern interest wanting, for, on emerging from the valley into the broad and fertile plain, one of the most important dynamite factories in Europe is passed, after which pastures and vineyards alternate, until nearly straight ahead the white dome of the Superga, the burial-place of the Kings of Sardinia, marks the close vicinity of the city of Turin.

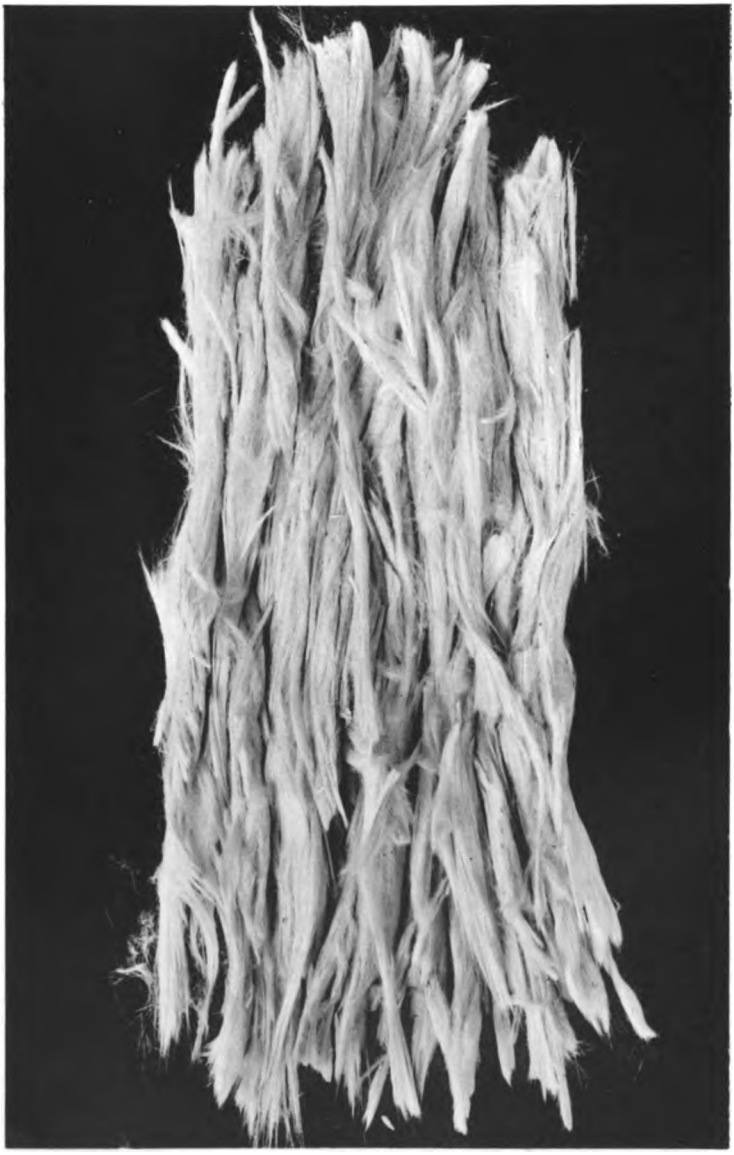
The second of the districts referred to is the Aosta Valley, commencing at Ivrea, a town of some importance, about forty miles, in a nearly northern direction, from Turin. From Ivrea to Chatillon, a distance of a little under thirty miles, the

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ITALIAN ASBESTOS. "THE SILKY"

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railway passes through the heart of the asbestos properties, which flank it on either side, the direction being north-westerly; and as the latter town is reached, the valley trends sharply to the westward, when the city of Aosta, (the ancient Augusta,) is brought into view.

The history of the asbestos mining industry in this province may be recorded as follows:—In the year 1848, Signor Antonio Rè of Rome, finding himself implicated in political troubles, took refuge in this valley, where he lived for many years. In 1875, he became aware of the proceedings of the Marquis di Rovasenda and the Priest Corona, and set to work to investigate the question of asbestos in the Aosta Valley. He, like others, was aware of the existence of the mineral in the valley, but until then, the asbestos found in this district had been thought to be of inferior quality, and not serviceable for any industrial purpose, so that no trouble had been taken about it. In the year named, however, Signor Rè undertook a search for asbestos of better qualities, and having assured himself that such could be found in abundance, at once put himself in communication with the gentlemen mentioned, and they being satisfied with the samples produced, started working it on a large scale.

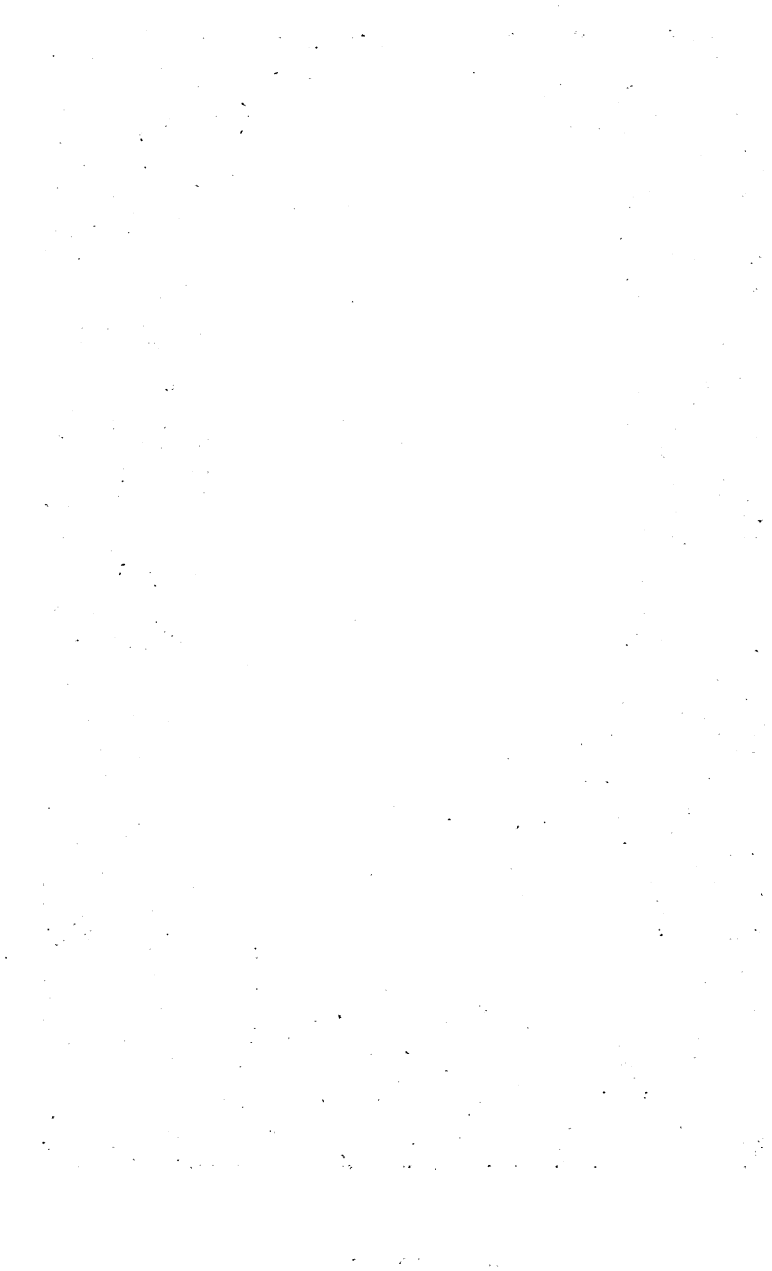
It is impossible to give, with any degree of exactitude, the extent of ground which covers the asbestos mines in the valley, it not yet having been all thoroughly explored; but as the valley is about seventy-five miles in length, and varies in width from five to forty miles, some idea may be formed of its ground dimensions. And notwithstanding the large quantity of asbestos that has hitherto been mined there, enormous deposits still remain untouched, so that the yield may be considered practically inexhaustible.

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

This district is situated in that portion of Lombardy known as the Valtellina, in the "Grand' Appenino," and is under the

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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, passing by the historical battlefields of Novara and Magenta; the cathedral of St. Ambrose; the Victor Emmanuel Gallery, a noble arcade owing its execution to British enterprise; the Arch of the Simplon, erected by Napoleon I., in memory of his crossing the Alps, like Hannibal, at the head of an army; and the notable fresco of the Last Supper by Leonardo da Vinci. Leaving the magnificent Milan Railway Station, 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. The clear waters of which reflect the surrounding mountains with remarkable distinctness, and as the steamers cross the narrow body of water from side to side, there is an ever-changing variety of view. The Lake of Como is in shape like an inverted Y, the town from which it is named being at the western point, Lecco at the eastern, and Colico near to the northern extremity. Como and Lecco are connected with the general network of railways of the country, but the lines from Colico to Chiavenna on the north, and Sondrio on the east, are still isolated. A line is, however, in course of construction from Colico to Lecco, which will presently bring the Valtellina into direct communication with the rest of the country, and greatly facilitate the transport of asbestos from the mines, obviating at the same time the necessity of putting it on barges to be transported from one end of the lake to the other. After arrival at Colico, a journey of about two hours and a half brings us to Sondrio, the chief town of the district. The line then follows the course of the river Adda, an affluent of which, the Mallero, joins the former river at Sondrio, giving the name of Val Malenco to the valley in which it has its course, and in this valley, as well as others branching out from it to the east, are situate the asbestos mines. It 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

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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 material in one piece which for quality was considered to be the finest in the world, and which weighs 45 pounds ; but even this is surpassed by a block from the same company's mines, which at the present moment is on its way to England. This weighs nearly $3\frac{1}{2}$ cwt.

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, in the bottom of the valley, is very great.

The surface of the ground, for about one-third of its extent, is 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 there 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, for such an elevation, is 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 are glad to get employment at the asbestos mines, in spite of its not being unattended by danger from landslips and avalanches.

For a long time the opinion was held that at a certain depth, greater or less according to circumstances, the veins of asbestos entirely lost themselves in the serpentine rock, but recent experience has proved that if the direction of the vein be followed it will again be met with. The work is carried on by means of shafts and galleries, dynamite being used for blasting. The fibre also, at the greater depths, is found to be of better quality, being less indurated than that nearer the surface.

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The high table land of *Acqua Nera*, 6,000 feet above the level of the sea, has its whole western face composed of rocks rich in asbestos, the seams of which run in a nearly vertical direction.

In searching for asbestos on the Italian hills, the prospector is not guided by the same rules as those which lead him in his search for chrysotile in Canada. He looks for cracks in the perpendicular face of the rock, which are sometimes filled with a white powdery substance, but which, when the surface is broken away, soon assumes a leathery appearance, and then, when further entry is made, the true asbestos is generally found.

The Italian ores are mostly mined by running driftways into the face of the rock, when the seams, on being followed up, often end abruptly in pockets, which sometimes contain as much as a ton or a ton and a half of asbestos. When first taken out from the rock the ore is in lumps, forming hard, closely-compacted bundles of fibres, varying in colour from light grey to a dingy brown. With a little care, threads of many feet in length may be drawn out from these bundles, the fibre closely resembling flax, but in appearance only, the difference being quickly perceptible to the touch.

Asbestos, as already explained, wherever it occurs, whether in Italy, or in any other part of the world, is found associated with many other minerals, more especially with chrome iron and magnetite; but occasionally, in the Italian deposits, minute crystals of a green-coloured garnet are found with the asbestos, which the miners call the asbestos seeds (*semenze dell' amianto*).

The operations carried on by this company, the machinery and plant for which is of the most complete description, may be concisely stated as follows:—The crude asbestos, when extracted from the mines, in rock-like blocks of fibre, is packed up in bags containing from one to two hundredweight each, which bags are brought over to England, and discharged into lighters in the Thames, whence they are conveyed, by way of the Grand Junction Canal, to the company's works, at Harefield, in Hertfordshire. Here the bags, on being opened, are found to contain the asbestos in rough lumps, from the size of a man's head to about

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as much as one man can lift. And here all classes of asbestos goods are manufactured, in the several forms in which they are now offered to engineers and others.

The company's works are divided into several departments. First there is the sorting and opening department, where the crude asbestos is dealt with. The blocks of fibre or "rock," are crushed and opened up by special machines, in such a way as to loosen, without destroying, the fibre, but rather to free it from the material which compactly binds it together, and which, it will be observed, has no counterpart in the method of dealing with Canadian ore. The masses of fibre are passed thence to "shaking" machines, where the long fibre is separated from the short, and all particles of rock removed.

The long fibre, suitable for spinning into thread, is then taken into the carding and condensing department, and the short, to the millboard and boiler covering departments. The tanks here are each provided with a rotating beater, which maintains a thorough circulation, by first taking up the fibre, then opening and drawing it out, and afterwards sending it on to be soaked, until it comes round again to the beater. 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 the weaving of wool or cotton alone. These latter staples, examined under the microscope, exhibit a notched, serrated, or imbricated, appearance, which explains the readiness with which these materials cling together when twisted. The peculiar nature of asbestos presents other difficulties which are rendered more evident when its behaviour in the machines is watched, but these difficulties are overcome by special appliances attached to the condensing machines. As the fibre comes from the condensers in the form of sliver, or condensed thread, without any twist, it lightly folds itself in cans placed there to receive it, and is then taken to the spinning and doubling department, where it is twisted into threads of every degree of fineness required. The thread then passes to the weaving and braiding

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department, where it is made into various forms of yarn packings, tapes, and cloth. The cloth is then taken to the india-rubber department, where it is proofed, and made into what is known as asbestos and india-rubber woven sheeting, tape and rings for steam and other joints, as well as into rolled cloth and square block packings for glands.

The short fibre, reduced to fluff, is taken to edge-runners and ground and prepared for the beating engines, where the binding material is added, and the whole thoroughly incorporated, after which it is drawn off into a receiving-tank, and placed in the millboard machine-room. From this tank it is conveyed to the millboard machine, to which agitators are attached, to keep the fibre from settling. The water is drawn off, through a fine wire gauze, on a revolving cylinder, on which it leaves a thin coating of the asbestos pulp. This is then taken off by an endless band, and transferred to a second solid rotating cylinder, where it steadily accumulates until the desired thickness has been reached. It is finally cut across, and removed in the form of a square sheet of millboard or paper.

This is much the same method as that adopted in France. Describing the mode of preparing millboard and paper there, Jagnaux says:—"Quant aux fils les plus courts, et ceux qui rest en pelotes on en fait de la bourre. C'est cette bourre qui, agglomérée au moyen d'un colle végétale, sert à la fabrication du papier et du carton d'amiante."

When the sheets leave the machine, they contain a good deal of water, which is got rid of, partly by pressure and in part by drying. They are then put between zinc plates and subjected to a powerful hydraulic press, which expels most of the remaining water, after which they are hung up, by spring clips, in a steam-heated room, to complete the drying, when the sheets are once more subjected to pressure, to flatten them out and improve the surface, after which the edges are trimmed and the manufacture is complete. When trimmed, the sheets usually measure 40 in. × 40 in., their thickness varying by thirty-seconds from $\frac{1}{32}$ in. to $\frac{1}{4}$. The board is then cut up into shapes

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ITALIAN ASBESTOS "THE FLOSSY."

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and sizes suitable for the special purpose for which it is intended to be used. This is mostly for making joints not exposed to the action of moisture, such as dry steam, air, or gas.

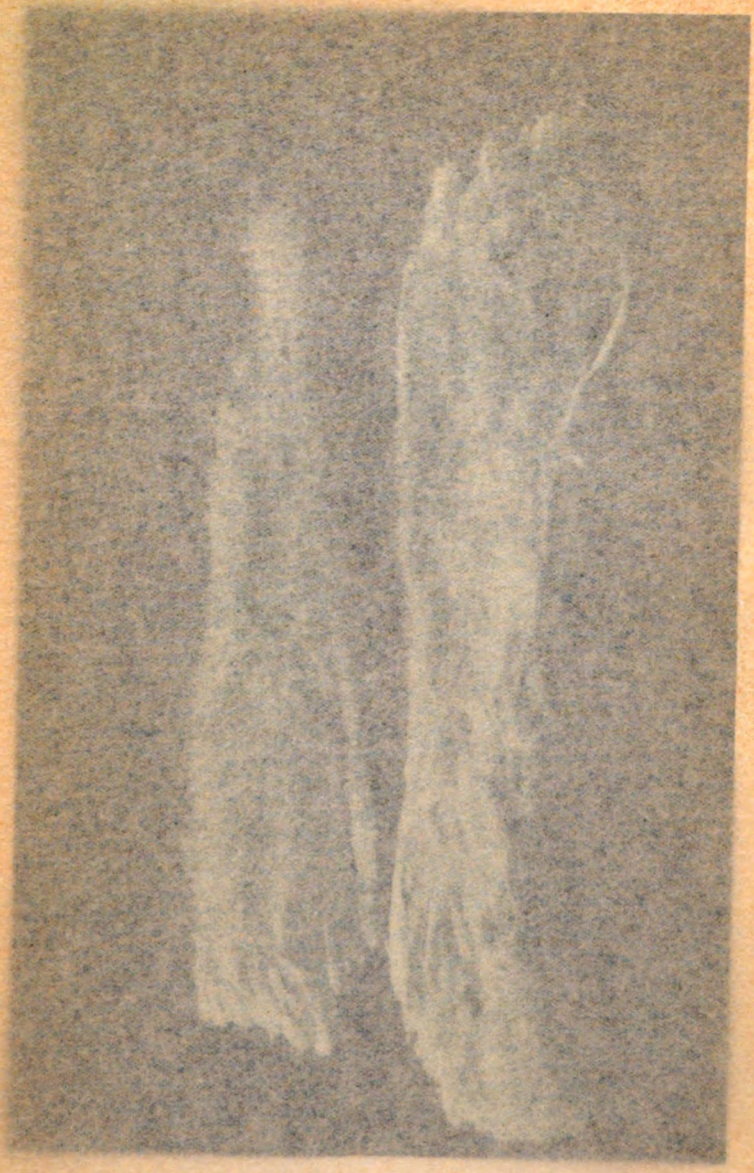
The step from millboard $\frac{1}{16}$ in. thick to paper is so small, that many attempts have been made to produce an asbestos writing paper, which, from its indestructibility would be invaluable in case of fire, for the preservation of charters, policies, agreements, and other important documents. Such a paper is made, but generally it is too uneven in texture, and too much akin to blotting paper, to permit of its use as a writing medium.

The other great division of the manufacture consists of such articles as require the production of yarns. To the initial difficulty of this manufacture we have already alluded. When yarn is wanted, the raw material is discharged from the boiling tanks into hydro-extractors, where most of the water is thrown out, and the drying process afterwards completed by steam heat. The fibre after having been passed through the shaking machine, as already mentioned, which separates the long fibre from the short, is sent, the latter to the millboard department, and the former to the carding-room, where it has to pass through several processes before the manufacture can be considered to be complete.

Asbestos cloth is woven in a loom exactly like calico except that the reeds and healds are much coarser. The narrow cloth or tape is woven in a smallware loom. Both the sheeting and the tape are used for making joints, and the former is sometimes rubber-proofed to render it water-tight. The asbestos and india-rubber woven tape is so constructed, that it can be bent round a corner without puckering, and thus is particularly useful in making joints in manhole and mudhole doors. If the cloth or tape be rubbed with plumbago, or powdered mica, before it is used, the joint may be broken and remade many times with the same packing. The cloth is also twisted up into square gland packing, by being cut into strips and twisted into a square rope, with a backing of pure rubber to give additional elasticity. The edges of the strips lie in contact

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ITALIAN ASBESTOS "THE FLOSS."

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and sizes suitable for the special purpose for which it is intended to be used. This is mostly for making joints not exposed to the action of moisture, such as dry steam, air, or gas.

The step from millboard $\frac{1}{64}$ in. thick to paper is so small, that many attempts have been made to produce an asbestos writing paper, which, from its indestructibility would be invaluable in case of fire, for the preservation of charters, policies, agreements, and other important documents. Such a paper is made, but generally it is too uneven in texture, and too much akin to blotting paper, to permit of its use as a writing medium.

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with the rod, and as the gland is screwed home, the compression of the rubber feeds the asbestos forward, so that a large proportion of the whole bulk can be actually worn away by the continual friction, before new packing is required.

It would carry this part of the subject to far too great a length, if even a summary account were given of the whole of the United Company's special machinery and manufactures; but it is evident that no one who has had an opportunity of considering the rapid advances made in the numerous and varied applications of this valuable material, will hesitate to admit that the persevering energy and practical skill exhibited by this company, have paved the way for other manufacturers, and consequently it has some claims to be considered the pioneer of many of the improvements which have been made in the machinery now in use for the manufacture of asbestos goods.

Mine owners in Italy, desirous of effecting a speedy sale of their property are, it is to be presumed, neither better nor worse than others in the same position elsewhere, in being apparently not averse to the wily practice of "salting." In Italy, this salting process seems to consist in driving fine asbestos fibre into the crevices of the rock, which have been previously primed for the purpose, and then, so far as possible, giving it the appearance of the real formation. Mr. Boyd tells us, that in one instance of the kind, which came under his notice, a sum of about £200 was actually paid for the right of extracting asbestos from the barren rock which had been so treated.

Many worse things than this have been done in Canada, which, unhappily for the colony, have brought its mining operations into grievous disrepute with the English investor. One well-known mine, at Black Lake, was actually sold for a large price, by substitution of its worthless rock for that from a first-class asbestos property at Thetford; and another, although it was known to furnish no fibre at all. But, although the scoundrels who perpetrated these tricks are well known, their conduct does not seem to meet with reprobation at home, being regarded rather, apparently, as "smartness" in the Yankee sense of the term.

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Before passing on to the consideration of Canadian asbestos, possibly a few words may not be out of place here, on the subject of the industry, as it is carried on in France, seeing that it is mostly Italian ore that is there used.

Attempts have, more than once, been made to establish the industry at Mantes, Paris, and elsewhere, but, until recently, with no considerable amount of success. In the autumn of 1889, however, a more ambitious enterprise was set on foot by the establishment of the *Société Française des Amiantes* at Tarascon-sur-Rhone as a *Société Anonyme*. The business having been commenced on a scientific basis, was so far successful, that in order to obtain further capital, the undertaking was launched as an English limited liability company, in January, 1890, under the title of the "New Asbestos Company, Limited," capital £120,000. The asbestos deposits in the hands of this company were stated to be sixty-two in Italy, covering an area of 700 acres, and eight in France, extending over about eight acres. The company had an establishment at Tarascon, for the manufacture of the general run of asbestos goods, and another at Gadagne on the Saône for the making of millboard and paper.

The Italian mines held by this company were situate in the Valleys of the Saône and d'Aosta ; in which district the deposits are essentially pockety, some of the pockets occurring on the level. Most of the works, however, are on the slopes of the mountain, extending up to 700 or 800 feet of altitude. Here a rather primitive method of work was carried on, a sort of isolated task work, each workman, at the close of his day's labour, being obliged to convey from the mines, to the store, the quantity of mineral he himself had obtained during the day. The ore, when brought in by the men, was bagged up, and at once transported to the works at Tarascon, where the bags were emptied, and the contents dealt with, in much the same fashion as that already described, with the object of loosening the fibres and separating them from the very large quantity of powdery admixture which was found in this company's mines, in common with all those of the Italian Alps. After this initial process the

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crude asbestos was separated into three divisions, each destined for its special purpose :—

1. The long fibred quality was set aside for spinning and weaving.

2. The shorter fibred material, sent to Gadagne for the manufacture of millboard and paper ; and

3. The powdery substance, part of which was reserved for conversion into cement, paint, etc., and the remainder sold to agriculturists for manure, and to viticulturists for use in the manner previously described, as a protection against noxious insects infecting the vines. In regard to which, M. Ville, a Parisian professor of chemistry, stated that he had discovered a new chemical manure, intense and almost miraculous in its effects. This is a mixture of phosphate of lime, carbonate of potash, and sulphate of lime, which if placed round vine growths would, it was stated, enable them to defy the onslaughts of the phylloxera. This company met with great opposition, by a few of the existing London manufacturers, and is probably now defunct. This is rather an unpleasant characteristic of the trade, which if done with a *bonâ fide* intent to enlighten the public, would be praiseworthy, but is more generally an unscrupulous trade manœuvre, for the maintenance of a comparative monopoly, and inflicting pecuniary injury on a new comer, which, although sometimes more or less successful, in some recent cases has violently recoiled on the parties' own heads, not only by drawing special attention to their peculiar trade artifices, but by exposing their unworthy motives of action. When the prospectus of this company was first issued, the writer called at the company's office, where he saw the engineer, who informed him that the company had obtained an order from the French Government department (*les Pompes Funèbres*) for the supply of an astonishing number of "Asbestos Coffins," a most remarkable purpose for the application of asbestos ; but as nothing more has ever since been heard of these coffins or their use, it is to be assumed that the Government department afterwards thought better of it, even if ever it was contemplated at all.

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CHAPTER V.

CANADIAN ASBESTOS (*Chrysotile, Schillerader asbest*).

First Appearances Unprepossessing—Chrysotile—Amianthus—Serpentine—Fibrous and Foliated Varieties—Rocks from which derived—Peridotites—Olivine—Associated Rocks—Talc, Steatite, etc.—Decomposed Serpentine—The Eastern Townships of Quebec—The Great Mineral Belt—Trade of the Province—Gaspé—Granulite—Width of the Asbestos Veins—Picrolite—Ornamental Serpentines.

Deriv. : χρῦσος, gold ; τίλος, fine hair.

Just about the time of the establishment of the United Asbestos Company, referred to in the preceding chapter, Canadian asbestos was beginning to attract attention, and it is by no means difficult to understand how it came about that a company, which had not only practically originated the manufacturing business in England, but, by securing a very large proportion of all the then known Italian mines, had, as they supposed, become possessed of a temporary monopoly of the trade, should, at the outset, have viewed the claims of a younger rival with jealousy, not unmingled, perhaps, with some degree of contempt. Nor was this last so entirely unjustified as would now seem reasonable, first appearances being decidedly against the new comer. The Canadian ore was not only of an entirely different character, and such as required altogether different treatment, but the staple was, or might easily be imagined to be, ludicrously short in comparison with that of the Italian fibre; much of it, as at first sent to England, was coarse, and the rough and careless manner, in which most of it was then prepared for market, might readily induce any one to

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believe it to be a decidedly inferior article. All that, however, is now matter of history, and Canadian chrysotile has, since then, taken for itself high rank among the economic minerals of the world. Its most strenuous opponents have not only adopted its use, but, urged by the necessities of trade, have secured a mine of their own in Canada, so that they have become producers, as well as consumers, of the formerly despised Canadian ore.

Chrysotile, to give the mineral produced in Canada its technical designation, is, as already stated, simply a fibrous form of serpentine,* one only of several minerals which, under certain conditions, have a tendency to assume that peculiar structural form.

According to local, mineral, metallic, or climatic associations, chrysotile varies in colour from a greenish-white, olive, or bottle-green, to a yellow, brownish, or amber shade. For the reasons already given, its analyses will not always agree, though the differences are usually by no means great; indeed, for most practical purposes, its composition may be taken as represented on page 87, *ante*. Optically, it is bi-axial under polarised light.

In somewhat early days, *Le Génie Civil* spoke of it in the following terms, which technically is as good a description of the mineral as can be given :—"*La chrysotile du Canada n'est pas comme l'amiante ordinaire formée d'un paquet de fils d'un blanc verdâtre et remplissant des cavités irrégulières : c'est une véritable pierre, d'une densité comprise entre 2 et 3, qui se trouve en couches de 3 à 10 centimètres d'épaisseur. Cette pierre possède la propriété de se reduire en fibres, perpendiculairement à sa longueur, sous un effort très faible. Ses fibres transversales sont plus résistantes et beaucoup plus facile à filer, à tisser, et à feutrer que l'amiante ordinaire.*"

Before the discovery of the economic use of chrysotile, all the finer qualities of asbestos (properly so called) were, on

* "Fibrous serpentine with a silky lustre is called chrysotile."—Dana, "Min. et Lith.," 1878. "On appelle chrysotil une serpentine en fibres soyeuses, d'un vert tirant sur la jaune d'or, qui se distingue de l'asbeste par sa solubilité dans les acides et sa teneur en eau."—De Lapparent, 408.

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account of their beautifully white, flexible and delicately-compacted fibres, distinguished by the Roman name of *Amianthus*, its peculiar satin-like lustre being caused by the greater separation of the fibres. This variety is usually found in the older crystalline rocks* in the Pyrenees, the Alps of Dauphiny, on Mount St. Gothard, and in some few places in North America, in the serpentines of Sweden, the Ural Mountains, Silesia, and New South Wales.

Now, however, this name is indiscriminately applied to all the finer qualities, both of asbestos and chrysotile alike, and that, not by commercial men only, but by scientists also.

Dana says, "Amianthus includes the fine silky varieties; much so called is serpentine, which is hydrous, and therefore easily distinguished."

And as Jagnaux puts it, "*L'amiante, que l'on emploie dans l'industrie, provient généralement du Canada ; il est fibreux, blanc et très réfractaire.*"

According to Sterry Hunt, "Chrysotile constitutes the common amianthus, and has hitherto been regarded as a variety of serpentine, with which it agrees in centesimal composition. It is, however, distinguished from it by a lower specific gravity, and by its fibrous character, which, like that of amianthoide amphibole, indicates a prismatic crystallisation."†

In regard to its hydrous nature, Professor Donald found the average quantity of water in five samples of Canadian serpentine, chosen at random from places in the chief asbestos districts, to be 13·49 per cent., whilst in four samples of chrysotile it was 14·25.

Chrysotile which, in some important particulars, is so different from asbestos, is in other respects singularly like it. In its analyses, it has 14·26 per cent. less silica, and 3·63 less ferrous oxide, while it has 19·4 per cent. more magnesia and an

* The author of "Les Schistes Crystallines" maintains that the designation of "crystalline rocks" is defective, inasmuch as we find associated with masses having a right to this title, and geologically confounded with them, other rocks, such as serpentine, obsidian, perlite, etc., which are not crystalline in character, but colloidal or porodic.

† "Mineral Physiology and Physiography," 1886.

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average of 13 per cent. more water. The whole group of serpentine rocks contains a large percentage of water, which is the especial reason why chrysotile is less capable of resisting the action of fire than asbestos; because, when the water of crystallisation is driven off by heat, the fibre becomes harder and more brittle, as is seen by the inferior quality of the ore produced from the Black Lake district, and which can be readily tested in the laboratory. At one of the Black Lake Mines, I have frequently seen in wet weather, barrow loads of ore brought into the cobbing shed and piled up all round the stove to dry, before being sent to the bin; and even such an amount of heat as that, when long continued, was found to have a prejudicial effect on the fibre. The ore, in this case, was of third-class quality only, the mine producing nothing better, the difference, therefore, was possibly very material.

As implied by its name, serpentine (*lapis colubrinus*) is so tinted by association with other minerals, with chrome iron in particular, as to exhibit a diversity of shades of green and other colours, which give it a mottled or spotted appearance, bearing a somewhat fanciful resemblance to the markings on a serpent's skin. For this reason Agricola named it *serpentaria*.* It is also sometimes called *ophiolite*,† and the commoner sorts *ophite*, both names being alike derived from ὄφις, a snake. The Italians look upon it as more froglike, and therefore call it *rannócchia*. Mineralogically, it is a hydrated silicate of magnesia, belonging to the talc group of rocks, but with more water and less silica than talc. It is somewhat soft and sectile, has a dull, splintery fracture, and a soapy unctuous feel. It occurs generally in compact granular, slaty masses, and when found disseminated through granular limestone it imparts to the latter a clouded green colour, forming what is called verd antique.

* Etym.: Lat., serpentinus; Fr., serpentine; Sp., serpentin; It., serpentino; resembling a serpent.

† Ophio and λίθος. The Ophites and Ophiolites are rocks composed of mixtures of sandstone or dolomite and serpentine, the latter predominating. They are generally of a clouded green, mixed with white or pale green. Dana says they are the same as verd antique.

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By the earlier geologists, serpentine was called "a mysterious rock." In alluding to pikrite,* a bitter fibrous variety of serpentine, Cole says, that perhaps among all the rocks of igneous origin, there are none which so much puzzle the petrologist, in his attempts at a rational classification, as the small group which seems to pass into serpentine. Comparatively few such rocks have yet been discovered, but whenever the stratigraphical details have been worked out, in conjunction with their mineralogical characters, they seem to establish the igneous origin of serpentine. De Lapparent calls it a colloid mineral, which, he says, holds in suspension the fine fibres of the minerals at the expense of which it has been formed, these fibres being distinctly seen in the compact rock under polarised light.† Gages formed it artificially in a transparent amorphous mass, by placing a solution of gelatinous silicate of magnesia in a dilute solution of potash, the serpentine being deposited after some months' standing.‡

In France, serpentine is used for the manufacture of the sulphate of magnesia, or Epsom salts. The magnesia, which may be easily obtained from this sulphate, makes good hydraulic cement, which is specially fitted for constructions exposed to the action of sea water.

Among the rocks, serpentine belongs to the same group as Mica. It is mainly derived by an aqueous process, from what are called *peridotites*, though there are several varieties which receive distinctive names. They are all characterised by the predominance of the mineral *peridote* or *olivine*. Peridotites are not commonly found on the earth's surface, one reason being that olivine is an unstable mineral, which readily absorbs water and passes into serpentine.

Olivine is often traversed by strong and irregular fissures, which bear no relation to the form of the crystals and some-

* "Studies in Micro. Science," art. "Pikrite." Or picrite, from πικρός, bitter, because of the quantity of magnesia, or *bittererde* present.

† "Im polarizirten Licht bemerkt man aber, dass auch das dichte Mineral aus höchst fein faserigen Theilchen besteht."—Tschermak., 494.

‡ "Report British Assoc., 1863," 203.

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what resemble those formed in suddenly cooled glass. Its change into serpentine commences along these fissures, and along the boundaries of the crystal. Under the microscope, it appears as a finely fibrous green fringe, the fibres lying at right angles to the surfaces from which they originate. Then, as the alteration proceeds, this fibrous structure seems to extend further inwards until the whole crystal is converted into a mass of interlacing and contorted, or radically disposed, fibres, which no longer display any of the optical characters that formerly belonged to it.* When the crystals are only partially altered, they appear in disconnected fragments, with moderately strong chromatic polarisation, the spaces between the fragments being occupied by fibrous serpentine, which represents the incipient decomposition of the olivine along those irregular cracks by which the mineral is so frequently traversed.

Fibrous and foliated varieties of serpentine are common in the ophiolites of the Silurian series, constituting the varieties described under the names of baltimorite, picrolite, marmolite, and chrysotile. But although talc, steatite, and serpentine, are of nearly the same composition, chrysotile is confined almost entirely to the latter. The serpentine in which it is found varies a good deal in colour; the colour, and even the tint, being a most important feature in the rock, which will be further alluded to later on.

Its hardness is 3 to 3½, and its specific gravity 2·5 to 2·7. It is usually found in massive form, though it may occasionally assume a banded or slaty structure, and is also sometimes marked with spots, veinings, and stripes of various colours. This mineral is now admitted to be a decomposition product of basic eruptive rocks rich in olivine, which probably accounts for its intimate association with chromite and platinum. Chromite has a hardness of 5·5, and a specific gravity of 4·4, and is therefore about twice as heavy as ordinary serpentine.

Traversing the latter in irregular veins, the fibre, unless affected by the dislocations of the containing rock, or dis-

* See Rutley on "Rocks," p. 118.

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torted by pressure, always lies in parallel lines at right angles to the sides of the fissure. The veins are often rendered impure by the admixture of grains, or small irregular threads of chromic iron or magnetite, which break the continuity of the fibre, and then the mineral has to be carefully cobbed in order to get rid of these impurities. Near the surface, also, the veins are occasionally affected by the infiltration of water impregnated with metallic oxides, which causes the asbestos to be discoloured and its value consequently diminished. This is especially noticeable where the serpentine is disintegrated, or shattered at the surface, by atmospheric action, or other causes; though generally the discoloration will cease in proportion as the rock becomes more solid. The size of the veins also varies greatly, and these are frequently affected, like other minerals, by faults or slides, which sometimes completely cut off a valuable working face. In some of these cases, the slickensided character of the faces of the fault is very marked; and sheets of impure or imperfectly formed asbestos, like picrolite, are found lying among them along the planes of fracture. The veins often have the precise appearance of true segregation veins, the containing walls in many places having a different aspect for a distance of two or three inches on either side.

The chief interest with regard to the important deposits in the province of Quebec, lies in the fact that, in so far as at present known, the mines of Thetford and Danville represent the only two places where the mineral can be obtained of first-class quality, for the finer purposes of manufacture. Some small parts of the Black Lake field and East Broughton follow next.

The areas of serpentine are very extensive in the two great geological formations of Canada: in the Laurentian, which stretches from the coast of Labrador to westward of the Great Lakes, and covers an area of about 200,000 square miles; and the Quebec Group, which occupies a large portion of that province lying southward of the St. Lawrence, between that river and the United States boundary. What may be termed the asbestos district in the Eastern Townships is a vast

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area of about 200 miles in length, by six or eight miles wide,* where the asbestos differs in many respects from that found in the Laurentian district, which will be referred to later on.

The main sources, from which the present supply of chrysotile is derived, lie within the province of Quebec, mainly in the counties of Wolfe, Megantic, and Beauce, to which must now be added Danville in the Township of Shipton; the most productive of the mines, yet discovered, being situate in that part of the province which is known collectively as "The Eastern Townships of Quebec," with Danville just on the boundary of that line. Here the areas of serpentine are very extensive and prominent, but those portions, in which the mineral abounds, are comparatively rare, and are practically limited to two small sections which lie about four miles apart, and that of Danville, second to none, which lies somewhat farther away. Other promising sections of country are always being carefully explored, but many of these are at present covered with forest growth, which greatly obstructs investigation.

The serpentines of the Eastern Townships form a series of disconnected masses, generally of small extent, surrounded by igneous rock, principally diorite, but occasionally rising through great outcrops of slate or schist, which sometimes assume the proportion of mountain ranges, as at Wolfestown and Coleraine, Gaspé, and parts of the Schickshock range.

The stratified rocks, with which the asbestos-bearing serpentine is found, are closely associated with masses of diorite or doleritic rocks, of certain varieties of which, rich in olivine or some allied mineral, the serpentine is, as already observed, in many cases an altered product; the asbestos, which is found in this serpentine, being a still later product of alteration.

These rocks are also frequently associated with masses and dykes of whitish-looking rocks, composed of quartz and feldspar, with which there is occasionally a mixture of black mica, forming a granitoid rock, and almost always with magnetic and chromic

* Dr. Selwyn, "Canadian Mining Review," No. 6.

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iron ores. In St. Francis, Beauce County, in particular, the serpentine occurs in connection with magnetic and titaniferous iron; in Roxton, Brompton, and some other places, it carries copper pyrites and other copper ores.

These stratified rocks are here mostly black, green, grey, and purple slates, with, occasionally, conglomerates, and sometimes beds of hard quartzose sandstone. The diorites, with which it is also associated, frequently form great mountain masses, as at Orford, Ham, Thetford, and other places; in texture they are both massive and concretionary, while in colour they range from different shades of green to brown. The rock which carries the fibre is usually a grey weathering serpentine of some shade of green on fresh fracture, mostly a greyish-green, but sometimes bottle-green, in which particles of iron, chromite or magnetite, are found. Usually those serpentines which have a hard, black, chippy appearance, as well as those which weather of a dirty reddish-brown, have little probability of turning out productive in fibre.

The minerals talc, steatite, and serpentine are all of much the same composition, though chrysotile may be said to be confined to serpentine alone, being, in fact, serpentine itself. It is much to be regretted that we, as yet, know so little of the genesis of these minerals; though chemical analysis and the microscope have taught us much since the days when Linnæus formed the strange opinion that "clay, after remaining a long time dry and compressed, was hardened into a rutile talc, which, by resolution, is often regenerated into fibrous asbestos, but when minutely resolved, is in a wonderful manner reproduced into scaly mica."

Talc is either foliated, fibrous, or massive. In some of its forms, it can scarcely be distinguished from corresponding forms of actinolite, asbestos, and serpentine. All three of these are to be found in Ontario, but the largest known veins are to be met with in the counties of Hastings and Addington. Massive talc or steatite occurs in several parts of Kaladar and Elzevir, and possibly some of the fibrous form also. Some fine veins of foliated talc are also found in Grimsthorpe. It contains about 4 per cent. more silica than asbestos and 9 per cent.

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more magnesia, but not a third as much water as chrysotile. Like this also it is low in alumina, and in regard to ferrous oxide, it is much the same as chrysotile.

Large areas of steatite occur about Ham Lake with small quantities of nickel. The country is exceedingly rough and uninviting from an agricultural point of view, and the serpentine shows several varieties; some portions of it are hard and very siliceous, and much of it weathers of a rusty colour.

Indurated talc, steatite, or French chalk, is much used by carpenters, tailors and others, because lines drawn with it are not so easily effaced as if made with chalk, and will remain unaltered even under water. When reduced to powder, it is used for removing grease stains from silk and cloth.

Serpentine is sometimes found, especially in Northern Italy, but in most asbestos countries also, decomposed to a considerable depth, and in decomposing it frequently parts with a large proportion of its magnesia and most of its alkalies. In addition to the formation of unctuous clays, this change also sets free carbonate of magnesia and silica, which are deposited in veins traversing the altered rock. Bischoff proved experimentally that carbonated water is capable of decomposing the silicate of magnesia, and of carrying some of it off in the form of carbonate; and Rogers has shown that digestion in simple water for three days is sufficient to remove an appreciable amount of magnesia from even such minerals as hornblende.

The asbestos-bearing serpentine rock also forms part of the great volcanic belt, which traverses the Eastern Townships, and can be traced with tolerable clearness, though with frequent interruptions, throughout a course of over 100 miles in length, in which it sometimes attains a width of more than 2,000 feet, bearing mostly from north-west to south-east, in this respect following the general trend of all fissures charged with metallic ores, which usually have an east and west direction, bearing about 45° on either side.

The district which comprises the Eastern Townships, like the more southern part of the province of Ontario, lying

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on the opposite side of the river (notwithstanding that the rock formations of the two districts differ materially), is singularly rich in deposits of minerals, not only of vast extent, but of a very diversified character. In the Laurentian Strata of Ontario, as well as in the Ottawa district of the Quebec province, the rocks are mostly pyroxenic, and abound, the latter especially, in apatite, which occurs, almost without exception, in association with pyroxenic or hornblendic rocks, whilst those of the crystalline and sub-crystalline formations which traverse the Eastern Townships and run through the Gaspé peninsula, are mostly of a hydrous character, magnesian and chromiferous; and it is chiefly among these last that the serpentine, which forms the asbestos matrix, occurs. In the serpentine limestones of the Laurentian series it is also found, but little has yet been done in these serpentinous limestones in the way of successful mining, on account of the expense entailed in working them. This part of the province forms a narrow zone of metalliferous rocks, within which is comprised the greater part of the mineral wealth of the province. The principal sources of this wealth are found in the slates and schists of the Cambrian and pre-Cambrian systems, which extend across the province in a north-westerly direction, following approximatively, and at a considerable distance inland, the course of the St. Lawrence. In connection with these slates and schists, there is an important area of eruptive rocks, diorites, granites, and serpentines, the latter not an eruptive rock in itself, but an alteration from some of the varieties of eruptive rock. To the schists of the pre-Cambrian, the oldest rock of the series, belong for the most part the workable deposits of copper at the present day, though copper mines have been opened in many places in Eastern Quebec, in the slate beds, and in the dioritic masses of the Cambrian as well. The slates and associated quartz veins of the Cambrian are apparently the source also of the gold in Eastern Quebec, and it is to the slates of this formation, on the Chaudière and the Ditton, that the richest deposits of the precious metal, so far as yet met with, occur. In the rocks of the same system (the Cambrian), are

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found also the slate quarries of Melbourne, Cleveland, and Shipton; and in the same formation also are most of the outcrops of serpentine, which are the containing rock of asbestos.*

A general view of the mineral industry of the province of Quebec, the chief seat of the asbestos industry, is shown by the following table, which gives the production and value of the minerals for the year ending 30th June, 1889.†

	Tonnes.	Value.
Phosphate	28,350	$460,950
Amiante (asbestos)	5,919	352,260
Cuivre	70,955	720,000
Fonte manufacturé avec bog-ore	4,000	120,000
Fer (mineral exporté)	3,000	15,000
Or	—	—
Graphite	450	23,500
Mica	—	—
Feldspath	250	1,750
Soapstone	150	1,200
Ardoises	20,300 square	90,000
Granit	30,000 pds. cub.	12,000
Calcaire à bâtir	200,000 vrg. cub.	200,000
Chaux	400,000 minots	70,000
Briques	30,000 milles	200,000
		$2,266,660

M. Mercier sums up the matter by stating that this mineral region contains about 1,000,000 acres of iron-bearing lands, 500,000 of apatite ground, 100,000 asbestos, 50,000 copper, 100,000 auriferous, and 10,000 oil-bearing; forming a total of mineral wealth covering 2,000,000 acres of land, mostly in workable deposits.‡ The metalliferous zone covers the whole district, extending thence to the extreme east of the Gaspé peninsula, and is met with again on the West Coast of

* Dr. Ells.

† "Rapport du Commissaire des Terres de la Couronne de la Province de Quebec pour les douze mois expirés le 30 Juin, 1889."

‡ "General Sketch of the Province of Quebec," by the Hon. W. Mercier, Premier of the Province.

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Newfoundland. This region of Gaspé, which would equally apply to the West Coast of Newfoundland, on account of the dense forests which cover the greater part of it, the want of roads and other obstacles, has not yet been sufficiently explored to bring its mineral treasures to light. The Minister of the Interior, in 1882, reported to the Dominion Parliament, "We can affirm that this vast country constitutes the principal *zone minière* of the Eastern Townships. The zone extends from the frontier of the United States to the north-east of Quebec. Until now (owing to the difficulty of exploration) we have not found anything more than serpentine rocks and chromic iron in the region of Schickshock; but as these minerals are generally found with cotton-stone, brass, lead, antimony, and iron, also with gold and silver, it is not unlikely that we may find those minerals in the unexplored region of Gaspé."

Since the above was written further progress has been made in the exploration of Gaspé, and it may be said that all the minerals found in the Eastern Townships abound there also, with rock oil in addition.

The volcanic range, which at the extremity of Gaspé is lost in the sea, passes under it, and rises again on the western shores of Newfoundland, where the formation is very similar, and where asbestos, gold, silver, chrome iron, and many of the other minerals named, are also found.

Until the comparatively recent discovery of the chrysotile mines at Thetford, the district comprised within the Eastern Townships was but sparsely occupied, being, in fact, in much the same condition as Gaspé is to-day; but the discovery of asbestos, with the pecuniary success resulting from the working of the mines, has had the natural effect of attracting thither large numbers of the mining and trading classes, and continued success has so rapidly increased the population, during the last few years, that this portion of the district has now become a populous, thriving, and very important part of the Dominion. This result has been a good deal facilitated by the comparative mildness of the climate, and the general fertility of the

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soil, in this part of the province. It is unquestionably true that the cold here is more rigorous than any experienced in England, the snow is deep and lasting, and the broad St. Lawrence is annually frozen over. But it is also true that no climate in the world can exceed that of England, in its pure balmy, delicious atmosphere during, perhaps, a few days in early summer and autumn; though, when it is considered how lamentably few those days are, it may be that the balance of enjoyment might be awarded to this part of Canada; for, notwithstanding the rigour of winter, the air being dry and clear is so exhilarating, as to render the cold far less disagreeable and hard to bear than what we have to endure in England, where a warmer temperature prevails, accompanied by humid and foggy atmospheric conditions. As a rule, people suffer much less from cold in Canada, or even in Russia, than they do in England, and pulmonary and bronchial affections are not so prevalent, which arises no doubt from the general clearness and dryness of the atmosphere and brilliancy of the skies in winter, in contrast with the humid fogs of England. In London a fall of snow is a misery, but in Russia and in Canada it is an absolute delight; it furnishes enjoyment for the people, accelerates business and augments the fertility of the soil. By an unfortunate confusion of ideas, the words Canadian, Siberian, and hyperborean are deemed to be interchangeable terms in popular estimation denoting the utmost severity of cold.

In regard to fertility, we have the authority of Dr. Ells for stating, that much of the Eastern Townships district is underlaid by a broad band of slaty rock, with which a considerable development of limestone is associated, the decay of which produces a soil of great value to the husbandman. The hard rocks of the Laurentides also are intersected in all directions by bands of crystalline limestone, of a soft and decomposing nature, which render the ground, especially in the valleys, unusually fertile.

Considered in relation to the mineralogy of this district, a matter of great importance is that nearly the whole of it is crossed, near the central line, by the great mountain range

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which forms, on the south of the St. Lawrence, a continuation of the Appalachian chain of the United States (of which the Alleghanies are an offshoot), and which, where it traverses Canada, is known as the Notre Dame and Schickshock Mountain range. From Gaspé to Quebec this chain forms the watershed between the basin of the St. Lawrence, the Bay des Chaleurs and the Bay of Fundy to the south; and throughout the whole of this region serpentines abound. The great chain just mentioned runs in a north-easterly direction from Georgia to the Gulf of St. Lawrence, a distance of 1,500 miles in length by fifty in width, and consists of several parallel ranges, embracing anticlinal and synclinal ridges and valleys, which in many places show remarkable instances of folded strata, and as we journey westward from Washington abundant opportunities are offered of seeing the palæozoic rocks that constitute the main typical structure of this great range, which, as it passes through the Townships, gradually approaches the river, running along its southern shore, at a distance varying from ten to thirty miles inland, and terminating in the high tableland of Gaspé, at the eastern extremity of the province. It consists of several roughly parallel lines of mountainous country, showing one or two points of nearly 4,000 feet of altitude (the elevation in the Gaspé peninsula averaging 1,500 feet), which is cut by deep gorges through which the rivers flow; it is largely made up of crystalline magnesian rocks, including talcose and chloritic schists and beds of serpentine, in places associated with micaceous and gneissoid rocks and other crystalline deposits. Cambrian slates and other strata have here been thrown up by a great fault, into a position apparently higher than the Hudson River beds. This fault touches the boundary of the province, not over a couple of miles from Lake Champlain. From this point it proceeds in a gently curving line to Quebec, keeping just north of the Fortress. Thence it coasts along the north side of the Island of Orleans, leaving a narrow margin on the island, of the Hudson River and Utica formations. From near the east end of the island it keeps under the waters of the St. Lawrence to within eighty miles of the extremity of Gaspé;

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where it again leaves a strip of the Hudson River or Utica formation on the coast.*

Resulting from some mighty convulsion, which has left indelible traces behind it, the country, near the great fault traversed by the mountain range, has evidently been subjected to enormous pressure, either arising from a shrinkage of the earth's crust, or by a forcing upward of the lower strata; the whole of which, or that part of it which lies south and east of the fault, has been greatly disturbed and broken up and more or less altered by metamorphic agencies. Crystalline, gneissoid and magnesian rocks appear in part to underlie them, and partly to be mixed up with them in intricate foldings, by which their stratigraphic relations become greatly obscured. In many places, also, they are broken through by trachytic and granitic masses. Whilst to the west and north of the great fault the strata are particularly undisturbed, those which lie directly east and south of it have been greatly tilted and uplifted, and sometimes even reversed in dip. Towards the more central parts of the district, many of the beds have been altered and rendered crystalline by metamorphic agencies, and these have been folded up with one another and with an older system of crystalline rocks, forming the axes of the higher elevations in such a way as to produce great complications of structure. In its physical features the district is more or less of a mountainous character throughout, and in parts, as already stated, of considerable fertility. In this latter respect it differs remarkably from the mountainous Laurentian region of the northern part of the province. The general features of the country, therefore, are very singular, having a rolling appearance, and, when viewed from any altitude, looking like an upheaval of mighty waves suddenly stilled and changed into stone. In his description of the mineral region east of the Rockies, Professor Geikie describes its peculiar uplifted formation, which is much similar to the region above described: there the ancient granitic and crystalline rocks have been

* Second Report on the Geology of a Portion of the Province of Quebec, 1888.

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driven up like a huge wedge through the younger strata of the prairies, and now form the axis of the Colorado Mountains, respecting which the Professor remarks that, had it not been for this wedge, the "Centennial State" would have been a quiet pastoral or agricultural territory, like the region to the eastward. The rise of the granite axis, however, has brought up with it that incredible mineral wealth which, in a few years, has converted the loneliest mountain solitudes into busy hives of industry.*

It is through the crystalline formations of the district bounded by the great fault, that the belt of serpentine runs, in which the chrysotile is found. The serpentine itself is one of the altered igneous rocks of metamorphic origin, resulting from the decomposition of rocks rich in olivine, or the transmutation of magnesian limestone, or some other more closely related strata.

That portion of the belt which more immediately concerns our subject, runs from the boundary of Vermont, in the State of Maine, to some distance beyond the Chaudière River, a little past the latitude of Quebec, traversing in its course the Townships of Potton, Bolton, Orford, Brompton, Melbourne, Cleveland, Shipton, Ham, Garthby, Coleraine, Thetford, and Broughton. The course of the belt, in its entire length, will be found elaborately traced out and described, in a very interesting report, by Dr. Ells on "The Geology of a Portion of the Eastern Townships," published by Dawson Brothers, Montreal, in 1887, by authority of the Dominion Parliament. Here it will be seen that in Cleveland and Shipton the belt assumes a transverse twist, which also affects the Cambrian and other formations in the vicinity, and changes the strike for some miles, in the Townships of Wootton and Ham, to an almost easterly course. The prolongation of the Melbourne and Shipton ridge, which terminates in the Little Ham Mountain, after an interval of about five miles, occupied by slates and sandstones, reappears in the Big Ham Mountain, which rises boldly from the somewhat flat country at its base, to a height

* Geikie's "Geological Sketches," 216.

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of 1,150 feet, where it forms a magnificent hill feature of the landscape.

The most important area is that which, terminating southward in Big Ham Mountain, extends north-easterly to and beyond the Chaudière. In this area serpentines are first seen in several hills, on the south side of the outlet of East Nicolet Lake, and both here and on the west shore (where a vein of magnetic iron occurs, having a thickness of six feet at the surface, increasing to eleven feet in the shaft at a depth of twelve feet), the serpentine is dark green, and contains a small quantity of grey copper ore. According to Mr. Coulombe, who first opened the mine here in 1881, the serpentine extends south-east from this point to near the foot of the Ham Mountain. It occupies also all the islands in the lake and the south and east shores, extending in a ridge to the road leading to Garthby village. On the south end of the lake there is a considerable area of soapstone. The principal mass of serpentine stops at Lot 55, but is found associated with diorites on the Garthby road. It again prominently appears on a ridge near the road leading from Wolfestown to Coleraine Station; on the north-east flank of which ridge the Belmina mine is situated. Here the serpentine is associated with considerable masses of the whitish granulite already mentioned.* These appear occasionally to cut the serpentine after the manner of dykes, and to its presence may possibly be ascribed some of the frequent faults which affect these rocks, and which are disclosed in the asbestos workings. There can be no doubt that the presence of these dykes favourably affects the quality, as well as the quantity, of asbestos; in corroboration of which opinion may be alleged the well-known fact that the nearness of a fault may be often predicated by some sudden change in quality, whether for better or worse, in respect to the veins of many other minerals besides asbestos. This granulite, interstratified

* Weiss-stein or leptinite, a granular compound of quartz and feldspar, the latter being orthoclase or microcline. In its schistose structure and mode of occurrence it is classed among the metamorphic rocks, and seems to bear the same relation to felstone as gneiss bears to granite.

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in a peculiar manner, is to be distinctly seen in some of the mines at Thetford as well as at Coleraine. In the latter place, it is found in all the mines on the western side of the serpentine ridge, where the asbestos is abundant and good; but, directly the ridge is crossed, the granulite disappears, and then the serpentine is found to be barren of fibre. This remarkable fact cannot at present be accounted for, nor is it known why the granulite exercises this influence over the serpentine. It is clear, however, that these intrusive rocks are newer than the serpentine which they traverse, their intrusion being marked by the alteration and shattering of the mass traversed, along the contact with these dykes. The white masses of these granulitic rocks, which are such an important feature in the serpentine areas of Coleraine and Thetford, form hills between Black Lake and Thetford, and are very conspicuous as seen from the railway.*

Crossing into the adjoining Townships of Ireland and Coleraine, the serpentine forms part of a harsh, rugged-looking country to the west of the Quebec Central Railway, the boldly outlined peaks and ridges to the south-west of Black Lake forming also very prominent features in the landscape. These ridges take their rise a short distance north of the boundary between Ireland and Wolfestown, extending thence into the Township of Thetford. In the vicinity of Black Lake Station, and between this point and Thetford, the serpentine is largely intermixed with granulite, and in so far as is yet known this area constitutes the richest asbestos ground in the province. The country rock in the great serpentine areas of Thetford and Coleraine is a black, greenish slate, with hard schistose quartzite; but at Coleraine Station beds of dark red slates, mixed with conglomerates, occur.

* This semi-granite is an elvanic or fine-grained rock containing in itself alkali, in the form of potash and soda, sufficient to melt the silica of which it is principally composed. It has been used for some time in the manufacture of glass, which, being the product of silica, a most refractory mineral, requires alkali and other fluxes to secures its fusion, whereas granulite requires no such flux to melt it beyond lime. It is a highly metamorphosed sedimentary rock, the whole mass crystalline, the crystals

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Large areas of the volcanic rocks also occur in the Schickshock Mountain range, in the northern part of Gaspé, in rear of St. Anne des Monts, the most easterly point being Mount Serpentine, which is situate about ten miles up the Dartmouth River from its outlet in the Gaspé basin. The district was partially explored by Mr. Obalski, Government Mining Engineer of Montreal, in the summer of 1889, and he states that Mount Serpentine, which rises 1,600 feet above the sea level, is not, as its name would lead one to suppose, composed of serpentine, but of hornblende. He, however, established the existence of a band of serpentine on Block 19 there, in which he saw numerous small veins of chrysotile. A specimen from this district in my possession cannot be distinguished from the usual run of Thetford ore, which would seem to show the desirability of a thorough investigation of this as yet unknown region. The serpentine here is associated with limestone, and surrounded by strata of Devonian age; to the west lies the great mass of Mount Albert, whence the ridge extends westward for some miles. Indications of asbestos are found at most points throughout the whole formation; but, so far as is at present discovered, the mineral is most abundant in the localities named above, although there is certainly no reason why it should not be found in paying quantity at other points, especially as it is now well established that the masses and dykes of granulite, already referred to, favourably affect the presence of asbestos.

Traversing the serpentine in irregular veins, the chrysotile, unless affected by the dislocations of the containing rock or

being arranged in regular lines, which furnish a clue to its origin. Garnet is especially plentiful in rocks of this class. The fine feldspathic granulite at Meldon, Dartmoor, is even finer than that found in Saxony; assays of this show—

Silica	69·34
Mixed oxide of iron and aluminium	3·56
Lime	1·34
Magnesia	1·00
Alkalies	23·36
Calcination loss	1·40
	100·00

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distorted by pressure, always lies in parallel lines at right angles to the sides of the fissure. In many cases the veins are rendered impure by the admixture of grains, or small, irregular threads of chromic iron or magnetite, which break the continuity of the fibre, in which case the mineral has to be very carefully cobbed in order to get rid of such impurities. Near the surface, also, the veins are occasionally affected, to some extent, by the infiltration of water, often impregnated with metallic oxides, the asbestos being thereby discoloured and its value proportionably diminished. This is especially noticeable where the serpentine is disintegrated or shattered at the surface, by the action of the weather, or other causes; but the discoloration ceases as soon as the rock becomes solid. The size of the veins also varies greatly, and, like other mineral veins, as already mentioned, they are frequently affected by faults or slides, which occasionally cut off completely a valuable working face. In these cases the slickensided character of the faces of the fault is very marked, and sheets of impure or imperfectly formed asbestos (picrolite) are generally found lying among them along the planes of fracture. The veins have also very frequently the aspect of true segregation veins, the containing walls in many places having a different aspect for a distance of from half an inch to three inches on either side. But the one feature of special interest regarding these deposits in the Province of Quebec is that, in so far as is at present known, they represent the only deposits in which this mineral can be obtained, of a quality adapted for spinning and the finer purposes of manufacture.

Mr. Obalski states that, when tracing out the bands of serpentine, he established the existence, north of Little Lake St. Francis, of a wide band of the dark-green rock containing asbestos, not yet worked, or even explored. This crosses the Indian reserve, and a block not named in the map, which he calls Block K. It then enters Ranges B and A of Coleraine, and probably Range A of Thetford. Dark serpentine then ceases to be found, and a light-coloured variety appears in the neighbourhood of Lake Bécancourt, and in Ranges 8 and 10, where a little asbestos is found of somewhat inferior quality.

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Asbestos of better quality has also been found at Shefford, on the line of the Quebec Central Railway, the deposits there being pronounced by Professor Selwyn as very promising.

Good specimens have likewise been obtained by the Chaudière River, and a small quantity from the River Desplantes, one of its tributaries.

As to the mineral in the adjoining Colonies, in Nova Scotia, asbestos has not yet been recognised, but Gesner states that samples of asbestos were found in Clare Township,* with fibres radiating from a common centre. These were found in veins penetrating a rock compounded of slate, quartz, and feldspar, and, were in all probability, radiated actinolite.

Fibrous hornblende is plentiful at Cape Breton, but no true asbestos has yet been found there, or in New Brunswick, where the serpentine rocks belong to the Laurentian system, and only exhibit mere thread-like veinings, of the peculiar Laurentian asbestos, which will be referred to later on.

But wherever it may be found, in its pure state, chrysotile is as heavy as the rock in which it is enclosed, so compactly are its fine crystalline fibres compressed together; but when once it has been disintegrated, it is quite impossible to pack or knit the fibres together again in such a way that they cannot be easily separated by the fingers.

The veins also nowhere present themselves in uniform abundance, although rich veins are sometimes opened up which have a certain continuity. As a general rule the quality of the ore improves, and the quantity increases, as the workings are prosecuted to greater depth; nor is it difficult to comprehend why this should be so. Moreover, as has been before remarked with reference to Italian asbestos, the better qualities are usually procured from deposits at considerable altitudes; these, however, are nowhere so great in Canada as in the Italian Alps, the altitudes in Coleraine and Thetford ranging from 700 to 800 feet, although some of the unworked parts of Coleraine are higher even than this; whereas in Italy, as we have already seen, they often attain a height of 3,600 to 7,200 feet.

* Gesner's "Geology and Mineralogy of Nova Scotia."

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The probabilities also point to a continuation of the deposits to some considerable depth, though that important matter cannot at present be proved in the absence of deep workings. No trial borings have as yet been anywhere made, except, as previously mentioned, on a limited scale, by Mr. Sheridan, at Thetford; but in one mine there a depth of over 250 feet has been reached without any indication of a cessation, or any diminution of the quality of the ore. The desirability of testing the lower portion of the serpentine has often been advocated in the Reports of the Geological Survey, but, as has been already observed, up to the present time very little has been attempted in this direction.

But we may take it as a general rule that the harder and darker-coloured serpentines are usually the most productive, the light-green rock being commonly either sterile, or yielding a brittle quality of ore only, to which but little value is attached. An extraordinary exception to this rule occurs at Danville, where the rock is unusually soft, generally of a peculiar lightish colour, and often coated with a very singular light-coloured skin of filmy translucent serpentine, the tint sometimes approaching that of the lovely sapphire; see a special sample of this in the frontispiece. Some of the thicker pieces of this light translucent serpentine often look as if they might be used for cutting, but are too essentially fibrous for any such purpose. The serpentine at Danville is somewhat like that at Broughton, where a pale rock is found accompanied by splendid fibre, the only difference being in the shade of green. Admixtures of hard and soft serpentine occasionally occur; but when this happens successful mining is always doubtful, whatever may be the nature of the surface indications. Should the serpentine be crossed by quartzose gneiss or transverse dykes of granulite, the prospects are much better, especially at the junction with diorite, the contact with granite being by no means so favourable.

The chrysotile found in the Eastern Townships may be roughly divided into three classes:—

a. A coarse, brittle, compact variety, plentiful, but of comparatively little value.

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b. Ore possessing well-defined fibres, of a yellowish-brown colour, fragile, and containing much foreign body ; and

c. A pure, white, silky, fibrous quality, easily separable by the fingers, and much of it adapted to the manufacture of textile goods.

The last-named variety is that chiefly sought after, and this is graded at the mines into three classes, known commercially as Nos. 1, 2, and 3, according to quality of fibre ; No. 1 commanding the highest price, as being considerably superior to the other two. This, when of a pure white colour, and free from silicic acid or metallic oxide, is rendered specially valuable by its native lubricating qualities, which last property is also possessed by one, at least, of the Italian varieties, and is owing to the presence of the large amount of magnesia in its composition. It is also said to constitute the chief value of a particular kind which occurs in some parts of the United States, but which I have not yet met with. At Danville an entirely different system of grading is adopted, which is fully described on p. 186, *post*.

Width of the Veins.—One often hears people talk of veins of six inches or more in width ; but samples of any such width as that, if ever found, are preserved as specimens for show, and are of by no means frequent occurrence, even at Thetford, where, as a rule, a much narrower fibre prevails. A width of two, or two and a half, or three inches is much more like the general average. Some specimens of Danville ore now before me are not even so wide as that, but are of singular beauty, and are certainly both broad enough and good enough for any purpose to which the fibre could possibly be put. On this point extraordinary ideas sometimes prevail among persons whose knowledge of the subject is limited, which is probably engendered by confounding Italian asbestos with Canadian chrysotile. An instance of this once came before me. A gentleman, who was commissioned to inquire for a good Canadian mine, for some parties in London, called upon me to ask my assistance in procuring one likely to suit the proposed buyers. Upon talking the matter over, he told me that unless the average

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of the fibre was about twelve or fourteen inches in width, it would not suit, and was then passing on to the question of price. To his great surprise, I stopped him there by saying that it was useless to go into the question of price, because, as a matter of fact, such a mine as he was desirous of purchasing had no existence in Canada, nor, as far as I knew, in any other part of the world.

It must, however, be borne in mind, when discussing the width of the veins, that the same rule which holds good with asbestos, obtains also with, and is by no means confined to, abnormal specimens of substances in either the mineral or the vegetable world, namely, that the largest specimens are not necessarily the best. Large crystals, for instance, seldom have the perfection, transparency, or flawless character of those of smaller size; the finest qualities of wool also are comparatively short in staple;* and the largest specimens of fruit are seldom the most succulent.† Nor do the broadest veins yield fibre of so fine a quality as those of a medium, or even of a smaller size. Moreover, the length of fibre cannot be determined with any certainty from the width or thickness of the vein. On the contrary, the broader veins are not seldom found to be separated at right angles to the length of fibre by minute bands of serpentine, chrome, or magnetite, sometimes even by a separation, without any perceptible layer of rock, the only indication of this being an irregular, scarcely visible line, readily detected by the expert. In many places the serpentine contains magnetic iron, disseminated in fine particles, the associated asbestos showing the same iron, not disseminated, but usually concentrated towards

* "Wool is divided into two classes, known as short or carding wool, which seldom exceeds three or four inches in length, and long or combing wool, varying in length from four to eight inches."—Dr. Bowman on "Wool Fibres."

† "The Russians are probably the possessors of the largest grown peach in the world; it is called the 'Venus,' and is of a magnificent colour. I have picked three peaches weighing 2¼lbs. They are better, however, to look at than to eat."—Barry's "Ivan at Home." This the writer can personally corroborate.

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the middle of the vein. It seems evident, Professor Donald remarks, that both the serpentine and iron oxide have been dissolved by percolating water, and redeposited in the crevices of the rock; the less soluble silicate first, and lastly, the more soluble iron in the middle of the vein.*

Under the hammer, the big veins, in which the separation exists, are at once divided into two, or it may be into three, lengths of fibre; but if the cotton be pure and clear, this is no very great detriment. Veins of an inch, or an inch and a half, extracted from compact rock, seldom have these intersections. In the principal mines, the workable veins rarely exceed two, or two and a half inches, and where the fibre is of good quality, and unbroken by threads of iron, this ranks as good No. 1. The veins, moreover, are extremely irregular in character, a small vein at the surface frequently developing into one of considerable size lower down, or breaking off altogether. This is the special characteristic of the veins in the Coleraine district, notably at Black Lake, at the mine of the Anglo-Canadian Company. At Thetford, on the other hand, where the ground is of a more uniform character, fine veins are frequently met with just below the surface, which continue with very little change for a considerable distance, unless crossed by bands of granulite, when the course is interrupted.

Another special point to be noted is that the probabilities of successful mining are much increased if the indications are found on the hill side, among the rugged rocks, where the surface is but sparsely clothed with soil. The serpentine, it is true, frequently underlies cultivated ground, but in such cases the rock, when reached, is generally found to be comparatively sterile. The harsh and rugged-looking Coleraine mountains, which the forest fires have denuded of trees, and on which little or no good land is found, offer every inducement to the explorer. In Thetford, again, where the land about the mines is somewhat flat, the best workings have been found on the hill or knoll where there was but little superincumbent soil, the colouring matter from which could, by capillary

* "Canadian Record of Science," April, 1890.

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flow, or through the planes of cleavage, penetrate the loose or shattered and decomposing rock, so as to deteriorate the value of the fibre by discolouring it. One of the mines there could of course be cited to show that this rule is not of universal application; three out of the four were opened on the knoll, but in the case of the fourth, which is situate upon a lower level, about thirty feet of overlying clay and gravel had to be removed before the rock was reached. When, however, this was at length uncovered, veins of fine quality were disclosed, which have since been successfully worked, although the lower level at which they occur causes difficulty with water.

Certain peculiar conditions, as already mentioned, possibly connected with the intrusive bands of granulite, appear to have prevailed in Thetford and the more northern part of Coleraine, which have led to the formation of asbestos in special abundance, though strangely enough, where the granulitic masses are most prevalent, viz., at Black Lake, the fibre is not so rich as at Thetford, the granulite there being confined to smaller and narrower dykes.

And, except at Thetford, the serpentine rock is usually so split up and seamed, in every direction, by the veins and stringers of asbestos that, disregarding Broughton, where the formation is peculiar, tunnelling, as carried on in Italy, can scarcely be adopted. Possibly when greater depth is reached, and the rock becomes more solid, means may be found to advance the work in this way if desired; but, at present, open quarry working, which has many advantages, is the rule, the main disadvantage being that the work necessarily suffers in bad weather, and is of course considerably interrupted by heavy falls of snow in winter.

Chrome iron and magnetite, always found in association with the asbestos-bearing rocks, are frequently found, as at Thetford, Black Lake, and Lake Nicolet, in the Quebec Province, as in many other parts of the world, notably in Newfoundland, Norway, South Africa, and South Australia, in large, sometimes very large, deposits, close by the mines, and it has already been explained how frequently the fine, thread-like veins of these metallic ores cut and destroy the continuity of the fibre. It is

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a curious thing also that the asbestos seems to deal with these ores in precisely the same way, for on examining the specimens of iron ores, brought by me from the neighbourhood of the asbestos mines, the stringers of asbestos, although very minute, are found intersecting them in a precisely similar manner; and I found this to be so to a remarkable extent in Newfoundland, where the fibrous veins of chrysotile penetrated the bed of chromic iron in several places for a distance of many feet.

The various distinguishing characteristics of the ore of the different mines are of so marked a nature that an expert can often determine the locality of the mine from which a sample has been taken, and occasionally name the mine itself from an inspection of the ore. This fact is worth noting, as it should effectually prevent the fraudulent substitution of one ore for another, which has been, twice to my personal knowledge, successfully practised by the same parties.

The rock also varies very considerably, and requires careful examination. In some places it is apparently still in the transition stage between the original rock from which it is derived and a true serpentine having almost the hardness of feldspar, while it yet retains the general aspect and colour of the serpentine in which it is found.

At nearly all the mines large quantities of so-called bastard asbestos (picrolite) are found. This is a woody, brittle variety of apparently as yet unformed mineral, for which at present no use seems to have been found; though judging from its composition and the many new applications of the mineral now being introduced, there can be little doubt that this inferior article will presently command its price in the market, a use being found for it in some of the many purposes for which coarse pulverised asbestos is specially applicable.

Occasionally, some very singular types of ore are to be seen. Some of the specimens, which approach the nature of mountain wood, as they lay on the ground after a blast, have so much the appearance of a wood-cutter's choppings (being in the coarse and peculiar grain of the fibre so like chips of wood) that, if placed side by side with actual chippings from rough timber

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exposed to the weather in the woods, the one could not be distinguished from the other except by handling, when the weight and stony feel of the asbestos would make the difference at once perceptible.

The characteristic colour of the ore largely depends upon the locality of the mine, and the nature of the rocky gangue. At Thetford, as already mentioned, it is of a greenish hue, something akin to bottle-green, being there found in a darker coloured serpentine, whilst at Danville the ore is of a softer and lighter colour, and at Broughton it is of a pearly yellowish-green, the surrounding rock being mostly of a grey or pale green colour. This difference of colour in the ore, however, in no way affects the value of the mineral, as, when crushed out, the fibre is mostly of a uniform whiteness, that of Danville being especially fine and of a peculiarly soft and silky texture. This has especial reference to the three places named, and in no degree relates to the technical differences in colour and texture previously referred to.

Ornamental Serpentines.—When treating of asbestos, serpentine must necessarily always be present in the mind, and whatever relates to that rock must consequently be interesting and worthy of note. It may, therefore, not be altogether out of place to mention here that serpentines of an ornamental character are abundant in Canada. Some very beautiful specimens were shown in London at the Colonial and Indian Exhibition at South Kensington. Many of these contain small quantities of chromium and nickel, and are associated with soapstone, potstone, dolomite, and magnesite. A band of limestone also occurs at Templeton containing masses of a light-coloured translucent serpentine, very beautiful in appearance, and often of a golden or amber tint, sometimes slightly tinged with a greenish-blue. Many of these ornamental serpentines are exploited with some success by the Canadian Granite Company of Ottawa, being used by them for monuments, mantelpieces, vases, and suchlike. One would certainly think that their importation into England would meet with success, seeing that there is always a demand here for fine

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Asbestos and Asbestic: Their Properties, Occurrence, and Use (1897)
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marbles and stones for architectural and other purposes. Variegated serpentine marbles of great beauty are found also at Gaspé, especially about Mount Albert, where the mass of serpentine is about 1,000 feet thick, and is mixed with chloritic and epidotic gravel, covering a space exceeding ten square miles. In this region, as well as in the Eastern Townships of Quebec, whole mountains are formed of serpentine marbles, of which abundant use could be made both for ornamental and building purposes; but although, on account of their richness, varied colouring and capability of taking a high polish, few stones surpass some of the varieties of serpentine for decorative purposes, yet they are more fitted for indoor than for outdoor decoration because, being easily acted on by hydrochloric and sulphuric acids, and atmospheric influences generally, they are liable to decay and to become speedily tarnished superficially; consequently they are not to be recommended for outdoor use in the smoky gaseous atmosphere of London or other cities.

Sir William Logan says: "Les serpentines, dans toute l'étendue de leur gisement, fournissent de très beaux marbres vert-de-mer souvent ressemblant au vert antique."

Jaspers of very brilliant and beautiful colours, yellow, red and green, called Gaspé pebbles, are also found in the Gaspé limestones.

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CHAPTER VI.

THE CANADIAN QUARRIES.

THE THETFORD GROUP OF MINES—Discovery of the First Mine at Thetford—The Johnson Company's Mine—King's Mine—The Ward and Ross Mine—Bell's Mine—The Beaver Asbestos Company's Mine—The Thetford Company's Mine—General Level—Dr. Reed's Property—Picrolite—The River—Winter Closure—Soft Serpentine—The Thetford Fibre—Difficulty of Dumping—Cost of Extraction—The Coleraine and Black Lake Group—Siliceous Serpentines—Harsh and Brittle Fibres—Dehydration—Granulite—The Glasgow and Montreal Company—The American Asbestos Company—The United Asbestos Company—Dr. Reed's Mine—The Anglo-Canadian Company—The Megantic Mine—King Brothers—The Frazer Mine—Broughton Ore—South Ham—Wolfestown, Brompton Lake—The Asbestos and Asbestic Company's Mine at Danville—Peculiar Nature of the Rock—Amount of Waste in Asbestos Mines generally—Nature and Qualities of Asbestic—Patent Asbestic Wall Plaster—Uninflammable Mural Decorations—The Buildings at Danville—System of Grading—The Asbestos and Asbestic Company—Laurentian Chrysotile.

The Thetford Group.—As long ago as 1862, specimens of Canadian chrysotile, or asbestos as it is commonly called, were shown in London, at the International Exhibition, and, before that date, the fact of its existence in the province of Lower Canada was known to, but not much regarded by, scientists, except as a mineralogical curiosity. Indeed, it was not until the autumn of 1876 that the first mine was opened at Thetford, in the above province. Its success at first was by no means promising, but as the demand improved, the trade met with more encouragement, fresh mines were discovered and opened, and prospecting was carried on for the mineral in every part of the province.

The burning of the forest, which formerly covered Thetford,

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Coleraine, and the entire range of the Black Lake Mountains, had laid bare a considerable stretch of country, which included the Thetford knoll and the adjacent hills of serpentinous rocks, and the weathering of these soon produced that peculiar appearance which the veins show when they lie near the surface. There is no doubt, however, that the building of the line of the Quebec Central Railway across the serpentine belt at Thetford and Coleraine, was the proximate cause of the discovery. It fell to the lot of an agriculturist, named Fecteau, to light upon the mineral which has since had such an important influence on the welfare of the district. The accidental knocking off of a fragment of rock, and the consequent exposure of a vein of chrysotile, would be sufficient to strike any man with wonderment, and set him on inquiry. When first exhibited, experts pronounced the quality to be good, and their statement, that asbestos of so fine a quality had never yet been found anywhere in the country, was abundantly justified on further examination.

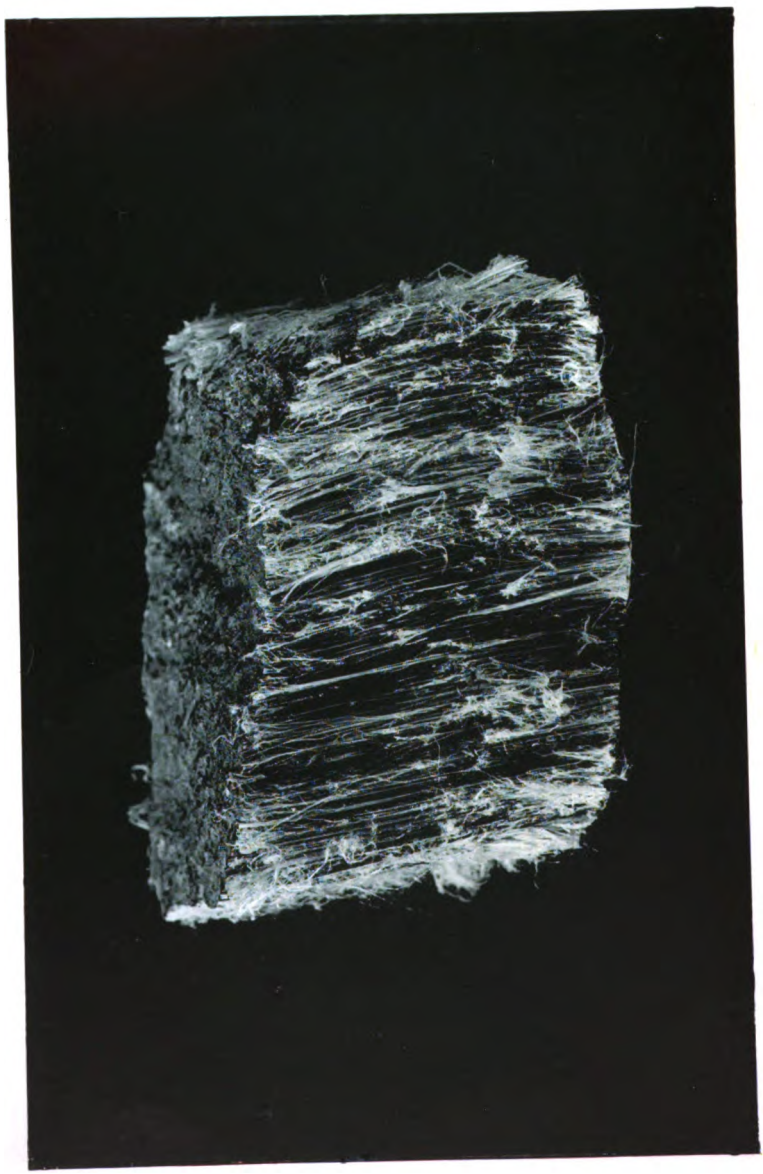
This is the first and main group of chrysotile mines in Canada. It consists of four principal mines, to which one more has since been added, which lies a little outside the boundary, and should, possibly, be more correctly included in the Coleraine group. The four spoken of are the Johnson mine, that of King Brothers, the Ward and Ross, and Bell's. The two first-named are so exceptionally situated, have such a world-wide reputation for the quality of their produce, possess such an abundance of the finest land for working, dumping arrangements, etc., and are so thoroughly indifferent to all trade artifices or manœuvres, that they have never needed to seek for public notoriety by means of such. The third, unfortunately, from financial or other causes, has for some time ceased to work; while, as we have no means of judging of the fourth, but by what we read in the local papers, its published reports, and the fluctuations of the dividends paid to its shareholders, this would seem to have had, from its establishment, a somewhat turbulent career. The fifth, the youngest of the group, has, consequent on recent events, preferred to close down quietly to await the course of events. It is owned and was carried on

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CHRYSOTILE. JOHNSON MINE. THETFORD.

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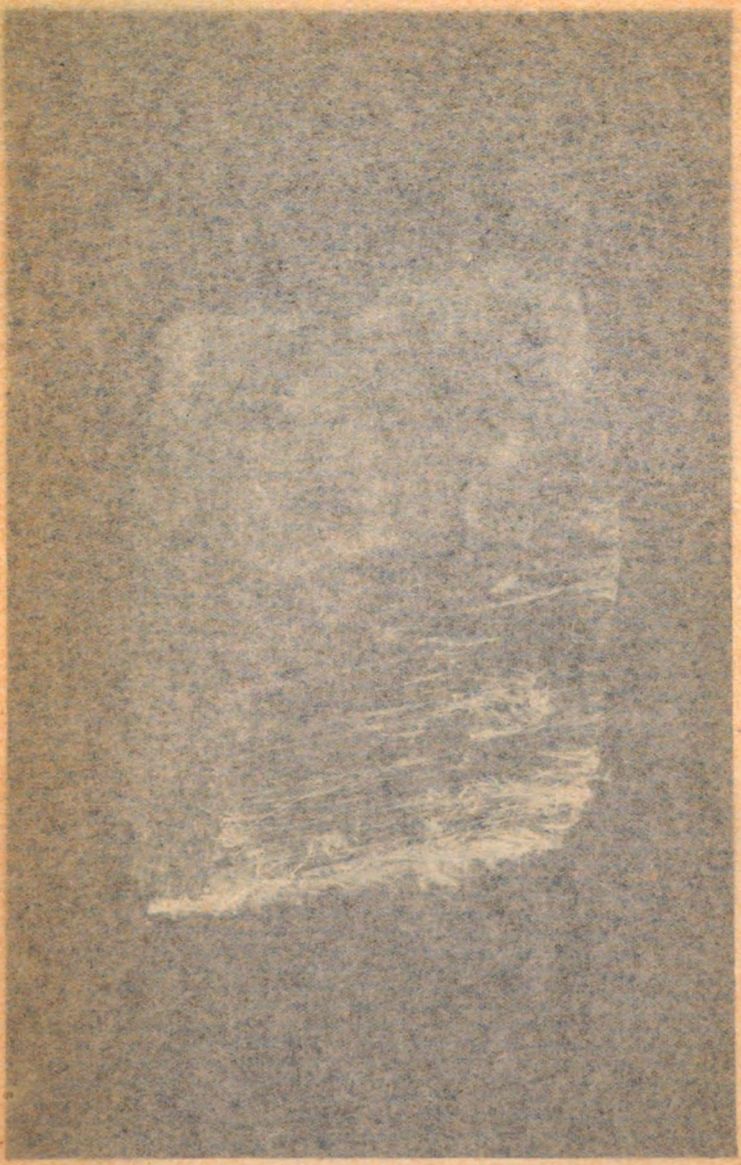
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year, while the

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CHRYSOTILE. JOHNSON MINE, THETFORD.

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by men of the highest standing for character, competency, and ability. All the five mentioned are producers of first-class ore, which has always maintained the highest price, and they have hitherto been regarded as second to none in the world.

The Johnson Asbestos Mining Company.—This is a private company. It was the first mine opened on the Thetford knoll, and is situate on Lot 27, of the 6th Range, Thetford. The company was formed in 1886, with a registered capital of $250,000, in shares of $500 each, all fully paid up. Until his death, which occurred in February of this year, the Hon. George Irvine was its president, and Mr. Andrew Johnson, its resident manager. The company own as much as 1,000 acres of land, and therefore have an abundance for mining, and every possible requirement.

The average number of hands employed are, in the summer season about 175, and in winter about 100, all of whom are furnished with very comfortable houses, close to their work, at a nominal rent. In this respect Thetford, since my last visit, has wonderfully improved, and, for a mining town, has an unusually comfortable appearance, which is largely contributed to by the superior look of that part of it which belongs to the Johnson Company. Their whole property is a first-class one; the Thetford portion, as already mentioned, being situate on Lot 27, Range 6; while they also own Lots 25 and 26, Range 10, of Ireland, and Lots 25, 29 and 30, Range 3, Coleraine, Megantic County. All this is good mineral land, though the Thetford portion of it is undoubtedly the cream of the whole. The general trend of the asbestos land in this district is in a south-easterly direction, the poorer quality taking a north-westerly course; though it must be remarked that nearly the whole of the Johnson land lies in the south-east, that is, the most desirable portion of the district. The company claim to be the first producers of asbestos in Megantic County, their first blast having occurred in December, 1877, but their mine was started in earnest in the spring of the following year, while the organisation of the company was only completed in 1879.

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In its main features this mine is very similar to King's. The formation consists of massive serpentine, which varies in colour from a dark green to nearly white; this is intersected by numerous veins of asbestos, the fibre of which is singularly free from any admixture of foreign substances. When first opened, a trench about fifty yards long was cut, exposing a wedge-shaped mass of feldspathic rock in the serpentine. From the original opening the mine has been very successfully worked, and its produce has always been regarded as second to none in the district.

From information furnished to me at headquarters, I learn that the company handles about 100 tons of serpentine rock, in a double shift of twenty hours per day, and that their sales of fibre last year reached to more than 2,000 tons, but no classification of grades is mentioned, though we know it to be remarkably good. Nos. 1 and 2 do not go through the mill, but are cobbed by hand in the usual old-fashioned manner.

The plant consists of two engines, of ninety and fifty horse-power respectively; one full electric plant; two Blake crushers; two pair Cornish rolls; picking tables, screens, blowers, and three boom derricks; one drier, 18 feet × 30 in.; the necessary sheds for storage; all complete and in good order.

King's (*The Hampden Mine*).—This mine was opened and is worked by Messrs. King Brothers, mine-owners and lumbermen. The partners are Charles, James, and E. A. King, who are deservedly reputed to be the largest, as they are undoubtedly, the wealthiest producers of crude asbestos in Canada. They own about 18,000 acres of mineral land in the Townships of Thetford and Ireland, in one block. On the occasion of my last visit to the mine, in November, 1896, I was grieved to hear of the loss of my friend, William King, the large-hearted and universally-beloved local director and resident manager, who seems to have soon followed his old friend, Thomas Sheridan, another well-known and much-respected inhabitant. Knowing the late William King's great qualities, it can be well understood how deeply his loss is felt by the entire community, where he was always regarded

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as one of Nature's noblemen, a gentleman in word and deed. *Requiescat in pace !*

The Thetford mine is situate on Lot 26, Ranges 5 and 6. It bears much the same character as that already described ; but its produce has always had a specially high reputation on account of the careful way in which the ore is cobbed and prepared for the market, which is in marked contrast with the work done at one, at any rate, of the mines in the adjoining township.

Their output in 1888 was returned as 580 tons, showing a considerable increase upon that of the previous year. This was classed as—

No. 1	. . . . .	170 tons.
,, 2	. . . . .	165 ,,
,, 3	. . . . .	245 ,,
		580 tons.

The large proportion of Nos. 2 and 3 was due to the opening up of fresh land, the general produce of the grading being in no way inferior to that of other mines. The average number of men and boys employed, to get out and prepare this quantity, was thirty-two men and twenty boys, but as the number of working days is not given, the information is not of much value.

In 1889, it increased to 1,500 tons of all grades. In 1890, it was 1,050; in 1891, 925; in 1892, 550; in 1893, 400; in 1894, 550; in 1895, 850; and in 1896, between 800 and 900 tons, classification not given, but nearly all of it Nos. 1 and 2. In this last mentioned year, a fine strike of unusually long and rich fibre was uncovered, and continues to give very satisfactory results.

The hands employed are from 100 to 120 men, in the summer season, and from eighty to ninety men and boys in the winter.

A plant erected here was mainly for the extraction of the asbestos from the larger pieces of rock from the old dumps, which formerly did not warrant the expense of blockholing and further handling. This mainly consists of a Blake crusher, from which the mineral is conveyed on to a set of Cornish rolls,

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with the object of having it reduced to powder. It is then conveyed to a revolving screen, so as to get rid of all the dust and leave the fibre clean. This object does not, however, seem to have been fully attained, owing to the failure of the rolls to entirely break up the rock, consequently an additional blowing and screening plant had to be put in, which now produces a fine clean product of one grade alone.

The general plant now in use consists of a Rand compressor, 16 in. × 24, and one mill engine, 14 in. × 16, with boilers, etc., complete ; one cyclone pulveriser, No. 2, running 2,200 revolutions per minute, with 24 in. beaters ; one 10 in. × 24 Blake crusher ; one pair Cornish rolls ; three double hoists, screens, fans, blowers, etc. ; one electric plant, complete ; and a drier, 16 feet × 30 in. This is for drying the asbestos, cleaning up the pits, etc., all the material being put through the machine at one end, when it comes out perfectly dry at the other. The roller is fixed at a sufficient angle to allow it to pass from one end to the other, with an internal arrangement to prevent its dropping through too fast.

They have also had to build a bridge over the line of the Central Quebec Railway, for the purpose of tipping the refuse, but it is hoped that at no distant day a large quantity of this refuse will be utilised somewhat in the same way as the asbestic at Danville, which, it is now generally admitted, is a most important article.

The King's mine has always been noted for its great care in the production of a very superior quality of fibre, their No. 1 being acknowledged to be the best in Canada for purity and length. None of their No. 1 is milled, but is all selected by hand, and specially cared for.

During the winters of 1895-7, the mines here were worked through the whole season, but prior to these dates, it was the usual custom to close down during the winter season.

In his report for 1889, the Commissioner of Crown Lands stated that "MM. King frères, en outre de leur mine du Lot 5, 26 de Thetford, ont travaillé avec succès sur les terrains bas du Lot 5, 28 (*Thetford Royal Mine*), où la même qualité

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d'amiante a été trouvée." The rock here looks remarkably well, but the work has been for some time discontinued.

The Ward and Ross Mine (*Thetford Asbestos Mining Company*).—This mine, situate on the south half of Lot 27, Range 5, is of more recent date than the last. It was formerly worked by the Brothers Ward, being owned by them conjointly with the representatives of the late Hon. James Ross, of Quebec. The property comprises a little over 100 acres, and is not quite so advantageously situated for work as those already described, on account of its being on a lower level; it, however, when at work, turned out very good material. The output for 1886 was returned at 150 tons, probably at that time a fair average of what was being done. The figures for 1888 and 1889 were not sent in, in time for the Government Report, so cannot be given here, but there is no doubt that under the stimulus of the high prices then ruling, the output has been very considerably increased. The same gentlemen opened ground on the other side of the railway, between the line and the river. Here also good ore was found, and the operations at that time seemed likely to be carried on with success, but being on a lower level it is probable they will be much troubled with water, so that continual pumping will be necessary. When at Thetford, on a former occasion, I saw some good ore on this land, all of which appeared to be of a promising character; and notwithstanding the low level of the ground, which must necessarily add to the cost of mining, the size and quality of the veins were in no degree inferior. From some unfortunate cause, this good mine has been shut down for some considerable time.

Bell's Asbestos Company.—Alongside the Johnson mine, on the same level, is one which was formerly sold by the Ward family to the Boston Asbestos Packing Company. In 1888 this was again sold, through the medium of Mr. Rust, one of the employées of the company, to the late Mr. John Bell, who then transferred it to a London limited liability company, with an authorised capital of £200,000, divided into 200,000 shares of £1 each. The company was formed "to acquire the option of

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purchasing this mine, with 100 acres of land at Coleraine, and a property owned by Mr. Bell, of about 700 acres, supposed to be asbestos land, situate at Belmina, in Wolfestown." The prices paid for these properties, as given in the prospectus, are worth recording.

These are stated to have been £41,300 for the Boston mine, £8,000 for the 100 acres at Coleraine (part of the Reed and Hayden property), and £8,394 for the Belmina land.

Mr. Thomas Sheridan was, until his death, early in 1892, the universally-respected resident manager, a man who was not only well-known to all the mining fraternity, but one of its best friends. After the death of Mr. Sheridan, Mr. George R. Smith was appointed to succeed him.

As soon as the purchase by the company was completed, a steam plant was put down and very energetic work prosecuted, the difference effected by the change, from hand labour to steam power, being very quickly shown by the increased output, which rose (for the season of 1888) to 1,350 tons. In 1889 the produce was said to have increased to 1,800 tons, of which the classification was claimed to be as follows :—

No. 1	1,200	tons.
,, 2	200	,,
,, 3	400	,,
	1,800	tons.

The evil effects of the early dumping arrangements, and the want of technical or engineering knowledge displayed in laying out the mine, are here eminently conspicuous, although the same remark may, in some measure, be made as to all the mines laid out in the early days during the search for asbestos. The depth reached in the excavation here is greater than that at any of the other mines, and the practice has all along been to dump the waste rock on to the land immediately surrounding the opening. The consequence is that the hills of refuse speedily towered up higher and higher, in such a formidable way that it was much to be feared that, in the near future, the work would perforce

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be brought to a stand, unless means were devised of removing this waste, by getting rid of the dumps.

Although out of the 100 acres, which were claimed to be owned by this company, as much as two-thirds of the whole is barren serpentine, so early as 1892, their enormous piles of refuse had reached the line of the Central Quebec Railway, by which they were estopped from further advancement. In order, therefore, to obtain an outlet somewhere, the company were compelled to cross the line of railway, by building a line of their own, which they carried on by means of an overhead bridge. They were thus enabled to connect their dumps with the new ground which they were compelled to acquire, in order to use it as new dumping ground.

These expensive works were more immediately necessitated by the shrinkage of their available ground, brought about by the decisions of the Court on the vexed question of boundary raised against them by their neighbours, the Johnson Company. The lie of the land, as already mentioned, is from north-west to south-east, while the general tendency is for all the richest land to occur in the south-east, and to become more and more barren towards the north-west, and as, unfortunately, the Bell's Company have considerably more of the latter than the former, the natural desire is to secure as much as possible of the land on the south-east. Continual questions therefore arose between the two companies, so that at last an action was brought by the Johnson Company, in order that the decision of the Court might be obtained and the question of boundary settled once for all. The Court decided the question in favour of the Johnson Company, awarding them, at the same time, heavy damages, as compensation for the value of the asbestos which they decided to have been improperly obtained from them. Against this decision the latter company appealed to the Court above, and ultimately to the Supreme Court, which confirmed the decisions of the Courts below, against the appellants and in favour of the Johnson Company. The most serious aspect of the case is unquestionably that the land which the Courts have decided that the Bell's Company have no right to, all lies on the

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south-east side, which is by far the most valuable portion of the disputed ground.

In the first two years of the company's career their dividends were maintained at 22½ per cent.

These were reduced to 15 per cent. in 1890, and in the following year fell to 10 per cent., and afterwards to 3 per cent. In 1897, *i.e.*, the financial year of 1896-7, the payment rose to 5 per cent., with an amount of £4,000 carried forward. The declaration of these dividends is here mentioned, because, barometer-like, they represent the company's somewhat erratic course, about which we can otherwise gain no authentic particulars.

During the past summer, the mine is said to have been worked with a full complement of from 250 to 300 men, boys, and girls, and, during the winter, with somewhat less. There is a good deal of talk of the output of this mine, and I believe that in 1888 it reached 1,350 tons, which at that time was undoubtedly considered something enormous. In 1889 it probably amounted to 1,800 tons, of which 1,200 tons was claimed to be No. 1, and 200 only No. 2, but whether 1896 would bear comparison with the output of 1889, so far as classification is concerned, is very doubtful, especially in regard to No. 1 grade, because the best paying ground is now becoming scarce. In former days, during Mr. Sheridan's managership, the mine was as freely opened for inspection and inquiry as any of the others, but now all such apparently is refused. I fully admit that, as a so-called expert, in December last, permission was given me "to walk over the dumps," but, inasmuch as a foot and a half of snow lay over these on my arrival, I was unable to avail myself of the privilege. Consequently nearly all the information here given is obtained from the local papers or reports, instead of from personal inspection or knowledge, though under the circumstances it is made as reliable as possible.

The Beaver Asbestos Company, Limited, was incorporated in 1890, with a capital stock of $100,000, divided into shares of $100 each, all paid up. The president of the company is

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R. H. Martin, of New York, and the vice-president James S. Mitchell, of Sherbrooke, the remaining directors being Messrs. Lawrence, Woodside, and H. J. Williams. The company was formed to acquire and work asbestos and other mineral lands in the province of Quebec, more particularly Lots 31 and 32, Range C, Coleraine, County of Megantic. The mines are situate on the Quebec Central Railway, about half a mile from the Thetford Station. They are well equipped with suitable buildings and substantial plant and machinery, including a spacious cobbing-shed and steam drier on a siding alongside the line of the Central Quebec Railway.

This mine has invariably maintained a very high reputation. In 1896, when prices sank to their present level, the company resolved to close down and quietly await the revival of trade, which they can well afford to do; the works and machinery being maintained in a highly efficient state, ready for a recommencement of work at the first signs of improvement.

The Thetford Asbestos Mining Company, commonly known as Murphy's mine, was incorporated in 1889, with a capital stock of $200,000, divided into shares of $100 each, all paid up. The managing director of the company is Mr. A. H. Murphy, and the company was formed to work Lots 30 and 31, Range A; Lot 32 in Range B, and Lot 28, Range C, all in the Township of Coleraine, adjoining Thetford, and comprising in all 500 acres of mineral lands. The company, in the first instance, struck some rich ground, but ceased work in 1894, because, as I understand, they had too much overdirt and water to contend with, insufficient capital, and very poor production. There seems, unfortunately, to be but little chance of resuscitation.

The Thetford mines are at a lower level, and are worked at a greater depth, than those of Coleraine and Black Lake, and probably for this reason the general output is of a more uniform character, and does not require such close classification. Nos. 1 and 3 are the practical grades, most of the produce being available for No. 1. No. 3 is a very inferior kind, which was formerly sold and shipped in bulk at $10 per ton. The low-lying ground, between the railway and the river, has been

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proved in various places, but, although good ore has been found here, it does not generally present so promising an appearance as that on the knoll.

In the summer of 1889, the belt of serpentine was uncovered by Dr. Reed on Lots 16, 17, and 18 (600 acres), in Range 4 of Thetford; and, although only a limited amount of work was done, a large number of veins of exceptionally good quality were disclosed. Indeed, all the mineral found in this locality is of excellent quality; the fibre is clear and fine and the rock easily worked; the veins generally, especially those in the lower cuts, being comparatively free from chromic iron and other impurities, and of a width ranging from three-quarters of an inch to four or more inches. Experience, however, has shown, as before stated, that veins ranging from one and a half to two inches give sometimes as good material as can be desired, the shorter widths being less often cut.

When the Thetford mines were first opened, the veins were often found to be cut or charged with grains and threads of chromic iron or of magnetite, the latter sometimes forming conspicuous masses between, and even occasionally entirely replacing, the veins; but as the work progressed this intrusion of foreign matter gradually became less troublesome. As a general rule, however, the upper veins at Thetford have been found nearly as pure as those lying deeper in the rock.

Here as elsewhere, faults are of frequent occurrence; and sometimes sheets of imperfect or immature asbestos in the nature of picrolite, having a long, coarse, woody fibre, are to be met with usually lying all along the sides of the fault.

The Thetford mine-owners are generally ready to give every information about their work, and to facilitate an inspection of their mines by any one taking the trouble to visit them, a trouble which I have usually found very amply repaid by the courtesy with which I was received, and the candour and obliging readiness with which all my inquiries were answered.

The workers are mostly resident on the spot, the proprietors appearing to act in a spirit of liberal consideration towards them, doubtless finding the advantage of looking after the

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welfare of their men by their not running short of hands at critical times.

The Quebec Central Railway runs right through the town where there is a commodious station facing the mines. On stepping out of the train the mines are seen all together in front of the platform, and as the train moves on, the rail has only to be crossed to reach them. At the rear, that is, divided from the mines by the line, are the dwellings of the workmen, at either end of the place, two houses belonging to two of the principal mine-owners, being of a superior class, and in the remoter background the Thetford River rolls sluggishly along.

This river was for a long time believed to mark the western limit of the asbestos-bearing serpentine, the rocks on either side being mostly altered slates and sandstones; but the existence of valuable deposits of the mineral on the further side has now been proved, though at present nothing is being done on that side. To the east, or fronting the railway, the serpentine forms a knoll which has an elevation of eighty or ninety feet above the line of rails, and it is upon this knoll that the present mines are all being worked, and which they are rapidly cutting away.

In the time of Mr. Sheridan's managership, an attempt was made by him, to test the value of the rock at a lower depth, when the trial boring proved very successful, veins of a beautiful silky character, some three inches in width, being brought up from about thirty feet below the present level; the expenses of the shaft were more than repaid, according to Dr. Ells, by the quantity of asbestos removed, but, very unfortunately, in the interests of scientific inquiry, the directors would not allow him to continue so interesting an experiment.

Until very recently but little had been done to ascertain the value of the ground between the rail and the river. Although the ground is low hereabouts, it certainly contains good indications of asbestos; and, as mentioned above, some very promising looking ground was formerly opened by the Messrs. Ward, which proved the fact of the prolongation of the serpentine area between the present workings and the river.

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Further west, both Messrs. King and the Johnson Company have since opened ground which has proved satisfactory as regards quality and quantity of fibre.

The uniform practice, until quite recently, at all the Thetford mines, was to close down entirely for the four winter months, as it was not thought that work could be advantageously carried on during that time on account of the inclemency of the weather. Now, however, they carry on the work through the winter season, though generally on a slightly reduced scale.

Chromic iron is found in this area, but the quality is not rich. Veins of a soft white mineral also occur here, which hardens on exposure to the air; but, unlike the soft serpentine found in the Megantic mine (*post*, p. 159), this does not acquire the peculiar waxy lustre there seen. It has rather the appearance of unglazed white earthenware, and absorbs water with avidity.

On analysis its composition was found to be—

Silica	43·191
Alumina	1·463
Ferrous Oxide	·293
Magnesia	41·520
Water	14·000
	100·467*

The fibre from Thetford differs a good deal from that obtained elsewhere. That from Coleraine and Wolfestown to some extent, and that from Black Lake to a still greater extent, is found to be affected by harshness and a want of elasticity, which causes the percentage of No. 1 from these districts to be very much less than at Thetford. The fibre also is mostly shorter in staple, and a good deal of it discoloured by the infiltration of water impregnated with iron.

As already mentioned, great mistakes were made, here as well as elsewhere, when the mines were first opened, arising mainly from inexperience and want of the knowledge now possessed, which has involved serious loss and expense, and much

* Professor Donald, of Montreal.

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valuable ground is now covered by the dumps which will have to be removed when the land is wanted for working, unless it can, in the meantime, be made available in some more profitable way. Moreover, these mines, being located on ground which, excepting the now fast disappearing knoll, forms a level plain, the clearing of the pits and the removal of the ore and waste rock will gradually become a more troublesome and expensive task.

The same want of foresight in selecting proper dumping ground, for which there was less excuse with the Thetford experience to guide them, has already caused trouble at Black Lake. At one of the main pits many thousands of tons of waste rock have been dumped on to some of the richest of the ground, and this will have to be again moved before that ground can be worked. From the peculiarity of the work, there probably exists no class of mining which so absolutely necessitates the services of a practical mining engineer, to mark out the land in the first instance, for mining and dumping, as that for asbestos does.

During the visit of the American Institute of Mining Engineers, in the autumn of 1889, these defects caused considerable remark, and many suggestions were made as to the desirability of putting matters on a different footing for the future working of the mines.

The cost of extraction of the ore varies in different localities, being dependent mainly on the mass of barren and refuse rock requiring to be removed, which, owing to the natural action of faults, is much greater in some places than in others.

The Coleraine and Black Lake Group.

A very short run from Thetford, on the Central Quebec Railway, brings us to the roughly makeshift shanty which is dignified by the name of the Black Lake Station. This has so little pretension to any civilised accommodation that the traveller at once recalls some similar place, in the rude, early days of Nevada, and is disposed to think he would prefer the bleak hillside as a resting-place. He is, however, pleasingly struck with the appearance of two buildings standing at some

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distance apart, which are the only visible reminders of civilisation. The nearest of these, he is glad to learn, forms the headquarters of the Asbestos Club, which was established a year or two ago, in this wild and desolate-looking spot, to provide a resting-place for asbestos and mining men to meet and consult. The members of the club are ever ready to welcome, in the most hospitable manner, any stranger or visitor who may venture to alight here, either with the intention of regarding



the hopeless nature of the country, or to inspect the mines located there—all information in regard to which will be cheerfully and readily imparted by the active and intelligent secretary of the club, Captain A. M. Evans, the well-known engineer and mining superintendent, or by Messrs. Statham and Bennett, who reside on the premises. He will, first of all, naturally want to refresh the inner man, and his wants in that direction will be promptly and admirably supplied by Mrs. Bennett; after which, he will have nothing more to do than to step over the line of rails, when, with his back to the wretched-looking station, he will find himself in no fairyland, but face to face

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with the ruggedly precipitous and wildly desolate mountains among which the mines are situate. These are scattered over the hillside, where they are found to be next in importance to those last described; but, although the distance from Thetford to Black Lake is less than four miles, there is a very perceptible change observable in the face of the country. The rock formation alters as the station is approached. Nearer to Coleraine it becomes much more massive, occurring also in larger areas, but more generally associated with chromite, magnetite, or particles of mica; and when Black Lake is reached, the traveller is face to face at once with the grim and rugged-looking hills which rise somewhat precipitously from the shore of the lake to a height of 600 or 700 feet, forming the beginning of the bare and cheerless-looking district of Coleraine. There is but little soil here to cover the rocks, and the growth of timber which covered these hills when in a state of nature, has been destroyed by forest fires, while the comparatively thin layer of soil having been washed away by the rains, the bare and sterile rocks are left exposed to view. This is a far more likely-looking country for the prospector than that about Thetford; but, although reasonably good ore is abundant throughout the district, it does not come up to the standard of the latter place, is altogether different from that found at Broughton, and has no comparison with the silky nature of that found at Danville. The general quality of the ore is found to have perceptibly changed, becoming, especially in the upper veins, coarser and more brittle; in places also where there is less depth of soil, the rock is a good deal shattered and occasionally decomposed by weathering, so that it offers greater facility for the infiltration of surface water, which, being a good deal impregnated with metallic oxides, detrimentally affects the value of the fibre by discolouring it.

In the hard siliceous serpentines of Wolfestown, Ireland, Coleraine and Black Lake, asbestos only rarely occurs, and often when it does appear is found to be only imperfectly developed, or in short veins. In the mine of King Brothers in Ireland, the serpentine is regularly stratified in places, just like sandstone

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or quartzite, in layers dipping to the north-west. In some other places, the veins cut the rock almost horizontally, and when seen on a knoll can be traced across from one side of the hill to the other on the same plane, but as a rule they are irregularly placed. Moreover, they seldom reach two or two and a half inches in length, though the fibre is good.

Owing to the destruction of the forest over the knolls of serpentine by bush fires, to the action of the weather, or to the intrusion of masses of granulite, the fibre here is often found to be harsh and brittle, especially near the surface, changing, sometimes, to greater softness as the veins are opened out deeper in the solid rock. This peculiarity has given rise to a good deal of speculation, and various causes have been suggested to account for it: difference of level, for instance, the forest fires, or the granulite, which is here abundant, and the heat from which on its protrusion through the mass of rock, has undoubtedly had a tendency to dissipate a certain proportion of the contained water in the chrysotile, in the same way as caused by the forest fires, though on a more extended scale. Professor Donald has shown that harsh and brittle kinds of chrysotile contain less water than those of a softer nature. In very flexible fibre he found 14·05 per cent., whilst in a harsh-fibred sample there was only 12·62. The same effect can be produced by placing a piece of the ore on a sufficiently heated surface, when the fibre will be found in a very short time to have lost its softness and flexibility, and to have become harsh and brittle, and in this state it may often be crumbled between the fingers. The writer has frequently, at Black Lake, seen boxes of ore brought into the cobbing-shed after a wet night, when the men would set to work to pile it up round about the stove, so as to dry it somewhat before cobbing, when that which was placed nearest to the stove, or possibly kept there too long, would gradually, in some measure, become changed, and present the harsh and rough features mentioned.

If the aqueous origin of asbestos be admitted, it seems reasonable to suppose that all the fibre, when first deposited, was soft and flexible, containing a maximum amount of water, and that

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movements of the rocks, producing heat, have, in the course of time, driven off a portion of the water of the contained asbestos and thereby destroyed the softness of the original fibre. Veins at considerable depths may have been subjected to the heat produced by these movements, and yet not deprived of any portion of their original water, because of the resistance of overlying rocks.

On this point, Professor Donald suggested the following explanation: "Asbestos is principally a hydrous silicate of magnesia, *i.e.*, a silicate of magnesia combined with water, and this water is not present as moisture—the moisture of bread for example—which can be driven off at a temperature of 212° F.; it is water more intimately associated with the silicate, but which may be dissociated from it, and driven off by a high temperature, just how high I have not yet determined. When harsh fibre is analysed we know it contains less water than soft fibre. In fibre of very fine quality from Black Lake, analysis showed 14·38 per cent. of water, while a harsh-fibred sample gave only 11·70 per cent. It is also 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 thumb and finger." There is evidently therefore some connection between the consistency of the fibre and the amount of water in its composition. It is probable that the harsh fibre was, when originally deposited, soft and flexible, and has been rendered harsh by having a portion of its water driven off by heat, either produced by movement of the associated rocks, or resulting from the injection of molten matter through volcanic action.

Granulite.—The granulite referred to above is of a greyish-white colour, and mainly consists of orthoclase feldspar and quartz, which is thrown up after the manner of dykes. Near the contact with this, the serpentine is often considerably shattered, as though the presence of the granulite had exercised a marked effect on its condition. At Thetford, the intrusive rocks in the mines are limited to small and thin dyke-like veins, which do not appear to have produced any marked effect on the ore; but here the granulite forms masses of a much greater size, and these have produced a correspondingly greater effect.

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Dr. Ells, however, truly remarks that the stiff-fibred mineral is not in all cases confined to the vicinity of the granitic masses, and consequently it is just possible that other causes may have tended to produce a somewhat similar effect. It is scarcely likely that the difference in level can have anything to do with the change in quality of the ore, because the operations of the Glasgow and Montreal Company are carried on 300 feet higher than the Thetford mines, and Dr. Reed's mine (now belonging to the American Company) is at least 300 feet higher still, and in both these mines excellent fibre is found. The most likely cause is that of dehydration, brought about by the intrusion of the heated masses of granulite when forced up from below.

In one of the granulitic dykes, on the Glasgow and Montreal Company's property, Professor Donald found and sent to me a sample of *scolecite*,* which occurs in transparent glassy needles, filling minute veins, and in masses of white, grey, and colourless radiating fibres. This is believed to be the first zeolite found in the dykes cutting the serpentine here, and the first known to occur in Canada. Enstatite, conspicuous because of its bronze lustre, is also found here in the serpentine.

Glasgow and Montreal Asbestos Company.—This company was formed to take over the property formerly owned by the Scottish Canadian Asbestos Company, and was registered in Scotland in July, 1891, with an authorised capital of £70,000, divided into 35,000 preferred and 35,000 deferred shares of £1 each; the preferred shares to rank first for non-cumulative dividends of 7 per cent. per annum and take one-half the surplus profits, the remaining half to go to the deferred. The preferred shares also have a priority as to the capital.

The property includes the Martin Mines in Coleraine, Megantic County, and the Frazer Mines in the Township of Broughton, County Beauce, with all the machinery, plant, and tools, of the defunct Frazer, or East Broughton, Company. The property is a good one, having broad, well-made roads traversing it, a good manager's residence, capital accommo-

* From σκώληξ, a worm, in allusion to its action when heated before the blowpipe, when it will curl up in worm-like fashion.

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dation for the men, and generally efficient, well-built premises. The company's property in Coleraine lies in the form of a parallelogram, and covers somewhat more than 100 acres. Towards the north, and along the northern boundary, the ground rises to about 100 feet above the level of the railway, which is distant about a quarter of a mile. To the south-east the hills, mainly composed of talc and mica schists, increase in elevation until, at a distance of about 1,800 feet from the railway, it attains a height of 900 feet above the level of Black Lake. At this point the serpentine formation begins, forming a ridge 300 feet higher than the highest point of the shales. The serpentine belt crosses the company's property east and west, and is bounded along its northern margin by a mass of quartzose granulite, which is here separated from the serpentine by a narrow band of steatite. The mine is fully equipped with powerful machinery, and a new set of appliances for crushing and separating the lower grades of ore, which, as we have already seen, are very considerable in all the Black Lake mines, as well as to save the expense of hand cobbing. In 1888 the production here had risen to 400 tons, of which amount 40 tons were No. 1, 110 tons No. 2, and 250 tons No. 3.

The developments of the Martin Mine consist of an excavation on the hillside, 225 feet long by 100 feet wide. The lowest level of the quarry, at the time of my last visit, was about 80 or 100 feet below the highest point of the profile of the mountain (now much lower) and communicated with the dumping-ground by a cut through the granulite and soapstone.

Another quarry opened on the same property is called the "Bonanza." Both quarries are, from their position, well drained, and free from the water which is so great a trouble at the Frazer Mines. The houses for the manager and workmen, stores, factories, stables, and workshops form groups on the hillside, which give a cheerful appearance to this part of the country.

The works here have recently been equipped with a new plant, consisting of a Corliss engine, 90 horse-power, a tubular boiler, 100 h.p., with a cyclone, 24 in. beaters, running 2,200 revolutions per minute, a double fan, one large shaking screen,

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a Blake crusher, a revolving picking table, and one pair Cornish rolls, 24 in., with some necessary sundries. In the mines also there is an Ingersoll straight line air compressor (with seven drills), two Bacon winding engines 8 in. × 12 in., pumps and derricks, and an 18 ft. × 30 in. drier, the whole being under the general superintendence of Mr. James Costigan, ably assisted by the well-known Captain A. M. Evans.

This was the first mine which made any attempt to solve the difficult problem of cobbing the ore by the use of machinery, that is, freeing the veins as much as possible from the encumbering rock; and considerable progress was being made in this direction when, unfortunately, the full development was suddenly interrupted, by the unexpected closing of the mines in 1888. This mine has had a somewhat variable existence from the commencement. As the Scottish Canadian, it was first bought in 1886 from Mr. Charles Lionais. In 1891, it was bought by the Glasgow and Montreal Company, which commenced working in the spring of that year, but continued for only two seasons. In 1893 the mines continued at work until about the close of 1896, when they were shut down.

In the Black Lake District mines (by which, of course, I mean only those which are honestly conducted and not mere plunder traps, which can have no interest for the general public) the much larger percentage of No. 3 than is found at Thetford, makes some arrangement for machine cobbing specially desirable; and even quite recently it was a matter of constant difficulty with the manufacturers to find so much useless rock sent with the crude asbestos. Of course, much of this is due to imperfect or careless cobbing, but on one occasion, in the early days of the industry, I was witness to a scene which caused me much amusement. A quantity of bags were being filled, in completion of a purchase, when the seller of the stuff, a man ostensibly of exceptional piety, occupied his leisure moments by deliberately "sanding the sugar"—that is, thrusting into the bags lumps of unmistakably fibreless rock, to add to the supposed weight. As I was going over to inspect the manufactory, at New York, I carefully timed

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my visit for the arrival of these bags, when the manager, for my edification, turned one of them into the crusher, so as to explain the operation; but as the process went on, he stooped continually and threw out on to the floor lump after lump of useless rock. At length, losing patience, he exclaimed to the seller, who also was looking on, "Look here, Mr. ——, just understand that when we buy asbestos, we want to get asbestos, and have no use for rock." Nothing more was said at the time, but on leaving the factory, the pious fraud remarked, "That's all very well, you know: these precious manufacturers fancy they know all about asbestos, but we shall have to educate them up to the point." It is possible that the education is still proceeding, though I doubt much if it be in the laugher's direction. Of course, it will be well understood that this is merely an illustration of an amusing act of scoundrelism carried on there, of which only too many are within the writer's own personal cognisance, and has not the remotest connection with the Glasgow and Montreal Company, all of whose *employés* were and are men of a different stamp, and far too respectable either to substitute one sample of ore for another, or to "sand the sugar" in the way described. This company has also recently been trying to manufacture asbestic from some portion of picked rock from their dumps, but their success has not hitherto been of an encouraging nature. No buyers could be found for the so-called "float," as it passed from the cyclones, and I understand the company has now ceased working, though it is doubtless a temporary stoppage only, as there are 300 or 400 tons of good material still lying about the pits, which will doubtless be cycloned in the coming spring, when we may have a better time than has recently been the case.

The American Asbestos Company, Limited, formerly known as Wertheim's, occupies the south-western halves of Lots 27 and 28, Range B, of Coleraine, about 104 acres in extent, purchased by Mr. Louis Wertheim from Dr. James Reed, and afterwards by him transferred to a company, under the above title, for $40,000. The mine and works, situate on the high ridge near the Black Lake Station, are at present the

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most elevated in the district, being as much as 600 feet above the level of the lake. The mines were bought from Dr. James Reed, of Reedsdale, in 1888, and operations were commenced in the spring of the following year. Some houses were previously built for the men, and a gang of Belgian miners brought over and located near the mines, where they apparently formed a contented little colony. A good steam plant was put in, consisting of a 16 × 24 Rand 7 drill compressor, five boom and cable derricks, one Blake 9 in. × 15 in. crusher, two Copeland and Bacon's hoisting engines, and a disintegrator, with the necessary fans, screens, blowers, &c. The mill and other buildings, boiler and engine houses, with some thirteen double tenement houses, four cottages and dwelling-house for manager, are all well and substantially built. Mr. L. A. Klein was, until the close of last year, the company's resident engineer and manager.

A new departure was some time ago taken here. In order to facilitate the development of the mine, a tunnel was run in from below, under the Nos. 2 and 3 pits, where a shaft was cut 100 feet in length to reach No. 2. This tunnel is six feet by six, and both the tunnel and shaft run the whole distance through asbestos-bearing rock, all pumping being thereby avoided, and a good working face formed.

During the first six months of the year hand labour only was employed, after which the steam plant was put in operation. The mining figures for the first year are worth recording; these were:—

No. 1	79¼	tons.
,, 2	81¼	,,
,, 3	357¾	,,
Hornblende	12	,,
	530¼	tons.

This company, I now learn, has apparently come to grief, being at the moment of writing in the hands of the liquidators, who, as I am informed, are offering the same for sale. In 1890–91, it was the next to start experimental crushing, the main object being to get rid of the objectionable grade No. 2, which seemed difficult to accomplish until the fibre had been

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thoroughly loosened and freed from rock. The best class of fibre, as we all know, is easily freed, but some of the poorer class of Black Lake fibres are exceptionally difficult. The Danville fibre, on the contrary, is unusually easy to separate, the bulk parting at once from the rock even if dropped on to the floor.

The material from the mine is conveyed by an inclined railway to, and automatically dumped in front of the crusher, after passing through which, the crushed matter is dropped on to an inclined shaking sieve, which separates all the loose fibre and the dust from the larger pieces of rock and the veins, the former of which is then passed directly on to the cleaning and grading machines, while the latter drops on to a revolving picking table, where the barren rock is removed by hand to one side, the asbestos veins being retained on the other. At the end of the table there is a receiving shute, divided into two compartments, into which the asbestos and the rock are separately discharged. The rock falls into a lorry to be wheeled off to the dumps, while the asbestos is conveyed to the drying kilns or to the fine crushers for further manipulation. Ultimately, the stuff is conveyed to the cleaning and grading machines, which are a set of inclined sieves, set in rapid shaking motion in connection with fans, blowers, &c., the unbroken stone and unloosened fibre going back to another set of still finer crushers so that the process may be again repeated. These mines were worked regularly, with the exception of the one season of 1892. Last year they were worked only on a limited scale until the closure, which took place at the beginning of the present year.

The United Asbestos Company's Mine (formerly the Frechette and Deauville).—This company bought the property they now own in 1889. It contains about seventy-five acres, situate on Block A, Coleraine, about a quarter of a mile from the Black Lake Station of the Quebec Central Railway, bounded on one side by the Glasgow and Montreal Asbestos Company's property, and on the other by the Anglo-Canadian Company's land. The company also in 1895 operated on the Broughton asbestos property (the Frazer Mine), under lease from the Glasgow and Montreal Asbestos Company, where

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their work has been principally in the nature of opening and developing new ground, a small force being set to work on the main vein, from which extraordinary results were obtained in Dr. Reed's time, when the Frazer was first started. About midsummer last, the company made an arrangement with the Glasgow and Montreal Company to work their Broughton property by royalty, intending to commence the work by means of shafts, or stopes, of which three had been commenced by the former owners of the property, the work being contracted for at per ton; but up to the time of the suspension of operations the yield scarcely seems to have equalled expectations. The fibre formerly obtained from this vein, the only one worked, was considered, from its length and silky nature, not only second to none at Thetford, but superior to anything in Canada, and fetched a correspondingly high price; but this main vein—I believe there was only one—was lost by a fault in the strata, and the Glasgow and Montreal Company had good hopes, when they took over the property, of striking it again, though up to the time when they agreed to lease the property to this company, they had not succeeded in doing so.

Speaking of their Black Lake property, Mr. Fisher, the company's manager, remarks that in the asbestos-bearing rock proper, the veins of asbestos are seen, without any special arrangement, intersecting the mass of the rock generally, in every direction. In size they range from mere threads, sometimes lying quite close together, to a thickness of one to two, and, occasionally, three to four inches. The asbestos from these larger-sized veins, provided it contains no serious impurities, is classed as grade No. 1, and is used for spinning and weaving; the shorter stuff and such as contains impurities is classed as No. 2 and No. 3 respectively. These latter grades are used principally in the United States for millboard, boiler and pipe covering, and other purposes. The mines are calculated to produce a considerable amount of what is called "Paper Stock," the produce being both white and silky, though short in staple. Nearly all the rock is impregnated with small veins of good asbestos, and occasionally some fine Nos. 1 and 2 are

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met with; but altogether, the mining must be said to be difficult by reason of most of it lying at such an acute angle, the formation being altogether different from that of any other mine in the district.

The form of the company's land here is of so inconvenient a character that, as they progressed with their work, it was found they could dump no more waste rock without encroaching on their neighbour's land; so, in order to prevent a stoppage, the company were under the necessity of building an inclined tramway, 3,800 yards in length, by means of which cars could be drawn up the mountain side as far as the shore of Cariboo Lake, where, for the present, they can find room for dumping.

The character of the ground, and nature of mining, or more correctly quarrying, asbestos in Canada is altogether different from anything to be seen in Italy. Hand labour, which is compulsory in Italy, owing to the difficult nature of the ground, has been largely superseded here by the use of steam derricks, drills worked by compressed air, and other appliances.

When a block of asbestos-bearing rock has been displaced by the usual methods employed in blasting, the pieces are broken up, all barren or waste rock removed to the dumps, or waste heaps, and the remainder passed through the cobbing process, by means of which the remaining rock is removed, and the asbestos exported in the form ready for the manufacturer.

This company has a full equipment of machinery, with a winding-engine to operate the tramway already spoken of, on the main and tail rope system by the Bacon engines, in order to carry the waste to the dumps, where it is deposited in a valley on the other side of a hill, on what is believed to be non-bearing asbestos land. The company have now shut down their works, preferring to quietly wait the result of the great discoveries at Danville, and buy rather than mine, if they shall find it more expedient to do so.

Adjoining this property is one belonging to the so-called *Anglo-Canadian Company*, which, like the White's Asbestos Company, has no interest with the general public. This is

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noteworthy only as having been fathered on the London market by the once well-known Baron Grant.

The Southwark Mine is opened on the northern halves of Lots 27 and 28 on Range A, part of what was formerly known as the "Reed and Hayden" property; it comprises the 100 acres of land which formed part of the purchase of the Bell's Asbestos Company, Limited, as previously mentioned. It was formerly under the charge of Mr. Calvin Carter, late of Belmina. The output, up to 30th June, 1889, was returned as 198 tons, but the comparative grades were not given. What, if anything, has been done since, we have no means of knowing; probably very little, as I am informed the property is not considered a valuable one.

Reed's Mine.—On the north side of the Poudrier Road, on Lots 27, 28, and 29, Range A, work has been commenced by Dr. Reed, by clearing the ground and opening it up sufficiently to show the quality of the ore: some good veins have been disclosed and remain open to view. In the spring of 1890 active work was commenced by the owner, about thirty men being employed on contract, with highly satisfactory results.

Between these properties and Cariboo Lake the serpentine extends in a continuous ridge, and shows at intervals very good indications of asbestos. This area, however, has not yet been sufficiently explored for much to be said, from actual observation, of its value as asbestos land, though it seems reasonable enough to suppose that this portion of the serpentine belt will presently be found equally valuable with that of the adjoining section.

Megantic Mine.—On again entering the onward path and progressing further towards Coleraine, serpentine is found to occur near the station; but the main ridge of the rock, extending southwards, keeps to the north-west for about a mile and a half, where it forms a conspicuous hill feature. An opening made on this south-west extremity some years ago, by Mr. Kennedy, disclosed a number of asbestos veins, one of which had a width of nearly four inches. In 1888, preparatory work only was carried on, but the result was sufficiently satisfactory to justify active operations. Dr. Ells reported for 1889 as follows:—

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"The rock here is very much shattered near the surface and the fibre is consequently discoloured. Veins up to one inch and a half are found, and in the more solid portions the quality improves. The output from this place has been necessarily small, owing to the time spent in opening the mine, and the delays from bad weather. The quantity mined in the four months, ending 1st October, was 39 tons, of which one-third may be classed as No. 2, the rest as No. 3. An average number of twelve men was employed."

A peculiarity has been observed here, the serpentine wall for a distance of many feet being laced with infinitesimal veins, often not more than the twentieth part of an inch in thickness, which, on fresh surfaces, present just such an appearance as it would do if the rock were striped with white paint, thus giving it a great similarity in look to the Laurentian deposits at Templeton and Buckingham.

In the immediate neighbourhood of this last mine, operations were commenced by Messrs. Lambley and Co., of Inverness, and some good veins were met with at the top of the hill.

Mining in this locality was commenced in 1886, when the longer veins were not found to be persistent for any depth, the rock being greatly shattered near the surface and for as much as fifteen feet down, and though a great many veins were found, some of them in the solid rock, much of the fibre was discoloured. Another peculiar feature here, which has not been observed in any other of the mines of this district, is the presence of irregular veins of mica, in scales of an inch or more in diameter, in a paste of decomposed serpentine or soapstone. There is also a singular form of serpentine which occurs in narrow seams, of so soft a character that it may be compressed between thumb and finger, and varying in colour through white, blue, green, and yellow, but, when exposed to the air, it becomes hard and assumes a waxy lustre.

On the same ridge, but on the extreme west limits of Lots 24 and 25, Range 3, Ireland, Messrs. King Brothers have started two openings. The elevation of these above the level of Black Lake is, by aneroid, 500 feet. The asbestos is there principally

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met with in two knolls lying about a quarter of a mile distant from each other. Many of the veins show a selvage of white weathering serpentine, separated by a vein of asbestos from a quarter to three-quarters of an inch in width. The general aspect both of the rock and veins strongly resembles those found at Belmina, but the quality of the ore is much better, and successful mining far more likely. Messrs. King Brothers have developed considerable amounts of asbestos in Wolfestown, on the opposite side of the Lake, short in fibre, but no doubt valuable. And there have also been many minor concerns started, which it is scarcely worth while, at present, to particularise.

The serpentine in this neighbourhood appears to be in some parts regularly stratified, like sandstone or quartzite, the layers dipping to the north-west, and the asbestos following the bedding planes of sedimentary rocks.

East Broughton.—In order to visit the Frazer Mine here it is now necessary again to take the train and return through Coleraine, Black Lake, and Thetford, after which the East Broughton station is soon reached, whence it is only a short drive to the mine, the road passing through a much more cheerful-looking country than that previously traversed. Broughton, which marks the extreme eastward limit of the asbestos region, so far as yet opened up, is in Beauce County, just outside the boundary of the Eastern Townships, and here the land is of a more pastoral character, with many pleasing stretches of woodland scenery.

The Frazer Mine was first opened and worked by Dr. Reed. The discovery made a great stir at the time, as no mine in Canada had then, or indeed has since, produced asbestos of quite the same quality; but, to all appearance, the big vein (there was only one) was soon worked out, the ore exhausted, and work in consequence discontinued. When first uncovered the vein was nearly a foot thick, and remarkable for the silky softness of its fibre. It was found at the contact of the serpentine with blackish slates, which in places have a greyish or purple shade, containing bands of hard bluish-grey quartzite of the Cambrian series, thickly veined with quartz. It is overlaid in places

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with soapstone of good quality, from ten to fourteen inches thick, with which the asbestos here seems to be intimately associated. The vein had the general aspect of a well-defined vein with, in some places, a hanging wall of soapstone, and was worked for a distance of several hundred yards to a depth of about seventy feet. In the lower workings it was found rapidly to decrease in size, and ultimately it split up into minute strings which rendered it worthless.* As a rule, it may be taken that the association with talc or steatite is not promising, especially if the latter occurs in any quantity, because, under such circumstances, the serpentine rarely carries veins of asbestos to any extent; consequently, such steatitic rock is not usually looked upon as good mining ground. The Broughton ore is an exception to this, the vein there being of large size and unusually good quality, and this was found to lie between walls of serpentine and soapstone; though, even in that case, as the soapstone became more abundant, it was found that the veins of fibre rapidly diminished. At the Thetford, Black Lake, and Danville mines, steatite is generally absent.

Although at some little distance from the station, the Frazer Mine lies close to the rail. It is now the property of the Glasgow and Montreal Asbestos Company, and comprises 116 acres of freehold land extending over about 2,000 acres more, which, as already stated, has been leased by them to the United Asbestos Company, supplemented by mining rights. Large sums were expended in laying out this property during Mr. Lionais's time, perhaps somewhat too lavishly, in the erection of buildings, factories, machinery of all kinds, tram lines, etc., the extravagant outlay being, no doubt, the primary cause of the Scottish Company going into liquidation, which was felt at the time to be a great misfortune for the district.

When I visited the mine, in the autumn of 1886, I went all over the ground with the late Mr. Frazer, but we were quite unable to trace any part of the big vein. Our search, however, was a good deal impeded by the depth of water in the

* Dr. Ells, on the "Mining Industries of Eastern Quebec," Second Report, 1888.

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cut, which prevented our making so complete an investigation as I could have wished, although by manœuvring in the water I was able to get one or two good samples.

The vein was from eight to ten inches thick, near the surface, but decreased at the bottom of the workings, some sixty-two feet down, to two or three inches, when it became irregular, splitting at times into many fine strings disseminated through the serpentine; in other places it presented a continuous vein of fibre. Three shafts were sunk to a depth of sixty-one, sixty-two, and seventy-five feet, following the slope of the bed or vein at an angle of about 75°, the rock dipping S.40° E. to true meridian. The mass of serpentine, which lies to the west, was carefully examined at several points, but only in one place, about 150 feet in rear of the openings, were small strings of asbestos seen, of one-fourth to half an inch in width. Much of the fibre in the north slope appeared to be stiff and harsh, while other portions were beautifully silky. The serpentine resembles in character that found near St. Sylvester, and along the Chaudière.

The belt in one part is very narrow, contracting in places to not more than fifteen feet in width, the veins of asbestos being found closely compressed together. This imparts a certain regularity to the deposit, which up to this time has been observed nowhere else. Schists, talc, and serpentine are interstratified to a depth of from eight to ten feet, and the asbestos veins in the serpentine connect with and join each other, forming distinct leads, from fourteen to sixteen inches wide, which occur as congeries of divided or partitioned-off seams. There is less waste here than usual, but the breaking out of the rock is more difficult.

The Broughton ore has a pale yellowish-green hue, as distinguished from the darker greenish metallic lustre which distinguishes the finer samples from Thetford, which is another peculiarity of this ore, the light-coloured serpentines being almost always barren everywhere else. The colour of the ore, however, does not always affect the clear whiteness of the fibre when crushed out, although it affords a means of identifying the locality of production. There are, in fact, as I have already

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mentioned, certain peculiarities, even of colour, attaching to the ore of each locality of so marked a character that an expert can at once tell, on inspection, from whence it was obtained.

The cost of extraction was put by Mr. Obalski at $35 per ton, which is caused by the peculiarity of stratification and the greater difficulty of mining, and he is of opinion that the output will certainly be limited.

Operations were going on here, some time ago, for the utilisation of waste, and at Coleraine also, previous to the stoppage, the narrow veins of only a few lines in thickness usually passing as waste, and as such thrown on the dumps. There is certainly no reason why this should be so, because, if properly treated, these thin veins would pay for the trouble bestowed on their separation. Thousands of tons are annually wasted, much of which is as much due to careless work as to inefficient machinery; but this will no doubt be presently remedied as the mineral becomes more valuable and improved machinery is employed in its preparation for market.

There is abundance of soapstone at Broughton, much of it of good quality, some remarkably pure, and some of it curious. I brought away with me a fine specimen, having all the grain and fibrous markings of asbestos, but otherwise pure and unmistakable steatite. No use is made of this at present, all attention being devoted to the production of the higher-priced chrysotile.

The following very interesting comparative analyses of some of the ores of this part of the country have been furnished me by Professor Donald, of Montreal, who has made a special study of the mineral :—

	No. 1. Asbestos.	No. 2. Asbestos.	No. 3. Asbestos.	No. 4. Asbestos.	No. 5. Serpentine.	No. 6. Picrolite.
Silica . . .	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	·89	—	—	1·32	—
Ferrous oxide .	2·26	·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 No. 1.

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No. 2. Very fair quality ore from the Glasgow and Montreal Company's mine at Broughton.

Nos. 3 and 4. Asbestos from Danville; analysis by Professor Smith, of Beloit College.

No. 5. Serpentine from Brompton Lake.

No. 6. 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.

South Ham.

The mines here, of which a rough sketch is shown, are situate on land known as the Nicolet Estate, in the Township of South Ham, about seven and a half miles from the Garthby Station of the Quebec Central Railway.

It was on a brilliant morning in the latter part of October, 1886, that I started from Black Lake, where I was then residing, to visit Nicolet, on the invitation of the owner. There had been a sharp frost in the night, forerunner, as it proved, of an early and severe winter; but when the sun rose the air was delightfully crisp and invigorating. A quick run on the rails took us to Garthby, a characteristic Canadian settlement, pleasantly situated on the shores of Lake Weedon. The view over the lake, with its background of timber-clad hills, bathed in brilliant sunshine, was very charming; but as that was not what we had come out to see, we had to mount our buggy and start off at once for a drive over a rough mountain road, in order to reach our destination before evening set in.

On arrival, we went straight on to examine the owner's antimony mines, to which he was then devoting his whole attention, he being satisfied with knowing that asbestos existed in abundance on the property, leaving its exploration for a future day; but as it was that mineral only with which we were then concerned, we will reverse the operation.

The asbestos deposit here was first discovered on what is called Big Island, being the largest of seven islands ornamenting the sheet of water called Lake Nicolet. The serpentine rock which forms Big Island, rises very abruptly out of the water to

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SKETCH MAP OF THE LAKE NICOLET ESTATE [*To face p.* 165.

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the height of seventy feet, forming, on the western side, precipitous cliffs, the whole of which is seamed with asbestos. Recent exploration, however, has shown that the main body of the mineral, passing under the lake, occurs on the hillside, and is of such extent as altogether to eclipse that proved to exist on the island, which was at first thought to be the chief source of supply.

The mine on the island was not being worked, but had been fully proved by numerous openings which had been made at the most promising points, revealing in every case veins of asbestos of remarkably good quality and in great abundance. These pass under the lake, and can be seen cropping out in many places, off the shore and on the hillside.

The mineral as seen on the island presents many points of difference from that at Thetford and Coleraine; and in the Geological Survey of Canada, written many years ago, it is stated to consist of four varieties, viz. :—

1st. Small veins, rarely exceeding half an inch in width, the fibres 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.

Very little (the report says) has yet been done on the island to develop these asbestos veins, perhaps owing to the difficulty of transport across the lake. *This, however, would probably be*

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*more than counterbalanced by the magnificent returns which this locality promises to afford.**

There could, however, be no practical difficulty in arranging this question of transport; but when mining for asbestos is undertaken here, there will be but little temptation to commence operations on the island, as the deposits on the mainland (which were not known to exist, at the date of Mr. Willimott's visit) will furnish abundant scope for energetic work for many years to come.

The temptation to describe the scenery round the lake is very great, but as that does not fall within the scope of the present work, it must be sufficient to say that it is of a very charming character.

The estate itself might very justly be termed unique in regard to mineral wealth, for, comprised within its 2,000 acres, are found not only rich veins of antimony and asbestos, but enormous deposits of steatite, magnetic iron, chromic iron and bog-ore, as well as copper and sulphur, and it is believed both nickel and cobalt. Silver to the value of $4 a ton is found with the antimony, and reefs of auriferous quartz run through the entire property, a sample from which, on assay, gave 2½ oz. gold to the ton.†

The Commissioner of Crown Lands, in his report for 1889, says that the antimony mines have not recently been worked, except in the way of exploration, which has led to the discovery of many new veins. Since then a considerable amount of work has been done; an adit, from the bottom of the hill, effectually drains the mines, and some very fine veins have been disclosed, including much native antimony. Some fine crystals of *Senarmontite*‡ have also been found here. It is also worthy of note that Professor Dana, in his "Descriptive Mineralogy" (1877), instances these mines amongst the few places in the world

* Willimott's Report (1882) on some of the Mines in the Province of Quebec.

† Report of the Committee appointed by the Dominion Government to investigate the Gold Fields of Canada.

‡ The isomorphous sesquioxide of antimony.

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where veins of antimony occur. Some singularly fine specimens of native antimony, kermesite, stibnite, and valentinite,* from these mines, shown at the late Colonial and Indian Exhibition, for which a medal and diploma were awarded, are now in the charge of the Canadian authorities in London, having been presented by Dr. Reed to the Imperial Institute. These will be found specified in Dr. Selwyn's "Descriptive Catalogue of the Economic Minerals of Canada, 1886."

Everything necessary for the working of these valuable deposits already exists on the ground—unlimited water power, and timber for building and mining purposes, as well as for charcoal for any furnaces that may presently be erected; sufficient, if judiciously managed according to the rules of forestry as practised in Germany, Austria, and Russia, to last until a new growth matures. In regard to transport, the roads are good, and a line of rail connecting the Grand Trunk with the Intercolonial will presently touch the property, and will, it is expected, have a station there just below the antimony mine. In regard to steatite, the quantity is so enormous that an expert, lately sent to report on the property, speaking of this mineral, writes, "All I can say is, there are mountains of it."

Wolfestown.

The description of the asbestos area of Wolfestown is given by Dr. Ells, as situate on the north-east 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.

The Belmina Estate, distant about four miles from the railway station at Coleraine, comprises about 700 acres, and, as already stated, was formerly the property of Mr. John Bell, and by him transferred to Bell's Asbestos Company, on its formation in London, in 1888, for the sum of £8,394. The surface indications here are said not to be equal to those at Black Lake, but at several points numbers of veins are shown,

* Valentinite, with the same chemical composition as Senarmontite, differs from it in crystallisation.

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some of which are said to be from one and a half to two inches thick. A very fair showing of workable veins has been exposed on the upper part of a deep cut, which it is proposed to intersect at a considerably lower level. Should the same rule of increase which holds good at Thetford and Coleraine apply here, there should be good paying ground exposed when the lower level is driven in past the cap of barren rock, provided the veins already disclosed are not cut off by faults, the presence of which is noted here as at other points.

Brompton Lake.

Late in the autumn of 1889, operations were announced as about to be commenced by some capitalists of Montreal on property acquired by them near Brompton Lake, where deposits of asbestos are known to exist; a very fine sample of which was soon after sent to me for inspection. A company was, in the following year, formed to work it, under the title of the "Brompton Lake Asbestos Company," with a registered capital of $60,000. The property is situate on Lot 26, and half of Lot 25, Range 9, Brompton, in all 337 acres, about eight miles from the Grand Trunk and thirteen miles northward of Sherbrooke. The company is under the presidency of E. B. Greenshields, Esq., of Sherbrooke. The fibre, though somewhat short, is of good quality and remarkably free from intrusive iron. The rock seems to be in close connection with great masses of diorite and slate, which contain a profusion of white garnets.

To the north of Orford Mountain, and in the Township of Brompton, the Cambrian rocks have a wide development. The area about Brompton Lake is much broken by intrusions of diorite and masses of serpentine, many of very large extent. The serpentine here crops out continually, reaching as far north as Windsor Mills. The belt extends across the country, between Webster Lake and Brompton Lake, in a series of hills, which form a conspicuous ridge along the east shore of the latter, extending northwards to the line between Ranges 8 and 9; the Brompton Lake Asbestos Company's mine being, as stated, on Lot 26, Range 9. At one place further on, Lot 8, Range 7,

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SKETCH MAP OF THE DISTRICT OF DANVILLE.

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Bolton, an asbestos mine was formerly opened, but was not successful. The serpentine is here associated with black slate, but more to the west, chloritic and micaceous schists appear. The serpentine rock is much shattered and frequently slaty in structure, with a rich green unctuous appearance, unlike that of Thetford, but very similar to much of the rock about Orford Pond and the north side of Orford Mountain. Several attempts have been made to find asbestos in the southern belt of serpentine, but hitherto without success. Most of the serpentine in this locality is of a hard compact sort, and shows two kinds of asbestos, namely, a short, stiff, black fibre, which is of so harsh a character as to be totally unfit for spinning or felting; and another also of very short veins, of a whitish green fibre, of little use for any manufacturing purpose.

Some time ago a peculiar form of chrysotile was discovered on Lot 8, Range 9, of Ross, Ontario, and also on Lot 9, Range 7, close by. Openings were made in the serpentine limestone, and a vein of silky chrysotile was disclosed, the fibres of which were said to have been a foot in length, but inseparable, with the additional peculiarity of becoming brittle on exposure. In another part of the same land, a four-inch vein was met with, composed of separable fibres, which was flanked by long strings of picrolite, the filaments of which lay at right angles to the chrysotile.

And in 1890, *The Standard Asbestos Company, Limited*, was incorporated with an authorised capital of $100,000. This was formed to acquire by purchase or otherwise, and hold, asbestos and other mineral lands. The property consists of 249 acres situate in the Township of Elzevir, in the County of Hastings, Ontario. The directors are the Hon. J. E. Campbell, of Hamilton, Ohio, and F. J. Falding, of New York. In 1895, some development work was done, but little has been heard of the company since. Some of the fibre here was said to be nearly an inch long, white and strong, but harsh to the touch, like much of that about the Orford Mountain, but the crystals apparently were so crossed and interwoven, that the fibre was difficult to separate from the matrix without a large percentage of loss.

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DANVILLE.

The Asbestos and Asbestic Company's Mine. — Before closing this short account of the origin, ownership, and proceedings, so far as we have been able to learn them, of the various asbestos mines situate in the province of Quebec, we have now to speak of one other, which lies just beyond the boundary of the Eastern Townships, and has only quite recently assumed a most important character, not only on account of the peculiar beauty and economic value of its fibre, but also by reason of the singularity of the rock which contains it. Although well known almost from the earliest days of the asbestos industry, this mine never till now attained any special significance, when it has suddenly sprung into great importance, attaining also considerable scientific interest. But what is far more important still in a commercial point of view, is that, in the shortest possible space of time, it has stepped in front of all the other mines previously named, and effectually revolutionised the whole asbestos industry, by bringing the use of the important mineral it deals with within the reach of the whole world. Many very important mines throughout the district are in consequence of the discoveries here, now closed, while others have preferred to shut down for the present and await the natural progress of events.

This mine is situate near the boundary of the most western part of the Eastern Townships of Quebec, ninety-seven miles from Black Lake, but only four from the pleasantly situated agricultural town of Danville. It is also about eighty-six miles from Montreal and within easy reach of Quebec. It was first opened in 1879, and worked, almost continuously, from that time, by the late Mr. Jeffrey, until shortly before his death. Mr. Jeffrey commenced work here, on a sufficiently small scale, but gradually increased his operations until the mine became well known throughout the asbestos country. He was quite a characteristic figure in the regular haunts of asbestos men; essentially a man of the old school, somewhat obstinate and self-willed, independent in his ideas, by no means highly educated, but wanting in neither shrewdness nor intelligence, preferring

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always to walk in the old grooves, and curiously ready to suppose that no man living could teach him anything in his own particular line of business. He carried on the work of the Danville mines, somewhat spasmodically it is true, and like most of his fellows in the early days of the business, when the nature of the mineral was much less known than it is now, worked practically without system, or as one might rather say, by rule of thumb. He never attempted to do more than simply quarry out the rock *en masse*, removing the seams by hand and dumping all the remainder in prodigious masses, until, in the end, he had piled up many thousands of tons of what he called waste or refuse; having not the remotest conception of the special nature of the mineral he was dealing with, or its great economic value.

After many financial struggles, he eventually succumbed, and was forced to assign his property to trustees for the benefit of his creditors, soon after which the mines were closed. But it must not be supposed, that his want of knowledge was in any way blameable, because if this were so, then it must be said that all those commercial and scientific men who had, year after year, examined the property, or viewed it mineralogically, were equally so. Nothing of the peculiar nature and quality of the serpentine in which he worked was then known. The time had not yet come. So far, it lay absolutely unregarded, until suddenly it encountered the eye of intelligence and genius, when, all at once, such a flood of light was thrown upon it, that men looked on with astonishment, just as at the solution of the familiar egg problem, wondering where their eyes had until that moment been. Doubtless great advances in mineralogical knowledge have recently been made, but apparently we were all, at that date, more intent upon devising theories concerning the genesis of the fibrous structure than in giving consideration to what more immediately lay before us. At the very time, when Mr. Jeffrey most wanted money, a fortune lay unregarded beneath his feet, of which he knew absolutely nothing. Among asbestos men of that day, asbestos was simply asbestos, and serpentine serpentine—the one was

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useful, the other an incumbrance; the main thing to be regarded when asbestos was found, was the grade of which it was composed. The extraordinary variations of this particular mineral were totally disregarded, until we suddenly woke up to the knowledge that the familiar serpentine was really an all but sentient rock, so that one might almost go back to the days when it was believed to be of organic, that is, vegetable origin. Its changes are marvellous, and its susceptibility to the influence of mineral or metallic oxides so great, that the valuable fibre, which it sometimes carries, can be found precisely alike in no two countries in the world, or in any two places in the same country, or even in the same district; these differences being either in form, colour, or texture, or in two, or all three, of them, but mainly in accordance with, or attributable to the peculiar mineral properties of the soil, and generally perceptible to none but the experienced eye, though occasionally the changes are radical and to be seen at once by the most inexperienced inquirer; as, for instance, if regard be had to the speciality of the Thetford fibres, and afterwards to the produce of Black Lake, East Broughton, Lake Nicolet, Brompton Lake, or the deposits in the Ottawa Valley.

Nor is this peculiarity attributable to serpentine alone. Even gold is curiously affected by association. It is rendered quite brittle, for instance, by the presence of so small a particle as the five-hundredth part of bismuth. Copper also is so affected, by about the same proportion of the same mineral, as to render it completely useless for electrolitic purposes. Many hypotheses have been suggested to account for these phenomena, but we have not yet arrived at a true explanation of them.

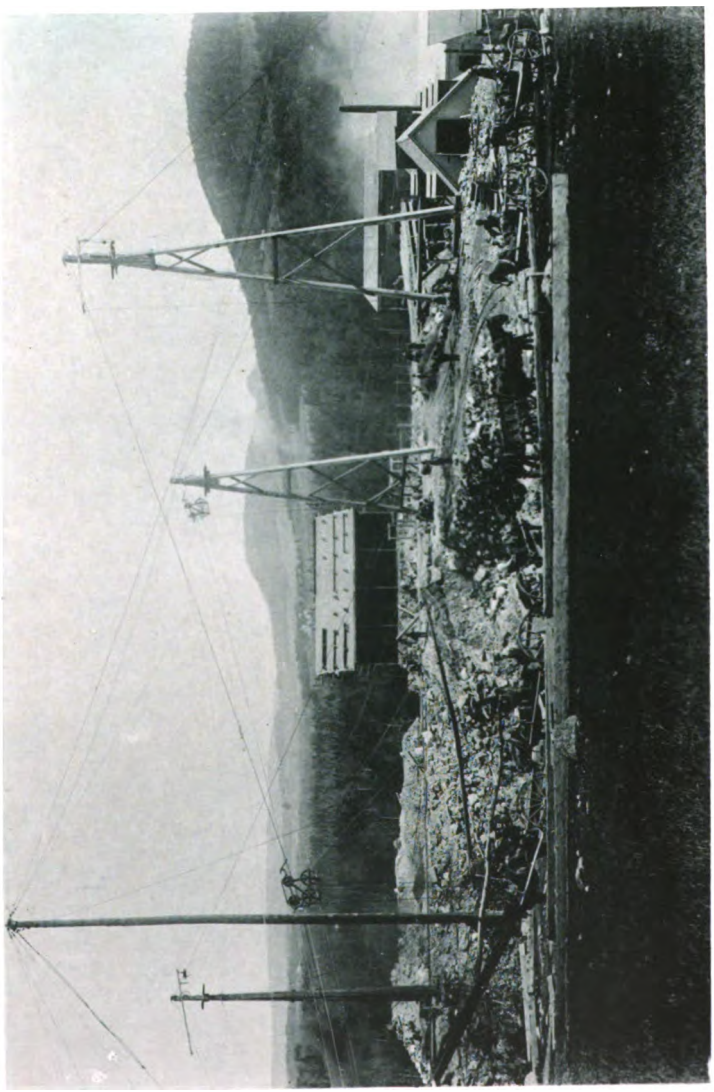
Some time after the closing of the mine by the trustees, suggestions were made to Mr. Boas, of St. Hyacinthe, one of the epoch-making men of his generation, that he should take it over, or endeavour financially to promote its resuscitation. When he accordingly went over to examine the property, as he was not a mineralogist or one who professed to know much about asbestos, he was untroubled with any preconceived theoretical opinions; but, regarding the matter simply with

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THE DANVILLE MINES.

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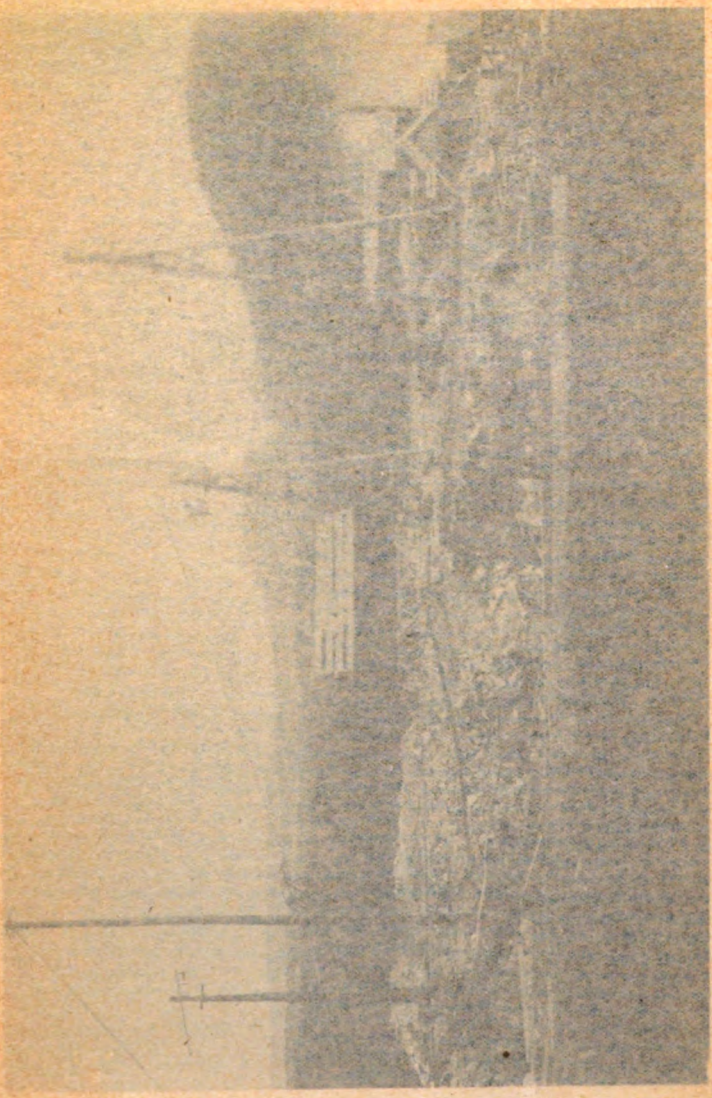
the eye of shrewd intelligence, he was struck with the remarkable character of the rock which carried the fibre. He thereupon immediately set about instituting a series of experimental inquiries, which fully satisfied him of the unusual character of the rock and its extraordinary importance, from a commercial point of view. No sooner, therefore, had he taken over the property, than he characteristically commenced energetic operations with specially-constructed, automatically-working machinery, when the mines, under his guidance, soon gained far more activity than they had ever attained before, and in place of the recent aspect of depressing desolation, the whole country began to smile with cheerful industry and content.

Not only were the works resumed with far more than their old activity, but the men who had left the place on the stoppage, with one accord flocked back again to resume their employment under the new auspices, and their numbers so rapidly increased that, in a short time, the population of the place became more than doubled. Following out his discovery of the peculiar nature of the rock, Mr. Bell successfully succeeded in establishing an enterprise of an entirely novel character, which, having arisen spontaneously, as it were, out of the bosom of commerce, at once made its mark, and now bids fair to become of immense importance to the trade of the province generally, as well as largely to promote the welfare of a good and a rising number of the people. His first idea was to utilize the new material as a plaster or cement, and this will be more fully described in another chapter.

The property of the mine occupies [illegible] somewhat near to the centre of which [illegible] mound rises to a height of [illegible] level. And respecting this [illegible] peculiarities, by no means the least of which is the singular fact that it forms one only of a series of [illegible] which stretch a long way across the country through Kirkdale, Cleveland, and Tingwick; and curiously enough all [illegible] whole surrounding district may be said to be [illegible] asbestos country, not one of this series of [illegible]

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the eye of shrewd intelligence, he was struck with the remarkable character of the rock which carried the fibre. He thereupon immediately set about instituting a series of experimental inquiries, which fully satisfied him of the unusual character of the rock and its extraordinary importance, from a commercial point of view. No sooner, therefore, had he taken over the property, than he characteristically commenced energetic operations with specially-constructed, automatically-working machinery, when the mines, under his guidance, soon gained far more activity than they had ever attained before, and in place of the recent aspect of depressing desolation, the whole country began to smile with cheerful industry and content.

Not only were the works resumed with far more than their old activity, but the men who had left the place on the stoppage, with one accord flocked back again to resume their employment under the new auspices, and their numbers so rapidly increased that, in a short time, the population of the place became more than doubled. Following out his discovery of the peculiar nature of the rock, Mr. Boas presently succeeded in establishing an enterprise of an entirely novel character, which, having arisen spontaneously, as it were, above the horizon of commerce, at once made its mark, and now bids fair to become of immense importance to the trade of the province generally, as well as largely to promote the welfare of a great and increasing number of the people. His first idea was to utilise the new material as a plaster or cement, and this will be more fully described in another chapter.

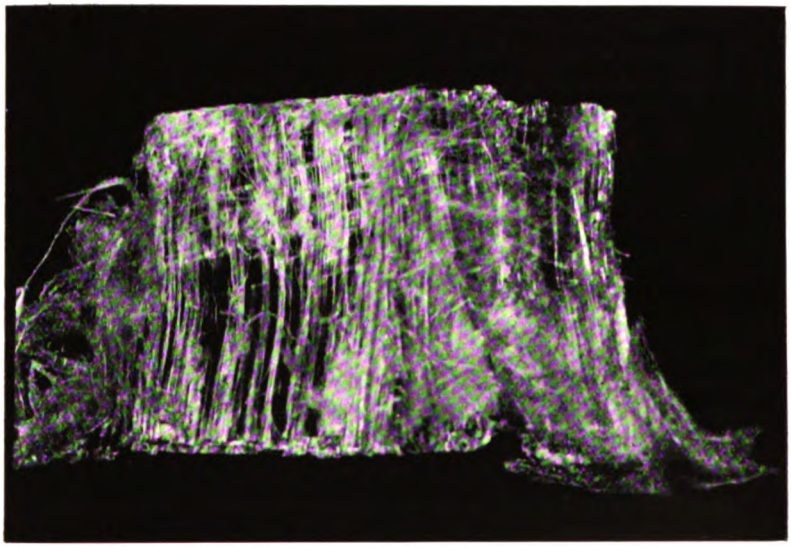
The property of the mine occupies about seventy-five acres, somewhat near to the centre of which, a peculiar knoll-shaped mound rises to a height of about 250 feet above the surrounding level. And respecting this knoll there are several striking peculiarities, by no means the least of which is the singular fact, that it forms one only of a series of apparently similar mounds, which stretch a long way across the country, through Melbourne, Cleveland, and Tingwick; and curiously enough, although the whole surrounding district may be said to be included in the asbestos country, not one of this series of knolls, with the

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exception of this particular one of Danville, has shown any trace of fibre, although each of the others has been carefully prospected. It may, therefore, be said, with a fair amount of truth, that the whole asbestos wealth of this part of the country is concentrated in and around this one particular spot.

Another of its peculiarities lies in the unusual quality of the serpentine, of which the mound, with the subjacent rock, and



that adjoining and surrounding it is composed. This everywhere carries abundance of well-developed veins of magnificent chrysotile, which permeate the rock in every direction, generally running in regular and converging lines; although I have seen two considerable veins, of equal width, crossing at right angles in a curiously unprecedented manner, to the confusion of many theories of formation. And although none of these veins are of more than medium width, they are invariably found to contain the finest silky fibre, such as is admirably adapted for every

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purpose for which the manufacturers require a specially delicate quality.

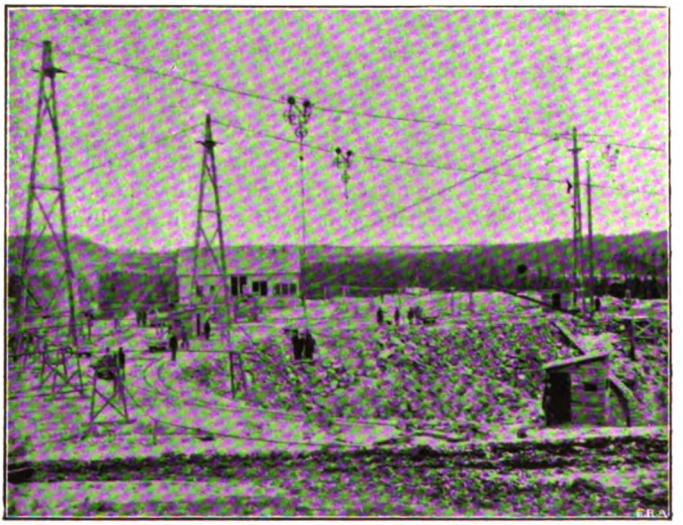
And what is perhaps more remarkable still, the whole of this Danville rock is of so extraordinarily fibrous a character that every part of it can be utilised. After yielding from 20 to 25 per cent. of Nos. 1 and 2 merchantable asbestos, the whole of the remainder, which was formerly treated as waste, is now found to consist of fibrous material of extraordinary value, known under the name of asbestic, which is simply short, unweavable asbestos, the like of which is to be found in no other part of the country.

I spent about ten days in the investigation of these mines, and was frequently in the pits, watching the operations, and, on one occasion, after a blast, carefully examined the result before any of it was touched, and I then calculated that the whole mass contained at least 90 per cent. of good merchantable asbestos, or asbestic, that is, fibrous material, which required nothing more than crushing and screening, for conversion into asbestos and asbestic. Practically there was no waste at all. Some of this rock was sufficiently soft to be broken off with my fingers, and this I rubbed round in my hands, in the way the men rub up tobacco before filling their pipes, and this simple rubbing converted the rock into a snow-white pellet of soft, elastic fibre, which to me was a most novel and unique experience. In the Italian mines, as I believe has been before remarked, one often meets with minute crystals of a green-coloured garnet, which are called by the miners the seeds of the asbestos (*semenze dell' amianto*). Nothing like this is ever to be found in the chrysotile mines of Canada, but I was often delighted to find at Danville, extraordinary specimens of a clear, light-coloured translucent serpentine, which partly covered a vein of pure silky fibre, as though protecting it with a rich delicate skin, the tint of emerald without its gleam being as lovely as a newly-expanded willow leaf in spring, which, on examination, was found to be as compactly fibrous as the material held compressed in the vein. Some specimens of these are now before me, which I had the pleasure to exhibit at the Society of Arts meeting, on

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the occasion of my recent lecture there on *Asbestos and Asbestic*, and an example of which is shown in the frontispiece. The apparent lines, which look as if drawn obliquely across the fibre are, in reality, no lines at all, but a beautiful waviness, such as is more often seen in the light-coloured Laurentian fibre than in the Cambrian chrysotile, where it only appears in the finest and most silky ore. This peculiar glimmering mark is unattainable in the photograph, where it can only be seen as a harshly drawn line.



The plate here shown gives a somewhat contracted view of the outlook over the larger, or Factory Pit, and on the succeeding page is a corresponding view across the lesser quarry. These two are now being connected together, so as to form one extensive quarry, which will greatly facilitate the work and also economise the labour.

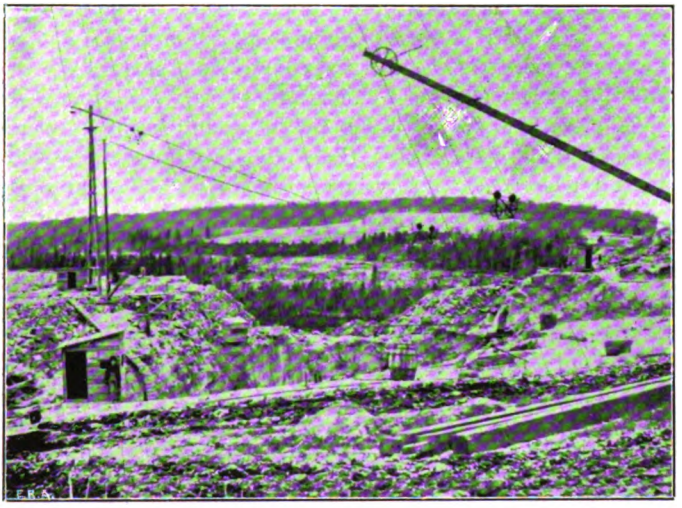
In regard to the produce, I have in my collection longer and apparently better looking samples of No. 1 grade, brought by

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myself from Thetford. A portion of one of these was presented, some time ago, to the Curator of the Natural History Museum at South Kensington, where it is exhibited in Case 25*a* (Serpentine) of the Mineral Department, as a specimen of the produce of the Johnson mine, and consequently the finest then known in Canada.

This was naturally a picked sample, and superior to the general run of the daily output. But I have since remarked



that if the ordinary run of Danville No. 1 is not of the extreme length of the above, it is, on the other hand, of exquisite softness and purity, and quite sufficiently long to compete, for manufacturing purposes, with any that is produced in the world.

The curious nature of the rock is well shown by a specimen now before me as I write, and of which also I have endeavoured to show the peculiar grain and texture in the collotype, which is a very indifferent work of art, although I am assured that nothing better could be done in England. This specimen I broke from a mass of rock in the Factory Pit, and brought home for my private

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Asbestos and Asbestic: Their Properties, Occurrence, and Use (1897)
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cabinet of specimens. It is an unmistakable fracture of the crude rock, the like of which has never before been shown in any part of the asbestos world. It needs no microscope, the peculiar texture of the rock being plain and palpably evident to the most inexperienced eye, needing not even a specimen of the ordinary hard, siliceous rock from any other mine to compare with it, in order to show its rich asbestiform character. Even the special nature of this was never pointed out before the time of Mr. Boas' discovery. It may be that the special peculiarity of the serpentine here consists in its being felspathic, and as the felspar becomes decomposed, it develops a kaolinic quality, which points to a special adaptation of some of the uses to which it is applied, as well as to its unusual softness.

To form an idea of what the foregoing actually means, it must be borne in mind that, according to the system of work rendered compulsory in all other mines, as soon as the asbestos has been extracted from the rock, every ounce of the waste material has perforce to be carried away and dumped wherever possible, at great expense, forming an encumbrance and a perpetual eyesore all over the country wherever it is placed.

Nor is this by any means all; the tremendous expense of handling this waste is a main factor in the inquiry as to the cost of obtaining a ton of asbestos, from any particular mine. Even in the best of these, it is seldom, indeed, that the number of tons of waste rock required to be disposed of, for every single ton of asbestos won, can be put at less than fifty tons. Mr. Klein, the manager of the American Company's mine (formerly Wertheim's), a well-known, thoroughly competent, and reliable man, in a lecture delivered by him before the Black Lake Asbestos Club, all the members of which are practical asbestos miners, owners, and managers, gave it as his opinion that the amount of waste to be removed was almost always understated, and that a fair average might be put at 100 tons, though not seldom it reached even 150, and might often be much more. In two well-known cases, this removal of *débris* had proved to be of such paramount, even vital, importance to the mines, that what might be called heroic measures had to be had

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recourse to for its disposal. As we have already shown, in the case of the United Asbestos Company, the formation of the land acquired by that company was such that the time presently arrived when, by the increase of their dumps, they were completely shut in, and had no more room for dumping, on their own ground. In order, therefore, to get over this difficulty, they had to build an inclined tramway along their southern boundary for a distance of 3,800 feet, by means of which their waste could be dragged up the northerly slope of the hill, so as to be got rid of near to Cariboo Lake. In the case of Bell's Company, as already explained, the difficulty was, in a great measure, brought about by the decision of the Law Courts, in the encroachment actions brought against them by the Johnson Company, by which the extent of their land was very seriously curtailed. In this case, the difficulty was surmounted by the purchase of additional land, beyond the railway line, and connecting their works with it, by an overhead bridge and a line of their own, for the conveyance of their dumping cars.

Bearing all these facts in mind, it seems, at first sight, incredible that, here at Danville, every particle of what was formerly regarded as such costly waste, should now be actually utilised; this so-called waste being all converted into money, and consequently, to that extent, reducing the prime cost of the asbestos. Every part of this formerly supposed waste is now brought into the market, as a profitable article of commerce entirely unknown before. This is the new material called *Asbestic*, which is found to be of very great importance to all connected with the building trade, and especially to architects and contractors for extensive works. Instead of the tedious and elaborate preparation, formed by the use of the ordinary dirt-creating mortar, with the after-scoring necessary to give cohesion to the final coat of plaster of Paris, a single coat of asbestic is laid on. In use, this is perfectly flexible when dry, so that, while presenting a smooth, glossy surface, it will neither crack nor break, even if put round a tin pipe. It can be put on raw brick, and in a room, the walls of which have only been built in the morning, before night it will acquire a smoothly-finished surface

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as hard as marble and as polished as a sheet of glass. In its preparation it requires neither hair nor sand, its own fibres replacing the former and the rock itself supplying all that is necessary in lieu of the latter. In New York I saw a man building a wall, and noticing that he was making use of asbestic instead of mortar, I got into conversation with him, when he told me that he found, when using asbestic indoors, it took somewhat longer to dry, but that when once it had dried it was so effectually hardened as to become a perfect cement, which I have found to be the fact, and that in its dried state its solidity is surprising. He also told me that it was a safeguard against a bricklayer scamping his work, the temptation being often very great for a man to put in an extra quantity of sand, which caused the mortar to crumble when dry, whereas, in this case, as we have said, no sand at all is required.

Another of its important qualities is, that it is a non-conductor of sound, so that it is admirably adapted for use in music rooms, halls, churches, chapels, theatres, &c., while for the wards of hospitals, or for sick rooms, it is of inestimable advantage: as such can be rendered perfectly noiseless and quiet by the use of asbestic on the walls, ceilings, and partitions, and if any outbreak of fire should occur in a room so treated, no fear need be entertained of the fire spreading. It contains no organic matter of any kind, and consequently can carry no germs, but is absolutely vermin-proof, and consequently endowed with inestimable sanitary advantages. Asbestic is also remarkably adhesive, and being at the same time a natural filter, if a pail be accidentally upset in the room above, so as to cause the wet to show through on to the ceiling below, it will afterwards exhibit no mark or stain, but as the ceiling dries again, will become as unsullied as before. The covering and labour-saving advantages of it are very great, being no less than 40 per cent. more than that of any ordinary plaster. It is quite that much lighter to handle, while the mixing of it is so simple, and its application so easy, that there is an actual saving in labour of at least 25 per cent. This plaster may therefore be considered the most economical of any in existence; and

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again, by reason of its elasticity, it will neither crumble, crack, nor chip, even when nails are driven into it, which they will enter as into a deal board.

In July last year, a trial of this new plaster took place in the north-west Court of the United States Treasury Department Building, at Washington, in the presence of the chief officials of the Supervising Architects' Office, General Steinmetz, the engineer in charge of the New York City Post Office Building, the Inspector and Surveyor of Risks for the Association of Fire Underwriters, and several other persons of experience in such matters. A structure representing a house was erected in the court, the roof being about four feet high, and the whole of the interior plastered with this new asbestic wall plaster, all around which, kindling wood, shavings, and combustible matter enough to make a grand bonfire were heaped up.

When this was set light to, the whole structure was speedily enveloped in flames, and continued to burn with great fury for about half an hour, when a more important test still was applied. A continuous stream of water was poured on to it, from a one and a half inch nozzle, which, so far as the plaster was concerned, left it perfectly intact, showing no signs of dropping, splitting, cracking, or giving way in any part, thus showing its superiority over any material of the kind that can now be used. Neither the heat from any stove or furnace, or even the "settling" of a new building will have any effect upon it. It is both adhesive and elastic, and will adhere to metal or glass, and I have seen it bent round a tin pipe without either crack or split. And when walls or ceilings are plastered with it, no sooner does it become dry, than all danger of having to do them over again, on the settlement of the building, is at once done away with.

Many of the large buildings in Montreal, New York, and other cities, such as the McDonald Building, Victoria Square, Montreal, the Waldorf Hotel, Fifth Avenue, New York, and the Parliament Buildings at Ottawa, are now plastered with it throughout. On the occasion of my lecture at the Society of Arts, when the matter was being publicly discussed, a gentleman

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stated that while he was staying at the Waldorf, he was awoke by an alarm of fire raised in the night, when he had to clear out half dressed, but had he only known then, that the Waldorf was protected by asbestic, he should have remained contentedly in bed, instead of seeking to make his escape.

Another kindred application of the material is now rapidly making its way and coming into general use, in the form of uninflammable decorations, cornices, and enrichments for walls and ceilings. Examples of these can be seen in many of the new buildings which are now rising in all directions in New York, and elsewhere, especially in those intended for first-class saloons or restaurants, where the maximum of elegance and ornamentation is looked for. It is also specially adapted for the saloons of steamships, in many of which it can now be seen embossed in very beautiful designs, being treated with gold, varnish, lacquer, and the most charming tints and colours, with especial view to brilliancy of effect.

One more additional, but very important, use of this material must be especially mentioned: that is, its rapidly-growing use in the form of pulp for the manufacture of paper, for which purpose it has been found to be vastly superior to any other kind of pulp, either of wood, straw, or fibre of any kind; its cheapness also tending to bring it into general use. The shortest Danville fibre, mixed with asbestic, is all that is wanted for its manufacture; and so rapid is the demand for this, that the H. W. Johns' Manufacturing Company have been compelled to put up a large new building at Brooklyn, near their other works, with extensive machinery, to enable them to compete with the growing demand, for paper-making.

It is quite impossible to do more than thus generally indicate some few of the infinite variety of uses for which this new article is now being made available, and which are daily increasing in the most wonderful manner.

A general view of the country around Danville is here given, which shows its pleasant nature in that part of the district where the mines are situate.

The buildings erected by Mr. Boas, in which the machinery

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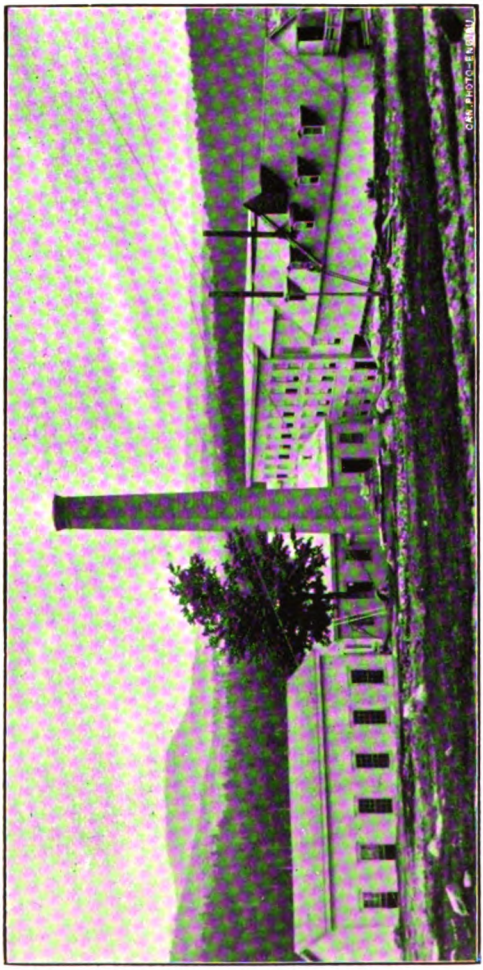
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is housed, the cost of which was about £35,000, are shown on page 184, and are well worthy of a moment's consideration. The main structure, which is somewhat ineffectively indicated in the cut, represents the reduction works, in which the main operations are carried on, and the asbestos and asbestic graded. It is a large and solidly-built structure, 160 feet × 70, with substantial posts 12 in. × 12, set ten feet apart below, and with all else in proportion, the main object, with that of the machinery it contains, being to avoid handling the raw material as much as possible. This five-story structure is so arranged by the hillside that the laden waggons may drive straight through the doorways and along the passages, to deliver and take up their loads at the required points, on four out of the five stories, the building in every part being excellently ventilated, and well lighted by electricity. The flat roof



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is covered with asbestos, and much more attention has been paid to exterior appearance than is commonly the case with



The Factory at Danville.

mining buildings. A second erection, close adjoining the first, 100 feet × 70, is built in conformity with it, as an annexe.

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At the entrance to the front of the fourth floor lies a mighty crusher, which weighs forty-eight tons. Its huge lips and jaws, on a level with the platform, are ever moving and at work, like those of a cow quietly and contentedly chewing her cud; and as the masses of rock are raised from the pit and dropped on to the cars, these are moved onward over the rails, which run from the mouth of the pit to the front of the crusher, where their contents are dumped on to the iron platform near to the working jaws, between which they gradually enter and disappear, a lump of rock of a ton weight being taken in with apparent ease, and quietly masticated by the huge monster which lies recumbent beneath. The mastication consists of simply crushing or chewing the rock in such a way as not to injure the fibre. There are no less than four other crushers, two of which are duplex, making seven in all, the least powerful of which weighs seven tons. These are placed in various portions of the machine's anatomy, the machine itself being so far a sentient animal that it needs no assistance in the digestion of its food, but hour after hour and day after day, its digestive process seems to go continuously on, every part working naturally, smoothly and automatically; until after leaving the big crusher, and passing through several sets of Cornish rolls, over a revolving picking table, through twelve cyclone pulverisers, with a whole series of fans, exhaust blowers, and revolving, shaking and jigging screens, with the rest of the necessary apparatus, the working of which can all be seen as the spectator moves onward, until at length he stands at the end of a long sloping table, to which a continual jigging movement is imparted, so that everything which touches it, being irresistibly impelled to join in the dance, runs gradually jigging, jolting, and jumping onwards and downwards until it reaches the end of the table. By this time the fluffy fibre is entirely separated from all gritty particles, when as these last reach the edge, they drop or are jerked over, to be dealt with further on, while the former are acted upon by a strong upward current, by which they are drawn on and finally sucked into a pendent receiver, as though they were pieces of paper carried by a draught up the chimney

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And then, leaving the remainder of the process to follow on, we descend to a lower chamber, where we find the digestion is complete, and we see the result exuding from the orifice of a pipe, dependent from the ceiling, whence it is discharged in flakes of immaculate whiteness, into bags, weighing 100 lbs. each, in which the contents, after having been duly compressed, are tied up, and then loaded into the cars in waiting to receive them, for conveyance by the Grand Trunk Railway, to be forwarded to their ultimate destination. Thus, from the time the rock is drawn from the pit until the fibre reaches the manufacturer, no handling of the material or any attention is required throughout, except that of one lad who is required to see after each cyclone, to watch that it does not become clogged by the fluffiness of the fibre.

The main shafting is five inches in diameter, and the whole plant is driven by an engine of 500 horse-power, housed in a separate building on one side of the main structure, with a complete battery of five upright horizontal boilers of sufficient capacity to furnish much more power if needed. The engine is supported on a platform of granite, the smoke from the boilers being carried off by a stack a hundred feet in height.

In the earlier stages of the work the necessary supply of water was obtained from a pumping station erected on the creek near by, the water being pumped into a huge tank set in the sand and made of heavy timber; but, as the work progressed, it was found necessary to secure the options for the water rights on the Nicolet River, which includes a fall of 180 feet, for the supply of all that may be required for the necessary power and for the generation of electricity, so as to make the works entirely independent of steam power. And as the old method of teaming is found to be altogether inadequate, a line of railway communication is being prepared to connect the works with the Grand Trunk Station at Danville.

Then, entirely to suit the convenience of the manufacturers, a special system of grading has been adopted here. Some few tons only of Nos. 1 and 2, the veins of which break off in

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transit, are still graded in the old manner. This is simply exported as it is, and the remainder, formerly all waste, with some part of what was called No. 3, and a portion of the rock itself, are all fibreized together, the resulting produce, as it falls from the cyclones, being then graded, according to length and quality, as C, D, and E, the C quality naturally being the finest of these; D, not so long in staple, and E the shortest and lowest grade, though all three are alike in being absolutely clean, uniformly white, and entirely free from any admixture of rock, dirt, or grit. In actual fact, as each leaves the works, it is ready for spinning, weaving, paper-making, or any of the numerous purposes for which it may be wanted in the manufacturers' business, without further manipulation in any way.

Mr. B. Marcuse is the general manager and superintendent of the entire work, who is ably seconded by Mr. Pharo, in the internal department, with the well-known H. J. Williams as mining superintendent; Mr. Boas himself, like all master-minds, being eminently a judge of men and their capabilities, as prompt to reward and encourage, as quick to deal with unsuitable workers, and is appreciated accordingly.

Such is an unbiassed account of this extraordinary mine, with what I saw there, and in and about it, so that it is by no means surprising that, in order to promote its more efficient development, a limited liability company was speedily formed, under the title of the ASBESTOS AND ASBESTIC COMPANY, with a capital of £500,000, divided into 50,000 shares of £10 each. The directors of the company are a strong body of well-known mercantile men, consisting of Gilbert Bartholomew, Wilberforce Bryant, A. Naylor, Henry Hayman, A. A. Allan, R. H. Martin, and Feodor Boas. And with the further announcement that the temporary offices of the company are at 27, Billiter Buildings, Billiter Street, London, we heartily wish them success in their new career.

Being old enough to have witnessed many great and radical changes in the manufacturing world, brought about by the advance of science and the development of machinery, I have been interested in watching the reception of the change amongst

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the mine-owners of the Canadian province of Quebec, who will be mainly affected by it, and to many of whom, in days gone by, it would infallibly have meant ruin, but now apparently men are generally becoming more enlightened and temperate. A good many, as we have already seen, more especially in the neighbourhood of Coleraine and Black Lake, have already closed down, apparently with the intention of waiting and watching the natural course of events. One large London company, always known for the honourable nature of its methods of conducting business, after making all necessary inquiries, have preferred, for the present, to lay down their arms and take advantage of the cheapness of the asbestos sold by the new company, to use it in preference to procuring it from their own mines, at an additional cost.

Laurentian Chrysotile.

It was for a long time generally supposed that the great Laurentian system of Canada, which mainly consists of orthoclase gneiss, was barren of mineral deposits of any great value, but for some time mineralogists have known that short veins of chrysotile, of a somewhat peculiar appearance, were to be found in many parts of it. In that great belt of rocks which lie on the northern side of the St. Lawrence, in connection with the serpentinous limestones, such veins have been frequently remarked in the Papineau district on the Ottawa, in the Gatineau Valley, and in parts of Templeton especially. In 1889, a few tons were got out in Range 8, Lots 10 and 11 of Templeton, and many geologists were then of opinion that this part of the Ottawa Valley would soon become an important mining district, but, up to the present time, such a prospect does not seem to be very hopeful. The work here was at first but little remunerative, and this, apparently, not owing so much to the limited nature of the deposits as to the smallness of the veins, consequently mining for it was discontinued for several years, mainly on account of the expense of working these small veins. Then, in 1890, operations were recommenced, and some excellent fibre was reported to have

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been got out at a profit, but afterwards the work was abandoned.

The serpentine in which the veins occur is singularly light coloured, generally of a pale golden or greenish-yellow tint, and the veins of a delicate transparency, quite unlike anything to be found in the Cambrian rocks. It is distinguished from that of Thetford by a peculiar pearly lustre, very often showing a slightly wavy appearance, a much lighter colour, and a total absence of any trace of impurity, in the form of grains, minute particles, or the oxides of chromic or magnetic iron. In many places this serpentine is intimately associated with large irregular masses of crystalline limestone; but except in regard to this one point of unusual purity, there seems to be really very little difference between the Laurentian and Cambrian fibres.

The rock, in which this class of mineral occurs at Templeton rises to a height of about 700 feet, striking in a north-east south-westerly direction, forming strata of massive crystalline limestone, closely shut in on both sides by gneiss varying in colour from red to grey and white. The fibrous stringers here have the peculiarity of occasionally widening out from about the eighth of an inch to sometimes an inch and a half or two inches, and when they have reached the maximum width, they rapidly split up again, and run off so as to once more appear as mere threads or stringers. This seems to be a general characteristic of the Laurentian asbestos. I found the same thing at Buckingham, on the Ottawa, and in the great class of similar rock which occurs at Port Lincoln, South Australia, called the White Rocks, where also the occurrence is precisely similar. In regard to general length, I have seen but one isolated sample which reached three inches. This seemed to be quite exceptional, and was not continuous, but quickly ran off again into the regular series of small, in many places, nearly horizontal stringers.

A conspicuous peculiarity in this formation is that the small veins, which occur here in such considerable number, have partings between them, generally of a light greyish serpentine

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of about the same thickness, enclosing roughly lenticular masses of limestone. Several of these small veins occasionally coalesce so as to produce a larger vein of remarkably clear fibres of which I have seen one of three inches, but none of these broad veins are continuous ; they rapidly split up again into several others of smaller width. A somewhat similar peculiarity has been observed in the Cambrian fibre, at Broughton, near to the lower part of the large vein, where the hanging wall is of soapstone.

A remarkable circumstance was noted in the works at Templeton, where a blue-black variety of fibre, from one and a half to two inches in length, was found at a depth of sixty feet below the surface, in a dark bottle-green serpentine.

In 1891, a company was formed to work these Laurentian deposits, under the title of the Templeton Asbestos Company, Limited, with a capital of £25,390, divided into £25,000 ordinary shares of £10 each and 390 founders' shares of £1 each, It was carried on for some time under the energetic management of Mr. Circkel, but was presently given up, on account of the great cost of mining. Some time ago, I saw a statement in the paper, that in some of the Templeton asbestos, in which no fibre could be detected, as much as 30 per cent. could be got from it, after it had been passed through a cyclone mill. I should have been much pleased had I had an opportunity of inquiring into this when in Canada, as there may be some little amount of truth in the statement, but the serpentinous limestone in which the mineral occurs is of a totally different character from the rock which produces the asbestic at Dahville.

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CHAPTER VII.

OUTPUT, COST OF PRODUCTION, WAGES, ETC.

Slow Advance of the Industry at First—Rapid Increase afterwards—Prices in 1892—Manufacturers become Mine-Owners—Yearly Output from the beginning—Consolidated Firm of the H. W. Johns' Manufacturing Company—Returns from Ontario—Production Returns—Rapid Increase in Consumption in America—Wages—Mode of Extracting the Ore—Grading—Cobbing—Cost of Mining—The Scott Act.

The exploitation of asbestos in Canada was by no mean rapid on its first discovery, but, very soon afterwards, its progress advanced by great strides. As a material product its value was speedily appreciated in the United States, but in England it made singularly little advance for some time; and even to this day its use there, as a manufactured product, seems to be comparatively in its infancy.

For the first ten years after the discovery, that is, down to 1887, the price of the crude ore had been gradually increasing in correspondence with the demand, with some, but by no means a proportionate, augmentation of the supply. In that year, however, several new quarries were opened, many buildings were erected, including two factories for the manipulation of the crude ore on the spot, while one of the companies had built a branch line of railway to connect their works with the main line; the general result of the year's progress being such as to make it clear that the industry was assuming such proportions, as in the near future would make it the most important, as it already was the most remunerative, in the province.

Satisfactory to the producers as was the result of 1887, still greater progress was made in 1888, while the returns for 1889

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showed a still greater leap forward; the large advance in prices which took place in the autumn of that year being a material consequence of the fact that, notwithstanding every effort, the mine-owners had found themselves unable to fulfil contracts; the supply for the previous year, although considerably in excess of any previous output, not sufficing to keep pace with the ever-increasing demand.

Indeed, up to 1890, the manufacturers had been able to consume the whole output of the mines as fast as it was produced, which is evidence that the manufacturing interest had also increased in about the same proportion. From 1884, the annual increase was about 1,100 to 1,700 tons, until in 1889 it had reached something like 6,000 tons, which was also about the total production of crude asbestos. Then, by the introduction of improved machinery, the output was suddenly increased by 3,800 tons in 1890, and 3,000 again in the following year, as compared with 1889, when a considerable quantity of crude asbestos was left on the market, the use of the manufactured goods having continued to advance at the rate of about 1,500 tons per annum. The prices continued much the same during the whole of that year.

In 1892 the price of—

No. 1,	Thetford,	was	$200	per	short ton.
No. 2,	,,	,,	$100	,,	,,
No. 3,	,,	,,	$50	,,	,,

some allowance being made for difference in grading.

In the European market, No. 3 also found a ready sale, but this was by no means the case in the States.

There were at this time thirteen incorporated companies at work, with an authorised capital of about three and a half millions of dollars, part of which was employed in the manufacturing business in England.

One unexpected result of the unusually high prices then ruling was, however, to drive all the more important manufacturers into the market to buy mines for themselves, and so to turn producers as well as consumers, in order that, by employing more scientific

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methods of work and improved machinery, they might raise for themselves such supplies of ore as, day by day, it became more difficult for them to obtain through the ordinary trade channels. This, again, had the effect of driving prices up still higher, because the produce of the mines so purchased, instead of increasing the available supply, really tended to decrease it, by practically withdrawing much of it from the general market, the new mine-owners requiring for their own factories all the ore they were able to raise from the mines so bought. Unusual efforts were, consequently, made over the whole of the productive areas to find and open up new mines, fresh capital was being continually brought in, whilst new developments of the industry were as constantly preparing the way for continued success.

Record of Output from the beginning.—The following may be taken as an authentic record of the progressive output of the mines, with the local value of the ore, since the commencement of the industry in Canada in 1878. It would have been more satisfactory to have been able to show the relative increase in price per ton in each year, but that could not be done without a knowledge of the proportions of the annual output, ranking as Nos. 1, 2, and 3.

	Tons.	Value at the Mines.
1879	300	$19,500
1880	380	24,700
1881	540	35,100
1882	810	52,650
1883	955	68,750
1884	1,141	75,079
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
1896	5,699	

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From the above it will be seen that in 1879, 300 tons only were produced, while the value, on the spot, was no more than $19,500. In 1880, 1881, and 1882, the average price per ton was close upon $65. In 1883, it rose to $72; then it steadily declined until it reached the lowest downward point, $49, in 1887. The following year, it jumped to $60, and in the next year it reached $69 75 cents; then, in 1890, the highest price of all was reached. In that year, mine-owners, in consequence of the upward tendency of prices, strained every nerve to increase the output, so that both output and prices reached their maximum, the former attaining the unprecedented total of 9,860 tons of all grades, and the value rising to $1,260,240. Then, for three years, came a fall in prices, on the ground, it was said, of the market being overstocked; at any rate, manufacturers suffered severely, on account of the high prices demanded by the mine-owners. In July, 1891, the long talked of combination of the leading manufacturers in the States took place, and in the same year a considerable fall, both in output and prices, occurred, and this continued, with slight fluctuations, for the next three years. In 1891 the amounts exported reached for No. 1, 5,180 tons, valued at $413,231; for No. 2, 1,449 tons, valued at $83,639; and for No. 3, 393 tons, valued at $17,039.

The new consolidated company of manufacturers was composed of the following firms, viz., the H. W. Johns' Manufacturing Company and the Chalmers-Spence Asbestos Company, both of New York, the Asbestos Packing Company and C. W. Trainer and Company, both of Boston, and the Shields and Brown Company, of Chicago. Mr. H. W. Johns was appointed president, and Mr. R. H. Martin, of the Chalmers-Spence Company, vice-president. The company retained the old name of "The H. W. Johns' Manufacturing Company," of New York, and it was at once seen that they were without question the largest asbestos manufacturers and dealers in the whole world, and could not only control the supply but regulate the prices also. Since the consolidation of these firms, enormous additions have been made to their several manufactories in New York, Chicago,

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and Philadelphia, which have more than quadrupled their former manufacturing facilities.

Apart from the Eastern Townships, the returns are practically immaterial. That from Ontario, (actinolite being taken as asbestos), was in 1887 about 400 tons, valued at $6,000, and in the following year it was *nil*. Since then the produce has been small and not sufficient to affect the returns. In 1894 a few small shipments of low grade ore were made from the Ottawa district.

In 1895 the total production was 8,315¾ tons, divided as follows:—

Shipments from Black Lake *viâ* Quebec Central	735½ tons.
,, ,, Thetford ,, ,,	5,235¼ ,,
,, ,, Danville, *viâ* Grand Trunk	2,310 ,,
,, *viâ* Gatineau Valley Railway	35 ,,
	8,315¾

Last year (1896) the corrected figures were :—

From Black Lake	996 tons.
,, Thetford	4,640 ,,
,, Broughton	63 ,,
	5,699

It will be noticed here that no return is made from Danville, the reason for which is obvious.

The following figures, taken from the Trade and Navigation Returns, are specially interesting as showing what countries are the best customers for the Canadian mineral, and the proportions of the various grades consumed by them, for five years ending 30th June, 1895.

	1891.		
	No. 1.	No. 2.	No. 3.
United States	4,255 tons.	1,063 tons.	21 tons.
Great Britain	772 ,,	187 ,,	181 ,,
France	85 ,,	143 ,,	28 ,,
Germany	68 ,,	58 ,,	162 ,,

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1892.

	No. 1.	No. 2.	No. 3.
United States	1,777 tons.	3,771 tons.	398 tons.
Great Britain	581 ,,	316 ,,	59 ,,
France	40 ,,	156 ,,	6 ,,
Germany	—	—	212 ,,

1893.

	No. 1.	No. 2.	No. 3.
United States	1,301 tons.	3,947 tons.	137 tons.
Great Britain	74 ,,	77 ,,	222 ,,
France	— ,,	— ,,	— ,,
Germany	4 ,,	49 ,,	20 ,,
Holland	20 ,,	— ,,	27 ,,
Belgium	— ,,	— ,,	20 ,,

1894.

	No. 1.	No. 2.	No. 3.
United States	1,936 tons.	2,659 tons.	297 tons.
Great Britain	186¾ ,,	190 ,,	137 ,,
France	50 ,,	— ,,	— ,,
Germany	¼ ,,	236 ,,	264 ,,
Holland	— ,,	93 ,,	140 ,,
Belgium	— ,,	— ,,	40 ,,

1895.

	No. 1.	No. 2.	No. 3.
United States	3,680 tons.	1,456 tons.	857 tons.
Great Britain	1,996 ,,	62 ,,	144 ,,
France	— ,,	— ,,	— ,,
Germany	20 ,,	186 ,,	164 ,,
Holland	— ,,	28 ,,	— ,,
Belgium	— ,,	12 ,,	— ,,

For the year 1889, the totals of the various mines were approximately :—

From Thetford	3,850 tons.
,, Black Lake	1,560 ,,
,, Coleraine	175 ,,
,, Danville and Broughton	334 ,,
	5,919 tons.

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In reference to which the Commissioner states that the Scottish Canadian Company and the Montreal Asbestos Company, of Black Lake, did no work during the year to which his report relates; and that the White's Asbestos Company, of Coleraine and Garthby, prospected only without any appreciable result.

"En resumé (the Commissioner concludes), l'industrie des mines d'amiantes est en pleine prosperité. Durant cette année, le prix a augmente de 25 per cent., et la production 50 per cent. La demande continue d'être très grande, et les terrains miniers sont très recherchés."

The following shows the amounts of asbestos exported, according to the several grades, for the four years, 1892 to 1895:—

Quality.	1892.		1893.		1894.		1895.	
	Tons.	Value.	Tons.	Value.	Tons.	Value.	Tons.	Value.
		$		$		$		$
No. 1	1,447	113,595	975	41,084	5,400	312,280	2,978	169,380
,, 2	3,185	228,133	4,592	287,619	1,322	106,374	3,159	205,777
,, 3	748	31,375	350	10,004	1,265	59,183	1,305	46,553
Totals	5,380	373,103	5,917	338,707	7,987	477,837	7,442	421,690

During 1889 the consumption of asbestos, in America especially, increased so rapidly that the demand was again greatly in excess of the supply. It seemed, therefore, manifest that, unless the production could be largely augmented, prices must continue to rise. During the autumn, when the season was closing, none of the producers would venture to make contracts on any terms. Contracts for the previous season's delivery had in many cases to be deferred, and as a consequence it was found impossible to fix a price for the raw material even for a month in advance; nor was it practicable to obtain a guarantee for the delivery of the quantity which had been contracted for in the previous year.

The contracts entered into, at the close of 1888, were at prices unheard of before, and as the whole of the produce of 1889 was bespoken, although not contracted for, there appeared

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to be but little prospect of a reaction. Owners confidently anticipated an advance of 40 or 50 per cent. upon the then current rates, refusing to bind themselves even at that; and subsequent experience has shown that their anticipations were more than realised.

To give a general idea of the increased prices obtained, it may be mentioned that, during the years 1881, 1882, and 1883, the prices of No. 1 crude were respectively $50, $60, and $70, rising by $10 each year; whilst in the autumn of 1889 they had risen to the following: No. 1, $125 to $130; No. 2, $75 to $80; No. 3, $35 to $40, and "waste," which had hitherto been unsaleable, $15 per ton, the ton being the short Canadian ton of 2,000 lbs. only; and the prices named being those obtainable at the mines. In the early part of 1890, $150 per ton was given for No. 1, and in the second week of April a parcel of twenty tons was bought in London at the rate of £43 or $208 per ton. The average price of No. 3 was then nearly as much as was given only a few years before for No. 1.

In June, 1890, the latest price received from New York was £53, with every prospect of its going still higher.

In 1892 the principal feature of the trade was that No. 3 found a ready market, anything not promptly taken by the American manufacturers being at once disposed of in the European market. In this year the shipments showed 6,000 tons of all grades, a decrease of 3,000 tons as against the previous year, and 4,000 tons in 1890, which was the year when the highest prices were realised. The average quotations for this year were $200 for No. 1, $100 for No. 2, and $50 for No. 3. Whilst in 1889 the value of the asbestos mined in Canada was $426,554, in the following year it reached $1,039,661, the increase being mainly due to the rise in price on certain grades, which fully amounted to 100 per cent.

It must not, however, be forgotten that in the quoted prices there is a considerable variation, which is due to the fact that no uniform system of grading is adopted at the various mines. Thus, while at one mine, No. 2 will be quoted at $75 per ton, at another, the price of No. 1 will be very little more. Extra

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quality of No. 1, again, naturally commands a higher figure than the ordinary run of that grade.

It follows, therefore, that, when estimating the value of an asbestos property, the question of the relative percentage of output should be carefully considered; since, while the number of tons produced by any two mines might be approximately equal, and to the uninitiated, therefore, the properties about equal in value, the one, from the large amount of No. 1 grade, would be capable of paying handsome dividends, while the other would require great economy of management and still yield far less satisfactory returns. Again, if a mine be worked on the hillside it is obvious that it will be comparatively free from water, and the removal of the ore and waste rock a simple process; while if it be on the level ground, and the mine be worked by sinking, the water trouble becomes greater every day, and powerful pumping machinery and steam apparatus for raising ore and waste rock must add greatly to the working cost, and consequently to the cost per ton of ore got out.

The work is usually open quarry work, mining, in the usual sense of the term, not being generally adapted to the run of the chrysotile veins, which occur throughout the whole mass of rock, ramifying right up to the surface. This necessitates blasting away the whole of the rock, so as to break it up and separate the veins from the rock by cobbing.

Wages run from $1 to $1.75 a day, according to the nature of the work performed, for men, and from 50 to 75 cents for lads and cobbers.

These rates do not much differ from those paid in the adjoining province of Ontario. There, surface men employed at the Bruce copper mines were paid about $1 a day, though of course some could get more. At Saulte Ste. Marie ordinary labourers at the mines get from $1.25 to $1.50 a day. On this important question of wages we see by the Report of the Royal Commission just published,* that in the Sudbury district, outside men can get $1.40, and miners $1.75, but it was then

* Report of the Royal Commission on the Mineral Resources of Ontario and the Measures for their Development, 1890 : p. 406.

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somewhat difficult to get labour at Sudbury, on account of the isolated position of the mines. The following is about the rate paid there in cash.

Drill runners . .	$2.10 per day.	Machinist . . .	$2.25 per day.
Miners	1.75 ,,	Pumpman . . .	2.00 ,,
Labourers . . .	1.60 ,,	Fitter	2.00 ,,
Foreman	2.00 ,,	Fireman	1.50 ,,
Watchman . . .	1.75 ,,	Blacksmith . . .	2.50 ,,
Engineer . . .	2.00 ,,	Asstnt. Blacksmith	1.75 ,,

As to the mode of extraction of the ore, the method of work in all the chrysotile mines of Canada, is simply open quarry work, except at Broughton, where the peculiar formation necessitates a mode more in the nature of regular mining; and at Mr. Wertheim's mine, at Coleraine, a new departure was some time ago taken, by driving a somewhat extensive tunnel from the foot of the hill, and then a shaft through the rock to reach the pits above; though, in this last case, the operation is simply performed to open out a fine working face.

All the old rule-of-thumb methods, of opening and working, are now being rapidly discontinued, these being found to be quite impracticable with large pits and the constantly increasing production. Air compressors, steam derricks, and all the most improved labour-saving appliances are being everywhere introduced, and a rich reward awaits the inventor who shall enable the mine-owners to dispense with the tedious and costly process of cobbing, more especially of the lower grades, and at the same time help him to get rid of some of the enormous masses of piled-up waste rock, much of which contains short veins of fibre, which under the present system will not pay for extracting, but every particle of which will be turned to good account, when some economical process is devised for extracting it.

Whether the drills are worked by compressed air or by hand, in the old-fashioned way, the effect is the same. When a sufficient number of holes of the proper depth are drilled and duly charged with dynamite or powder, they are linked together, and fired by a battery in such a way that the face of rock shall be thrown outward, on to the floor of the pit. The

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asbestos is then picked out, the adhering rock roughly broken off by men, who split them in smaller pieces with hammers, and pile the ore into boxes or tubs, which are then loaded on to trolleys, and run off on tram-lines to the cobbing-sheds, where the asbestos is chipped off and dropped into little barrels, one for each grade. As these barrels are filled, they are again looked over, and any particles of stone found attaching to the fibre taken out, and the fibre put up into bags of 100 lbs. or 200 lbs. as desired.

The refuse rock is loaded into cars, run off and shot on to the dumping ground. Of this refuse rock there is always an enormous quantity, as much as fifty, or even 100, tons of rock at least to one ton of asbestos, and not infrequently, in the case of third-class mines, very much more.

Thousands of tons of rock, containing thin veins only, were formerly cast on to the refuse heap as waste, which can now be utilised by the asbestos separator. In this, the rock is pulverised and the asbestos crushed while disintegrating in an agitated body of water, with an upward current to float off the fibre, the pulverised rock sinking to the bottom.

Boys are employed in the cobbing-sheds to chip, or cob, the rock cleanly from the ore, an operation which is much more troublesome with thin veins, than with those of the better sort, to which the waste rock is less firmly adherent.

The sorting, or grading, of the ore is done by the cobbers simultaneously with the cobbing; the lads, while striking off the adhering rock, dividing the lumps of ore into Nos. 1, 2, or 3 class, and throwing them into their separate heaps, being guided in so doing by the colour and purity of the fibre, with a due regard to length. The mode of carrying out this part of the work varies very greatly at the different mines. One or two of these, notably that of King Brothers, being specially careful about this important part of their business, which is always appreciated accordingly. An investigation into the method and cost of this work, carried out by Mr. Obalski, showed that fourteen young lads in one day separated 4,000 lbs., or two Canadian tons, into graded and marketable

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material, their wages, at 70 cents each, reaching $9.08, or nearly $5 per ton; and this he considered below the general average cost of the work, which is probably nearer $6, bringing up the cost of production and preparation for market to about $25 per ton. This coincides pretty accurately with the writer's personal experience.

Usually the cost of cobbing will vary very considerably according to the quality of the asbestos. Some ores will break off from the rock quite easily, while others will require considerable labour to separate the fibre from the rock. Some may be contracted for at $3 per ton, while others will cost as much as $15, $18 or more per ton, the average cost, at the leading mines, being about $7.

Taking, therefore, the prices at the mines at $125 only for No. 1, $75 for No. 2, and $35 for No. 3, and comparing these with the cost of production, it is evident there is a very large amount of profit in asbestos mining, and a considerable inducement for the employment of capital therein. And when it is stated that these calculations were made upon the old system of work by hand-labour, machinery being now the rule, whereby the cost of production is reduced to $15, and at old prices, it will be seen that the profit is very much larger than is shown above.

The cost of mining will depend altogether upon the quality of the ore and the nature of the ground, with its immediate surroundings, consequently every mine must stand alone and be calculated according to its own special circumstances; the cost of mining in one case being scarcely applicable to, or any criterion of, that of another.

There is no scarcity of labour, a sufficient number of hands, mostly French-Canadians, being always forthcoming; but at those mines where there is an insufficiency of houses for married men, accommodation has to be found in a barrack-like building for single men: the married men, who cannot be accommodated, residing frequently at a long distance from their work, which causes them to be of a migratory disposition, and gives considerable additional trouble to the management. This remark, however, does not apply to Thetford, to Wertheim's, or, indeed,

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to any mine started on a business-like basis, as in such cases proper regard is paid to the welfare of the men by providing them with suitable accommodation.

A disadvantage in the employment of French-Canadian labour lies in the great number of festivals incident to their religion, with consequent loss of work at the mines, but apparently there is no remedy for this at present. The greatest curse of the place, however, is drink. The hip pockets in the men's pants form very convenient receptacles for bottles, and these are always pretty well filled after pay-days and holidays. The liquor most in favour is a vile compound called gin, or "square face." It is supplied in the regular square Dutch bottles from the familiar green-painted boxes in which "Hollands" is exported, and which are labelled "De Kuyper;" but the vile stuff is not much credit to that gentleman's manufacture if it be so, which is much to be doubted.

Although the district is under the Scott Act, and the sale of liquor consequently prohibited, like every other place where the sale is interdicted, there is no difficulty in getting as much liquor as you please, if you know how to go about it, and sometimes even if you don't.* At any rate I never yet was

* Here is an instance: On one occasion I had been out driving in the pouring rain for several hours, had got drenched to the skin, and was bitterly cold. I pulled up, therefore, at a likely-looking house, went in and called for some brandy, but to my disgust was told that no liquors could be supplied, as it was against the law. As I turned to go out again, in no very cheerful mood, the man, seeing the state I was in, evidently took compassion on me, and said, "Better try some bitters;" so calling to mind the saying that all bitters are warm, barring a bitter cold day, which only proves the rule, I assented. He then pushed over a tumbler and a black bottle, when I at once poured out and swallowed a pretty strong dose, feeling when I had done so as if I had swallowed a streak of forked lightning. As soon as I had recovered my breath I muttered my thanks and paid up. "Have another?" says he, with a twinkle in his eye. "No, thanks," I replied. "Guess you'll remember our bitters," he then laughingly said, prefixing the name of the place, which I afterwards found was in a district where prohibition was very strictly enforced, and which I therefore purposely omit, his breach of the law having no doubt saved me from the dangerous effects of a chill.

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in any prohibited place where I did not find it to be so, the only practical difference being that, in the absence of competition, the spirits obtainable are the vilest compounds imaginable.

According to my experience, no sooner is the sale of spirits interdicted anywhere than a craving for drink sets in, like an epidemic, coupled with a determination to get it, and that unmitigated curse to any community, secret drinking, becomes rife. Practical experience, however, soon taught me the comparative uselessness of alcohol when travelling in cold regions; the Russian fashion of tea-drinking being far and away the best. A tumbler of hot tea, flavoured with a slice of lemon, is not only palatable and comforting, but will carry a man twice as far as any concoction of alcohol.

In concluding this part of the subject, it may be well to point out that prior to the purchase of an unexplored asbestos property, it would be well to learn something of the surface indications, as well as the geological formation and surroundings of the property; and if the ground be opened, the direction and dip of the veins, the presence or absence of chromic iron ore, pyrites, mica, or other minerals in association with the asbestos ore, the quantity and quality of the ore producible from the adjoining mines, and its analysis. Special regard should also be had to the tenacity, lubricity, flexibility, and infusibility, of the fibre. The most suitable method of extraction, the best arrangements for dumping, with the important questions of transport, cost and supply of labour, etc., and last, but not least (if the mine be at work), the relative proportions of grades producible, are all important matters for consideration.

Upon this last point deception may easily be practised on the unwary; figures of prospective output and corresponding profit are sometimes put forward, which, if accepted without proper advice, are certain to lead to trouble, and perhaps to disaster. In one case of a mine put on the English market, it was boldly stated that the output for the first year might be taken at about 67 per cent. of No. 1, whereas the first year's production showed 67 per cent. and upwards of No. 3, which did not pay for working, some small amount of No. 2, and an almost infinitesimal,

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if any, amount of No. 1. In another case there had been no reliable expert's opinion obtained as to the quality of the land before purchase, and when work was commenced the ground bought proved to be barren. In both cases, the money had better have been thrown into the Thames, as well in the interest of the shareholders, as for the credit of Canadian enterprise.

When failures occur, they may almost certainly be traced to want of practical advice in the first instance, to incompetency or extravagance in the management, or to over-capitalisation; but with due care, economy, and honest and capable management, there are but few things which will pay better or with more regularity and certainty than mining for asbestos.

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CHAPTER VIII.

THE USES OF ASBESTOS: ITS APPLICATION TO ENGINEERING AND ELECTRICAL PURPOSES.

EARLY EXPERIMENTS — Causes of Failure — The Specialities of Two principal Firms indicated—The H. W. Johns' Manufacturing Company, of New York, and the United Asbestos Company, of London—Packings — Victor Metallic Packings — Wick Packings — Asbestos Steam Packing — Standard Piston Rod Packing — Wound Cloth Packing — Millboard — Millboard Gaskets — Multiplex Asbestos Gasket — Impermeable Sheet Packings — Patent "Salamander" Joint — "Gladiator" Packing — "Eclipse" Packing — Durable Joints—Asbestos Cord—Asbestos Powder—United Asbestos Woven Sheeting—Boiler and Pipe Coverings—Economy effected by them—Loss by Radiation—The Lining of Furnaces Fire Felt—Patent Roll Fire Felt—Sheet Fire Felt—With Canvas Flap—"National" Coverings—Removable Quiltings—With "Superator" Jacket—Asbestic Cement — Cement with Air Space left — Cement Felting — Asbesto-Sponge — Asbesto-Sponge Felted Covering — Asbesto-Sponge Cement Felting—Asbestos and Hair Felt Removable Covering—Frost Protection Covering—Electrical Engineering—Electricity in the Household and Hospital—The Electrotherm—Electric Heat Pad—Electric Car Heater—Vulcabeston—Vulcabeston Packing—Moulded Mica—Asbestos Packed Cocks—Fox's Patent Asbestos Packed Side Bars.

ALTHOUGH, as we have already seen, many of the valuable properties of asbestos have been known for thousands of years, we are now only concerned with the mineral, in its modern adaptation to the industrial arts and practical mechanics. In this respect, its use dates from only a few years ago; nor can the first attempt to render it available, be, even at that time, looked upon otherwise than as experiments, which were mostly of an unsuccessful character. One of the main causes of this failure was that the varied and dissimilar properties of the different

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varieties were not, at that time, sufficiently appreciated, as, indeed, they are not even now; nor was the requisite attention given to variations in composition, which can only be known by close attention to chemical analysis. At the present time the economic value of the greater number of the species is so far unknown that but little use can be made of them; though as we know, there is nothing, in or under the earth, which cannot be made available for man's use now, or will not be at some future time. We may therefore confidently expect that the rich deposits known to exist in various parts of the world, in America, in Africa, and Servia especially, will presently be utilised and made available for man's use. At this moment, however, scarcely any but the fine silky and tenacious fibres of Italy and Canada find practical application; often some of these differ materially in themselves, and as the value of them, for an infinite variety of purposes, becomes day by day more perceptible, the demand for them as rapidly increases, to a degree, so far as Canada is concerned, sometimes beyond the rate of supply. No particular object would be served by enumerating a list of manufacturers, we consider it, therefore, sufficient to mention two only, though specialities of manufacture may be indicated wherever considered sufficiently noteworthy. These two firms are the H. W. Johns' Manufacturing Company, of New York, and of world-wide fame, and the United Asbestos Company, of London, who claim to be the pioneers of the asbestos industry in England, though I have since been told by Mr. Witty, that his firm of Witty and Wyatt were the first in the field. Both the firms mentioned are of the highest possible standing, and the goods manufactured by them need no guarantee. Of the former, it is sufficient to state that they are the largest dealers in asbestos and manufacturers of asbestos goods in the whole world, and of the latter, that they have been selected as contractors for asbestos goods to the British Admiralty, the War Office, the Office of Works, the Home Office, the India and Colonial Offices, and the Trinity House.

ENGINEERING PURPOSES.—The earliest modern application of the fibre to engineering purposes was in the manufacture of an

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improved packing. At first this was mostly in the form of mill-board, but the various modifications of this special manufacture now in demand are so many that it would be useless to attempt to enumerate more than the principal of them here. It may be, however, that a general mention of some few of those now in use in steam, hydraulic, and electrical machinery may not be considered out of place. The utility of asbestos for such purposes as these, like that of every other material so used, depends a great deal upon its freedom from impurity. When the manufacture was first commenced it was frequently found that the fibres were more or less charged with minute particles of pyrites, of magnetite, or other metallic impurity, which caused the piston-rods to be scored by the packing. The damage thus occasioned was at first erroneously attributed to the action of the asbestos itself rather than to the impurities contained in it. As soon, however, as the real cause of this scoring or scratching was properly appreciated, it became necessary, in order to prevent it, not only that the most suitable kind of asbestos for this special purpose should be selected, but also thoroughly to cleanse it from all gritty matter before spinning; and in order effectually to accomplish this object, special machinery had to be devised, but, as soon as this was done, the yarn produced was pure and capable of being woven into any kind of fabric.

Whatever the material may be which is used for this purpose, it is a matter of the first necessity that, under the action of steam or heat, it shall not become hard in the gland; and its nature must be such that it shall remain unaltered, however high the pressure, or fast the steam, to which it may be subjected. The native qualities of asbestos admirably adapt it for such purposes as these, its inherent lubricity rendering it additionally valuable, as by its use a perfectly pure piston packing can now be produced, through which the rod slides with a minimum of friction. Another great point is that it does not require frequent renewing; regularity in the motion of the piston is preserved, and all the machinery connected with it runs with perfect smoothness, its elastic nature keeping the joints tight longer than any other kind manufactured.

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The number of forms in which these packings are now prepared is extraordinary, and in these days of high pressures and ocean records, it is of supreme importance to the marine engineer that he should be able to obtain jointing and packing materials upon which absolute reliance can be placed. In order, therefore, to meet all the exigencies of modern requirements, every possible form of packing that can be devised is now constructed, especially many with combinations of asbestos and metallic wire, and with rubber cores for gland packing.

Sometimes, it is true, more is claimed for many of these packings than they can accomplish, it being occasionally asserted that their self-lubricating qualities enable them to be used without oil. This is not so; they require a plentiful supply of oil and very careful attention as well: but these being given, they will last from five to ten times longer than any ordinary packing now in use. They possess many advantages over rubber, their weight is less, they last longer, and one-half the thickness will generally suffice.

Victor Metallic Packings.—Most of the various packings, in all the ordinary forms, made by the United Asbestos Company, of London, are too well known to need description here, and their Victor metallic packings are used wherever such goods are required. These are now made with a fine brass wire in the centre of every thread of asbestos in both warp and weft, the wire adding greatly to the strength of the cloth, while the wires themselves are completely protected. Joints are also made by the same material of so dense and close a character as to be remarkably suitable for hydraulic work.

Asbestos Steam Packing.—The H. W. Johns' Standard Asbestos Piston Rod Packing, is composed of the best quality



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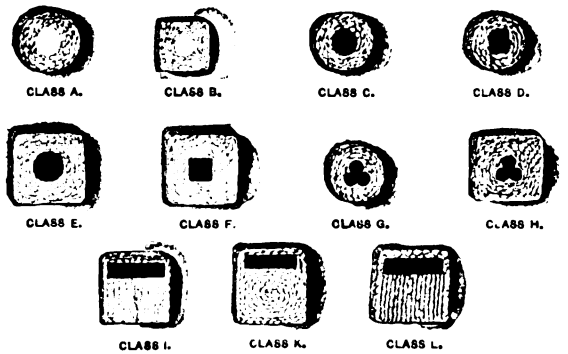
long fibre asbestos, spun into strands and combined with their patented elastic core into a rope of any desired size, so as to

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form a compact and durable packing for locomotives, marine and other engines, valve stems, oil pumps, expansion joints, etc. It requires less oil than any other, being, to a great extent, self-lubricating, and, as it is claimed, will outwear any other packing. It is easily applied, is indestructible by acids, long exposure to dampness, or any degree of heat. Lubricating oils, made from petroleum, work as well with it as with lard or sperm.

Asbestos Wound Cloth Packing.—For piston rods of triple and quadruple expansion, and high pressure engines generally. This is made from layers of asbestos cloth, coated with a patented



asbestos and rubber composition. It is very strong and elastic, and is suitable for joints of all kinds, including wet and low pressure steam, hot and cold water.

Wick Packings.—The H. W. Johns' Manufacturing Company's Standard Asbestos Wick Packings are composed of the purest asbestos fibre spun into strands, which can be separated, and made into the form of soft, strong, lamp wick, so as to be wound or packed in any desired shape round small steam and other valve stems, pumps, etc. They are both acid and fire-proof; and are, moreover, of very considerable use both at the lecture table and in the laboratory. Shredded or carded asbestos wool forms an excellent filtering material, used in the

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same way as paper pulp. As twine, or wick, it can also be used for binding together any parts of apparatus which may be exposed to fire or strong acids, and a crack in the neck of a retort or flask can be protected from spreading by binding 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 so formed.

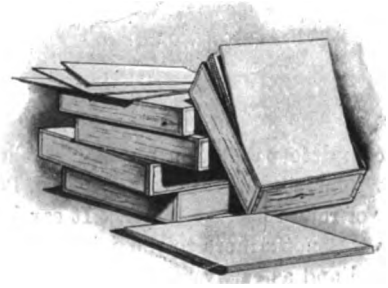


Asbestos wool mixed with a solution of silicate of sodium makes a fire-proof cement of unusual strength, which can be used for mending cracks in earthenware or stoneware, and by subsequent treatment with calcium chloride, a silicate of calcium is formed, by which it is made insoluble.

The paper and card also 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 also is invaluable for mending cracks in glass apparatus.

Millboard.—The above Company's Asbestos Millboard being



fire and acid-proof is used for a variety of purposes, including the packing of joints in contact with fire, oils, etc., as well as fire-screens, partitions, linings for ranges, stoves, or grates.

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Millboard Gaskets.—Their Asbestos Millboard Gaskets are less than one-half the weight of rubber, and are made in all sizes



not exceeding forty-two inches outside diameter, from $\frac{1}{32}$ to $\frac{1}{2}$ an inch thick, cut to order from asbestos millboard.

Multiplex Asbestos Gasket.—The "Multiplex" Asbestos Gasket is made entirely of Asbestos Spun Yarn, coiled into the shape required and bound together in compact, portable form. It is flexible and strong, and is unaffected by heat or moisture. Each



coil makes a complete packing, a number of them, therefore, ensures a tight joint, and as it is compressible, it will take up the inequalities of rough surface joints. It can be punched for bolts, and as it will not adhere to the jointing surfaces, it can be easily removed and as easily replaced.

Asbestos and Rubber Cloth is composed of asbestos cloth, covered with a composition of asbestos and india-rubber, so as to form a superior flat packing. Being very elastic, it adapts itself to all uneven surfaces, and forms a perfect joint, steam, acid, and air tight.

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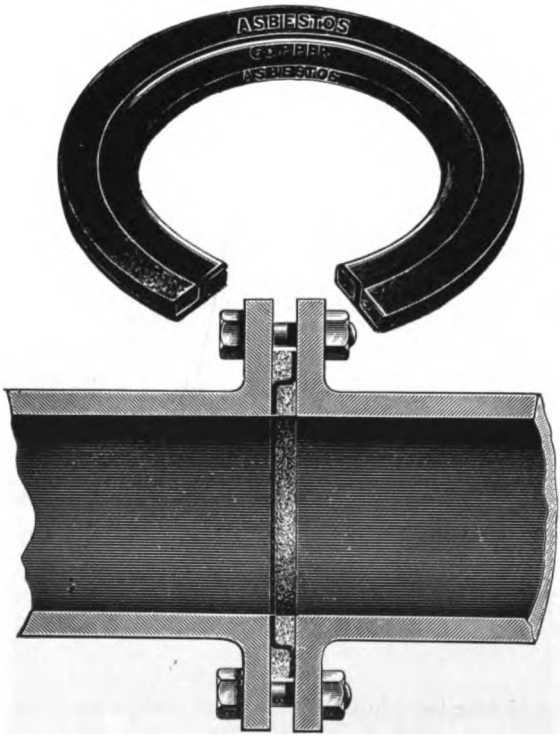
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A braided asbestos band or tape, is covered with the improved asbestos and indiarubber composition for forming gaskets, etc.



Impermeable Sheet Packings.—The same company manufacture an impermeable sheet packing from a special quality of asbestos for packing flange joints, steam pumps, cylinder heads, etc. This is a very elastic form, and can be removed and replaced without injury.

Patent Salamander Joint.—The Patent "Salamander"

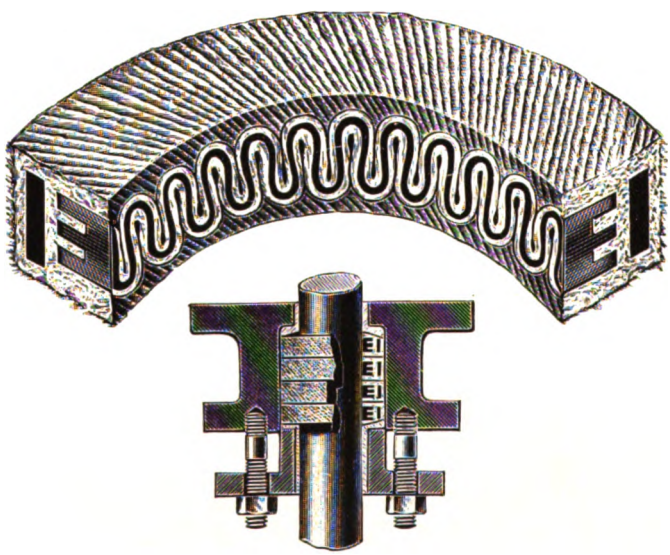


Joint is a novel, and, it is believed, an effective combination, of

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two concentric rings made from their "Victor" Asbesto-Metallic Cloth, or "A1" quality Italian Asbestos Millboard, sustained by a suitable metal ring, the vertical wall in the centre of which forms a partition between them, and absolutely prevents the possibility of their displacement either by steam or moisture. They are made in two forms, viz., Salamander Joints A, made with the "Victor" Asbesto-Metallic Cloth for the highest pressures, for wet steam, water, and other joints; and the Salamander Joints B, made with the "A1" quality Italian Asbestos Millboard, for dry steam and all joints where asbestos millboard is ordinarily used.

"**Gladiator**" **Packing**.—The United Asbestos "Gladiator" Packing is said to be the most perfect combination of asbestos



and metal ever introduced for land and marine engines. These are said to give excellent results in high pressure triple-expansion engines; they give no trouble and keep the rods in beautiful

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condition, whether the engines work at high or low pressure. The strips of soft metal are specially formed, built up with and firmly secured to the asbestos, with the result that a perfectly even and steam-tight asbesto-metallic surface is presented to the rods, keeping them bright and smooth.

Eclipse Packing.—Their patent "Eclipse," as a piston packing, gives excellent results, as also their "Victor" Metallic and "Quadruple" packings—the latter, a combination of asbestos and soft metal, are preferred by many engineers for marine work. White metal wire is interwoven with the asbestos on the side to be placed next the piston rod, which reduces friction, while the backing of pure asbestos cloth forms a serviceable cushion.

Durable Joints.—A durable joint can be made between rough cast-iron surfaces by the use of asbestos mixed with sufficient white lead to make a stiff putty. It will resist any amount of heat, and is so unaffected by steam or water as to be serviceable for mending or closing cracks in cast-iron retorts employed in the distillation of oil and gas from cannel coal. The heat being applied to the bottom of the retorts, and the temperature of the iron being maintained at a red heat, after a time the bottom of the retort will give way, the larger portion of the crack being downwards towards the fire. The method employed is to prepare the mixture and place it on the top of a brick, then put the brick on a bar of iron, holding it up for some time until it has penetrated the cavity and become somewhat set. During the operation, the lid must be removed from the retort, so that no pressure of oil or gas should force the cement outward until set.*

In making the joints of hot-air pipes for blast furnaces, which are necessarily exposed to an exceedingly high temperature, asbestos in the form of a cord has been found very serviceable; the jointing piece consisting of an iron ring, wrapped round with cord, which is simply put in place and nipped between the two flanges. Previously to the manufacture of asbestos

* *Invention*, September 5th, 1891.

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cord these rings were wrapped round with yarn, which gave incessant trouble.

Asbestos cord, a strong, hard finished four-strand cord, about one-eighth of an inch in diameter, is valuable for suspending metals, retorts, crucibles, etc., in contact with fire, and for use in theatres, chemical and acid works, etc., and is also used for covering rollers in print works. Asbestos sewing twine is used for sewing asbestos cloth and for binding materials subject to the action of fire or acids, for philosophical and chemical apparatus, and for insulating electric wires.

Asbestos powder made into a thick paste, with liquid silicate of soda, is used with great advantage for making joints, connecting pipes and filling cracks in retorts. This composition hardens very quickly, will stand any amount of heat, and prevents the escape of acid vapours. Hence it is very serviceable in the manufacture of acids and other corrosive products.*

For forming the joints of pipes exposed to the action of moisture, and for man and mudhole doors requiring frequent removal, asbestos woven cloth is very largely in demand. In these cases, asbestos millboard, which is the cheapest form of jointing material, is comparatively worthless, if, indeed, it is not absolutely objectionable, from its permeability to water, which soaks through and attacks the iron of the bolts, so that it was found necessary to devise a combination which would effectually resist the heat and damp. This is provided in what is known as asbestos and india-rubber woven sheeting, which is made in any thickness, and is supplied either in sheets cut to the required shape, or in a tape one inch to two inches wide, which can be cut to length and bent to circle or oval without puckering. When all other materials have failed to give satisfaction, this has answered admirably, and in the case of manhole and mudhole doors and feed-water pipes, the joint can be broken twenty times without requiring renewal of the strip.

United Asbestos Woven Sheeting.—The United Asbestos Company supply "United asbestos rubber woven sheeting," which is now being superseded, for high pressures, by their

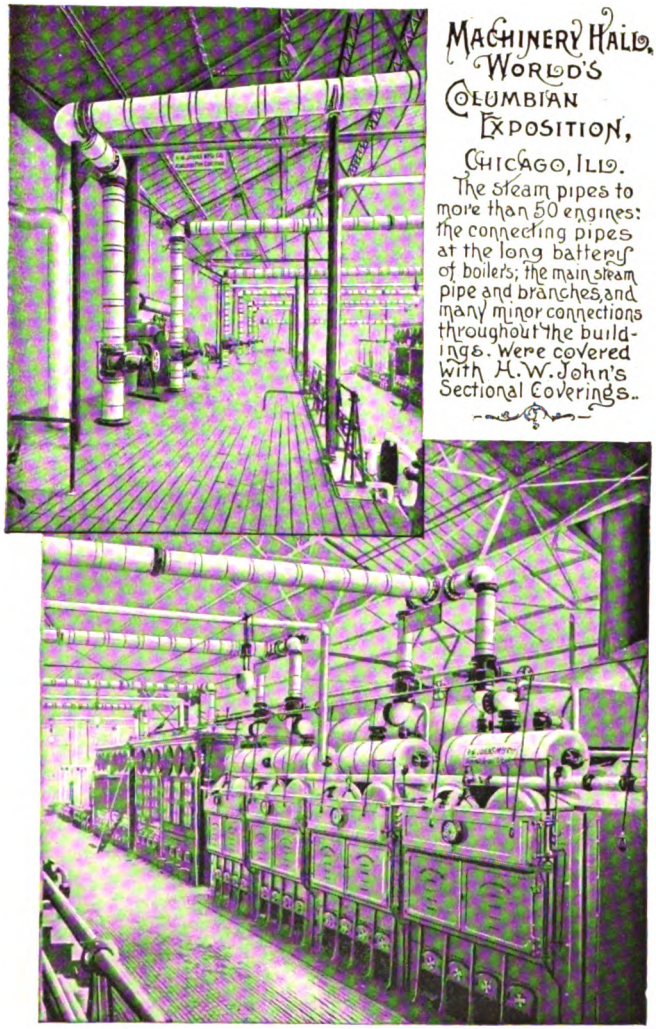
* "Ure's Dic. Suppl.," 85.

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MACHINERY HALL,
WORLD'S
COLUMBIAN
EXPOSITION,
CHICAGO, ILL.

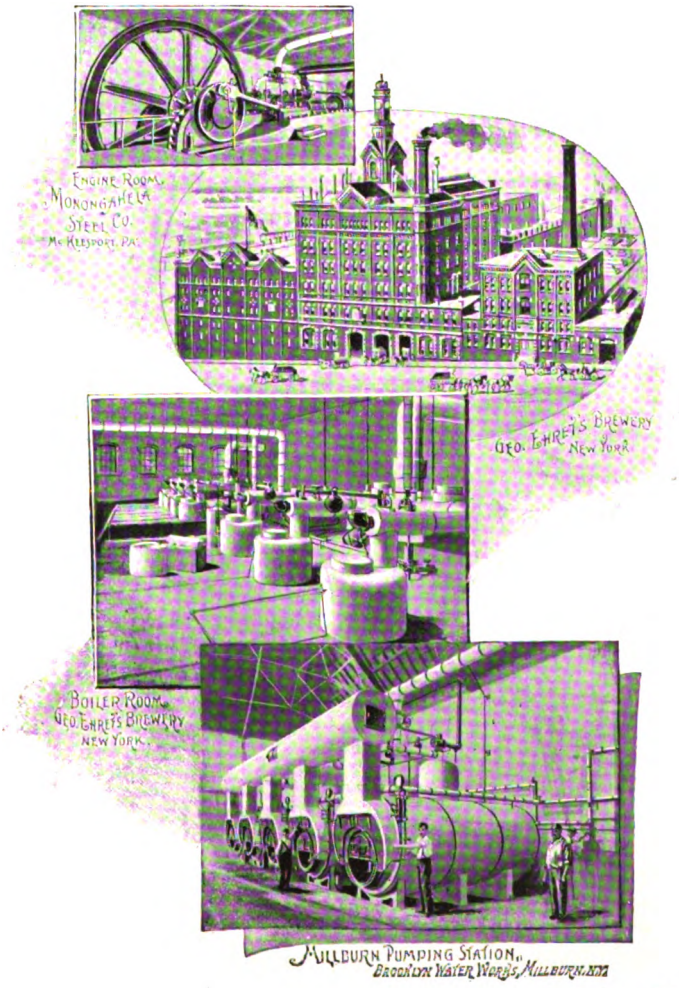
The steam pipes to more than 50 engines: the connecting pipes at the long battery of boilers; the main steam pipe and branches, and many minor connections throughout the buildings. Were covered with H. W. John's Sectional Coverings.

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asbestos-metallic "Victor" woven sheeting, in which a fine wire runs through the centre of each asbestos thread. Great durability is insured by the use of asbestos cloth, the requisite elasticity being imparted by a coating of india-rubber which fills the pores of the cloth and renders it waterproof. The "United asbestos rubber woven tape" is composed of the same materials, and being easily bent into position, without puckering, a joint can be quickly made without waste, and steam can be turned on as soon as the joint is screwed up. For manhole and mud-hole doors, which have to be frequently opened, it is simply invaluable.

Boiler and Pipe Coverings.—The various non-conducting coverings designed for the protection of boilers and steam pipes, for the preservation of the contained heat, and for the economy of fuel are specially numerous; and there are no approved forms of these which are not composed of the incombustible mineral asbestos.

Economy Effected by them.—Experiment has long ago 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 64*s.* 6*d.*, with coal at 8*s.* 4*d.* per ton. But by using the least efficient of insulated coverings, this loss is reduced to about one-fourth of that amount, and, with the best procurable, to about 10*s.* 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.

Loss by Radiation.—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. It is not the loss of the actual number of units of heat, which is the principal objection, but the attendant results, which cause a much greater loss in other ways. The condensation which

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takes place in a steam pipe has two very serious features; for, if it be carried into the cylinder, it may cause a break-down, 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 commoner kinds of engines, because in them the available part of the heat is often not over 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 Lining of Furnaces.—Being one of the most refractory substances known, asbestos is used in a variety of ways for the lining of furnaces. When the metal and fire are together, as in the cupola, or blast furnace, it constitutes a most enduring and heat-confining lining, and is particularly adapted for use where the metals or ores contain sulphides, as sulphides have no effect on asbestos. As linings for furnaces and kilns, and for use in the manufacture of crucibles, a patent has been granted for an improved refractory material composed of a mixture of the aluminous asbestos from Natal with fireclay, in the proportion of one part of asbestos to four of fireclay. Both are finely pulverised and formed into the desired shapes while in a plastic state. The patentee states that if a material of greater fire-resisting properties is required, the worn out "saggers" are pulverised, and a fresh supply of fireclay, equal to double the amount of powdered "sagger" is added. When this material is exposed to extraordinary heat it does not crack; but, on the other hand, it tends to fuse and bind its particles closer together. Another convenient property of the material is that it is capable of resisting the attacks of atmospheric and chemical substances, such as damp, sewage, etc. This special form of asbestos is stated to be additionally valuable both on account of its cheapness and the convenient form in which it is imported.

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Asbestos, in its fibrous form or finely-divided state, is filled with an extraordinary number of air-cells, and consequently contains in itself every requisite for a perfect non-conducting covering; therefore, the most satisfactory results are obtained by using it in this way, in its pure and fibrous form, without any admixture of foreign material.

Asbestos Fire-Felt.—The H. W. Johns' Manufacturing Company, of New York, have given to this department of manufacture considerable attention, and have designed and patented a material for the purpose, which they term Fire-Felt. In their construction of this covering, the mineral fibres are



formed into cylinders, blocks, and sheets, according to the shape and size of the surfaces to be covered; which, being light in weight, (1 lb. to the square foot, one inch thick), flexible, and easily handled, can be readily adapted to a surface of any shape; whilst, being strong and tough on the exterior, and spongy and felt-like on the inner layer, they form a non-conducting material of a high order, and susceptible of any desired mechanical arrangement.

Fire-Felt is made of pure asbestos fibre, closely united into a light, very strong felt-like fabric. Being absolutely fire-proof, it is adapted to withstand the highest steam pressures, for the protection of superheated pipes, and is especially valuable for those required for car heating purposes.

When tested with any of the various composition coverings produced, the superiority of the pure fibrous asbestos, in this form, is quickly seen. It gives better non-conducting results, and possesses a guarantee of durability impossible to be otherwise obtained, inasmuch as it cannot char or burn

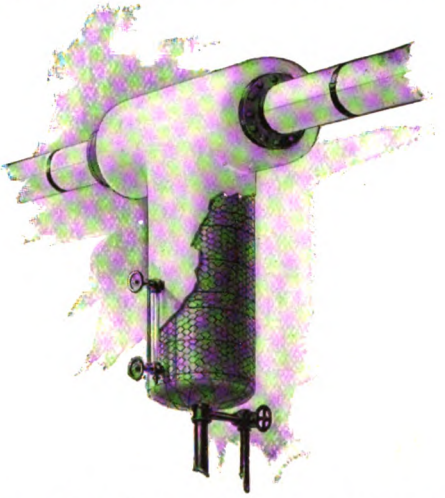
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out, because there are no organic or perishable materials included in its make-up.

Elbows, Tees, Valves, etc.—These asbestos fittings are canvassed and banded, the same as pipe sections. Irregular elbows, tees, and valves, if at all near the dimensions of regular sizes, are covered by cutting the regular asbestos coverings to fit, and using asbestos cement felting to make good the deficiencies. On large surfaces, sufficient is cut from a sheet of 1 in. fire-felt, to cover the iron, is then wired fast, and finished with asbestos cement in two coats. Sheet fire-felt is furnished $\frac{1}{2}$ in., 1 in., $1\frac{1}{2}$ and 2 in. thick, in sheets 24 × 36





inches. Ordinary No. 19 annealed iron or copper wire is used, and on large surfaces, hexagonal wire cloth. Long sweep elbows should be covered in this way, and in ordering material for such fittings, extreme lengths and circumferences should be given.

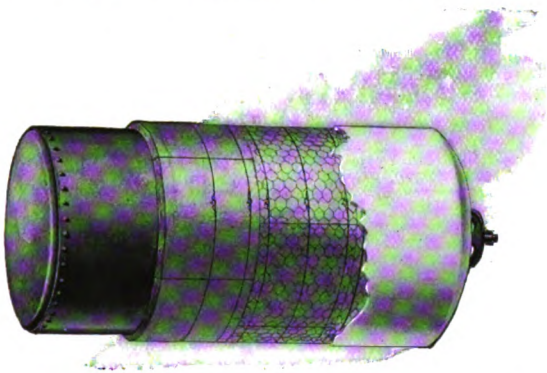
Drum, or Heater, covered with $1\frac{1}{2}$ in. Sheet Fire Felt, Hexa-

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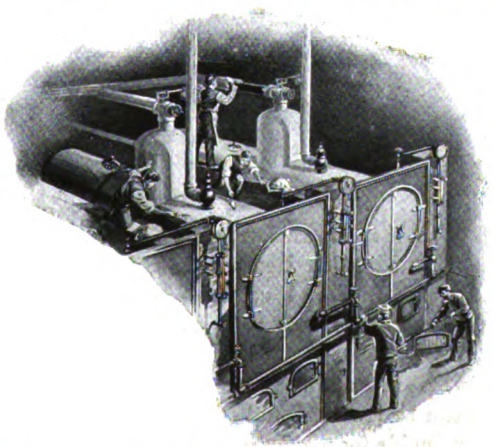
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gonal Wire Cloth, $1\frac{1}{2}$ in. mesh, No. 19 wire, and a finishing coat of Asbestos Cement Felting, $1\frac{1}{2}$ in. thick.

For large pipes, domes, boilers, and other large surfaces,



fire-felt is furnished in sheets. This sheet fire-felt is a firm even block of fibrous asbestos, surprisingly light in weight.



In sectional coverings for the protection of elbows, tees, and valves in connection with standard wrought-iron pipes, these are fitted by the use of asbestos cement felting. On large

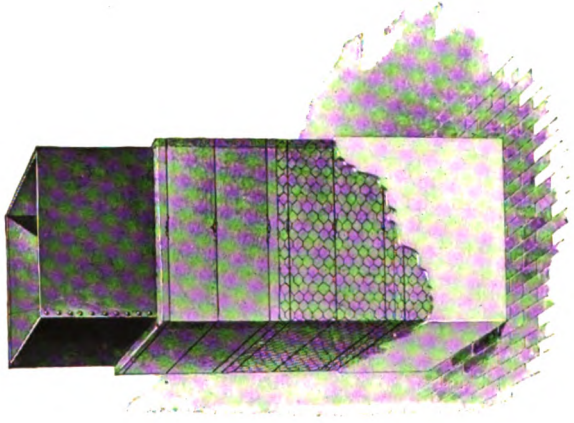
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surfaces, same is wired fast and then finished with the cement in two coats. It is specially adapted for heat insulation, and will remain perfect where other materials usually crack and disintegrate.

Sheet Fire-Felt is replete with air-spaces, and is the best form of heat insulator known, and permanently durable.

The Block on p. 221 shows a boiler covered with sheet fire-felt, with a jacket over of canvas duck banded. The covering is held fast by wires to boilers and other large surfaces, and canvas or asbestos cement felting is generally used as a finish.



Flues, Breechings, Bulkheads, etc.—A flue is shown covered with 1½ in. Sheet Fire-Felt Hexagonal Wire Cloth and Cement Felting. The expansion and contraction of large sheet metal surfaces is often so great as to injure the cement coverings when used alone.

Sheet Fire-Felt is made in sections, for covering boilers, etc., so that they can be removed and replaced without injury. It is particularly valuable for marine and other high pressure boilers.

Removable Quiltings.—A special boiler covering, manufactured by the same firm, and supplied by them under contract for several of the United States Government warships, is in the

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form of a quilting. These quiltings weigh about 2 lbs. per square foot, and can be removed without difficulty when required. The same firm also manufacture removable pipe coverings; some of these are made exclusively of pure asbestos fibre, and others of asbestos combined with other materials, according to whether high or low pressure steam is used, or whether it be for the preservation of cold-water pipes from freezing.

With Canvas Flap.—These coverings are made in sections of three-foot lengths, of the exact size of the pipe to be covered, the asbestos fibres in the covering being so interlaced that the sections, whilst combining strength with flexibility, afford so large a number of air-cells as to give this covering a very high non-conducting quality, while it is not liable to char or be otherwise injured by the most intense heat. It is occasionally found advisable to provide a heavy inner layer of asbestos fibre, with an outer layer of hair felt; but if a layer of asbestos fibre be substituted for the hair felt, greater durability is ensured. In whichever way the fibre is used, it is enclosed in a strong case or wrapper of non-porous sheathing, the inner section of which has a lining of asbestos to keep it from direct contact with the iron.

Patent Roll Fire-Felt.—Another form of this material is shown in the same firm's "Patent Roll Fire-Felt," which is made in rolls of about three feet in width, and of any required thickness. This is specially useful as a non-conducting fire-proof lining under other coverings, or as a covering by itself, where great thickness is not desired, as in most kinds of steam pipe work. In length each roll contains about 300 square feet. High pressure being now the rule, seldom less than 80 or 90 lbs., which means a body of heat of 300° Fahr., or over, contained in one quarter-inch thickness of iron, and rapidly conducting through the iron, it is of primary importance to prevent this heat from escaping, not only when the covering is first applied, but also during a term of years, and this requires a material of high non-conducting powers coupled with great durability.

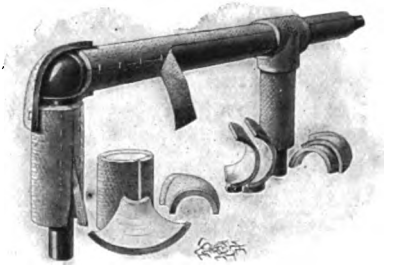
Their "National" covering, for use where 85 lbs. or less steam is carried, is made in sections three feet long, composed

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of corrugated soft wool felt, alternated for three rows with asbestos sheathing. Owing to the corrugations in the alternate layers of felt, the sections are full of confined air spaces, forming a covering unsurpassed for ordinary steam pressure. It is highly ornamental in appearance, and is therefore particularly desirable for public buildings, hotels and so forth.

Fire-felt possesses these qualities in an eminent degree, as it is free from any ingredients that will cause it to disintegrate under heat or deteriorate through use. Its mode of application to house furnace pipes is shown in the diagram above.



Flue covered with sheet fire-felt, hexagonal wire cloth, and cement felting.

With "Superator" Jacket.—This patent fire-felt is also furnished with a canvas flap cover, and when the pipes are to be used in wet places, out of doors, or in mines, a special class of "Superator" jacket is provided.

The material which the patentee calls "Superator" is another speciality of the same house. This is a flexible sheet of asbestos, strengthened by an insertion of wire-netting. It is made of mineral substances only (mainly asbestos), with an admixture of some insoluble chemical ingredients, the asbestos rendering the jacket fire-proof, and the wire netting giving it the necessary strength.

The material of which the Superator is made is waterproofed by a patent process, and will consequently resist any degree of moisture, thus forming a substantial protection to the covering.

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Superator is also used for roofing purposes, sheathing wooden structures exposed to the weather or to sparks, etc.

Asbestic Cement.—The asbestic which, in the form of cement, is now used in such enormous quantities, for building and other purposes, is composed of the finely pulverised asbestiform rock from Danville, which will be described further on. It is simple in use and indestructible when once applied to the covering of boilers, steam pipes, hot blast furnaces, or stills. In some cases, the retention of the heat alone is wanted, in which event, asbestos is mixed with some other substance, but where it is necessary that the protection should be fire-proof as well, then asbestic cement only should be used.

The utility of such a covering is well illustrated by the heating system now adopted for railway cars. The main pipe, from which the individual car draws its heat through side mains, if not covered in such a way as above mentioned, would lose a large proportion of its caloric, on account of the rapid motion of the car through the air.

Where the old-fashioned asbestos cement is used certain chemical ingredients have to be added in the preparation of it which, while in no way injurious to the metal, cause the asbestos to adhere firmly to the plates, so that when dry it becomes quite hard and can be walked over without being injured. Nothing of that kind is needed now with asbestic, which is thoroughly adhesive and hardens at once on application. With a boiler carrying, say, 80 lbs. steam pressure, the application of from one and a half to two inches of this composition so well retains the heat in the boiler that a thermometer with the bulb held close to the outer surface of the covering will not indicate more than 80° to 85° Fahr., and when the boilers, steam pipes, etc., are covered in this manner, a saving of fuel is effected, equivalent to 33 per cent. The non-conducting power of asbestos is twice as great as that of hair felt, which is believed to come next to it in value, but is soon destroyed by heat. When the steam pressure is not unusually high, one inch in thickness of the cement is sufficient; but the additional cost of an extra half-

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Asbestos and Asbestic: Their Properties, Occurrence, and Use (1897)
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inch is amply compensated for by the larger proportionate saving of fuel and power effected by its use.

The ordinary asbestos cement, which is made from a cheap quality of asbestos, was formerly in common use in Canada and the States, but this is now rapidly going out of use, in favour of the new asbestic cement, which is found to operate with a two-fold effect, viz., by lowering the temperature of the boiler-house, to the great comfort of the engineers and firemen, and also, in a very marked degree, by economising the expenditure for fuel. Unprotected pipes require a greater supply of fuel, and mean more wear and tear on grate bars, boilers, etc.; while in order to convey steam any distance, through unprotected pipes, a much larger pipe is required to furnish the requisite power.

It seems strange that the use of asbestos in this way, in England, has as yet made so little headway. In one of the palatial hotels recently erected in London, where engines are required to be in constant work for pumping water for working the lifts and for general purposes, as well as for the dynamos, the heat from the boilers formed so great a nuisance, and occasioned so much loss in other ways, that very considerable expense had to be incurred with a view to lowering the temperature. When conversing with an expert, who had been sent for to devise a remedy for this, I asked whether the use of asbestos would not effect the desired object. Certainly it would, was the reply, but it is too expensive.

Cement with Air Space Left.—In applying the cement the best results are obtained when it is put on with an air space left. This is another patent of the H. W. Johns' Manufacturing Company. A network of lathing or wire-cloth is formed round the boiler or pipes, at a distance therefrom of about an inch. On this framework the cement is applied, the material keying through the meshes of the wire, and thus obtaining a greater hold and consequently greater durability than if it were applied direct to the iron.

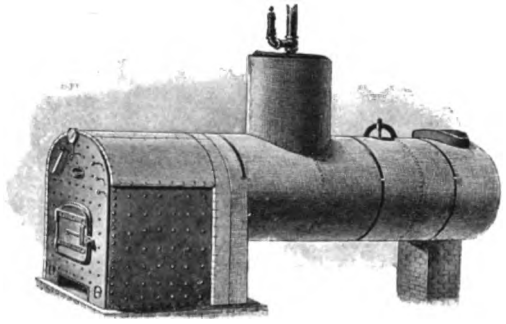
Boiler Tops, Irregular Surfaces, etc.—An asbestos cement felting is also manufactured by the same parties, for use in the

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same way as the ordinary asbestos cement. This is composed of fibrous asbestos, infusorial earth, and a cementing compound forming a light porous covering, partaking of the nature of a felt and a cement, to be applied with a trowel to steam pipes, boilers, stills, etc., while heated. It is recommended for all purposes where more than 80 lbs. of steam is carried. Mixed with water to the consistency of mortar, it can easily be applied by unskilled workmen.

Hot Air Furnace.—Furnace covered with sheet fire-felt, pipes with roll fire-felt. For this work the fire-felt is manufactured in rolls of 36 inches wide and $\frac{3}{32}$, $\frac{1}{8}$ and $\frac{1}{4}$ inch thick.



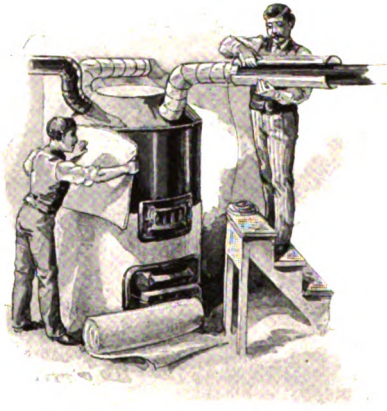
The importance of covering hot air pipes in cellars is not generally appreciated. Tons of coal are wasted yearly in each house containing a furnace, the hot air passing out to over-heat the cellar, the rooms upstairs suffering in proportion. The practice of wrapping hot air pipes is to be condemned. It does not sufficiently insulate the heat, and never proves satisfactory.

Asbesto-Sponge.—Another of their materials is a substance called asbesto-sponge. It may not be generally known that sponge has great powers of fire resistance in itself. The discovery of its usefulness in this respect was made quite accidentally, and then a consignment of sponge scraps picked up on the coast was made use of for experimental purposes.

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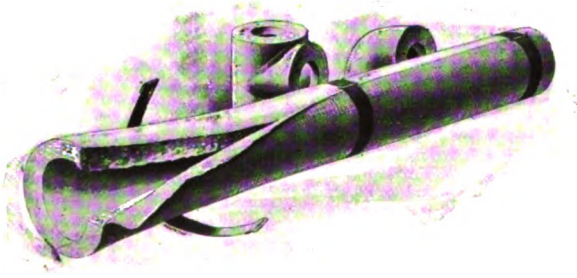
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The sponge was first finely comminuted, and then mixed with asbestos fibre, when it was found that the combination was



Patent Roll Fire-Felt Covering. (See p. 223.)

eminently successful for many purposes of fire-proof and heat-proof covering. The sponge being full of air-cells is naturally an excellent non-conductor. Recognising that in all non-con-

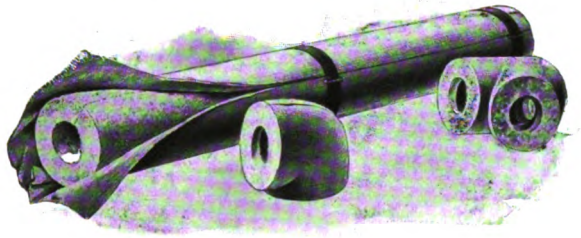


ductors, the manufacturer's endeavour is to provide as large a number of air-cells in a given space as possible, the patentee considers that sponge, which is composed of fine, flexible, tenacious fibres, interwoven in the form of cells and meshes,

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constitutes the ideal structure of a perfect non-conductor. The tintack-like barbs of the sponge are so interwoven, in asbesto-sponge, with the fine, silky fibres of asbestos as to form an elastic, highly porous material, of so light a character that a barrelful in the form of filling will barely weigh 50 lbs., and this with so small a percentage of sponge, that the material is practically fire-proof.

Asbesto-Sponge Felted Covering. — This is a special preparation of asbestos and sponge, felted and formed into cylinders, which are cut longitudinally, so that they can be easily "sprung" over the pipe. It is an excellent non-conductor, and is adapted for both high and low steam pressure.



It is very elastic, especially valuable wherever there is danger of injury from motion or vibration. The covering is finished with a canvas jacket, with lap to be pasted, and metal bands forming a neat finish over joints.

Asbesto-Sponge Moulded Covering.—This form of covering is the most durable and effective non-conducting covering yet produced. It combines the advantages of asbesto-sponge cement felting in a portable form, is absolutely fire-proof and adapted for highest steam pressures. It is supplied in sections, with canvas jackets and metal bands to hold them in place, and can be applied by unskilled workmen.

Asbesto-Sponge Cement Felting.—This cement felting is an improvement on the asbestos cement felting, and is much lighter in weight. It is first mixed with water, just thin enough to be rubbed or brushed on the surface to be covered.

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It will dry very quickly, and form a coating to which the felting will firmly adhere. Afterwards the desired quantity must be mixed with water to the consistency of a stiff mortar, worked up thoroughly with a hoe until fully amalgamated. Then it must be applied with a trowel in small lumps, so as to form a rough surface preparatory to the application of the next coat; after which other coatings are applied until the desired thickness is attained. If any cracks appear on the surface of the last coat when drying, they should be smoothly filled up with a little thin cement felting put on with a brush. When all dry, it can be "floated" or painted over with fire-proof paint.



Asbestos and Hair Felt Removable Covering.—This form of air-chamber covering is composed of standard hair felt, with an inner layer of asbestos fibre of equal thickness, and a lining of asbestos sheathing, the whole enclosed in a strong wrapper. This is the most durable portable form of hair felt covering suitable for all but high pressure service.

Asbestos Furnace Cement.—This is the strongest and most



durable cement in use for setting up and repairing broken joints in furnaces, ranges, heaters, stoves, etc. It is sold ready for use,

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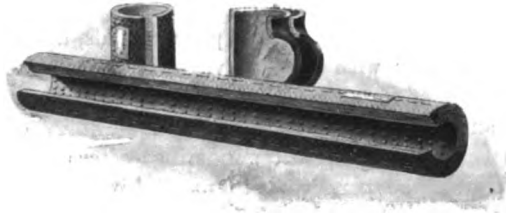
adheres readily and firmly to castings, tin, etc., and sets in a few hours. When subjected to heat it vitrifies without shrinking or becoming porous. It is inodorous and effectually prevents escape of smoke, gases, and dust, thus ensuring a perfect draught.

Asbestos Plastic Stove Lining.—This material is composed of asbestos and other fire-proof materials, prepared ready for use



in the form of a plastic cement, easily applied with a trowel. It forms a durable and economical lining for stoves, ranges, etc., and is useful for repairing broken fire-brick, iron linings, etc., and as a fire mortar for laying and facing fire-brick. It will not warp, nor will clinkers attach to it.

Frost Protective Covering.—This is a covering made in



sections three feet long, composed of alternate layers of corrugated and plain soft wool felting. It forms the neatest, most

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efficient, and economical covering for the protection of freezing in gas and water pipes that has ever been introduced, and is very easily applied.

Electrical Engineering Purposes.

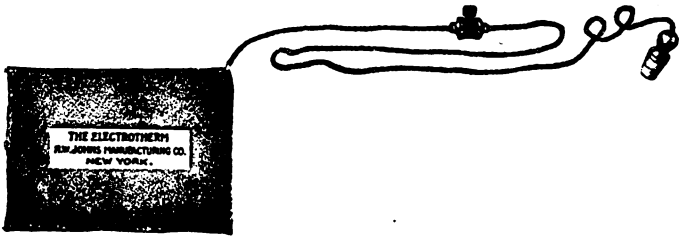
To the electrical engineer, asbestos is absolutely indispensable. Many electrical devices and parts of the machinery and wires, through which the current passes, occasionally become heated, and were it not for the insulation and heat-resisting qualities of asbestos, the apparatus would often be completely destroyed, especially in the case known to electricians as "short circuiting." For such purposes it is found advisable to combine asbestos with rubber and other gums, and this combination is now universally used, not only for electrical, but also for many steam and mechanical purposes.

Electricity in the Household and Hospital.—Among the numerous applications of electricity recently exhibited is a modern method of producing heat by electricity for household and hospital service, and in such a way as will appeal to many an individual "under the weather," as well as to the medical profession generally. Advantage is taken of the heating effect, produced by the passage of a current of electricity, to construct a flexible, fire-proof mat or pad of asbestos, in which are concealed conducting wires, the appliance thus formed being utilised in making the local applications of heat heretofore effected by the hot water bag, compress, soapstone, or brick. It has been the experience of most poor mortals, at some time or other, to wrestle with the elusive water bottle and suffer under its extremes of temperature. The device referred to is so simple and effective, that after the first "hurry call," the nurse can cease her periodical wanderings after hotter water, and the patient be permitted to nurse his pain in peace. It must happen, that the beneficial effect of a "local application," is often lost or retarded by the necessity for frequent renewals of the water bags. The "electrotherm," for that

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is the name of the new heating pad, necessitates no such changes, and a constant temperature can be maintained indefinitely. In prolonged, or acute cases of, rheumatism, pneumonia, or the good old-fashioned stomach ache, the electrotherm should prove a relief alike to patient, doctor, and nurse. All that is necessary, is to connect the flexible cord, which accompanies each pad, to the ordinary electric fixture, and regulate the temperature by a simple little switch provided for the purpose. The electrotherm has now supplanted older means in many instances, and has most satisfactorily proved its efficiency and convenience. It marks another step in the advance of electrical science as applied to therapeutic uses.



In the form of a heating pad it is invaluable to physicians and nurses as a substitute for the various troublesome methods of applying and maintaining artificial heat in local applications in hospitals and upon the operating table. Ordinarily it is furnished with a felt or flannel cover, in which form it is suitable for many purposes, and it is also covered with rattan for use as a foot-warmer, for warming beds, dishes, and food. It is such a clean, convenient, and sensible device, that we may soon expect to find it in all households so fortunate as to be provided with electric service.*

Electric Heat Pad.—In their electrotherm, or electric heat pad, the current is utilised by embedding the wire in an asbestos sheet-like pad. It has a switch for regulating the temperature, and there is an automatic arrangement for preventing the

* "American Electrician."

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possibility of accidental over-heating. The electrotherm is composed of wires insulated and protected by asbestos, woven into a flexible sheet or pad, which, when attached to the ordinary incandescent lamp socket, offers sufficient resistance to the current to produce a constant and uniform degree of heat. It can be safely used by any one, and the simplicity and convenience of this means of supplying heat renders it especially valuable for medical and household uses.

Electric Street Car Heating System.—The "H. W. J." electric car heater, patented by the H. W. Johns' Manufacturing Company, is both simple and effective. Any such system



must not only possess both these qualifications, but to be entirely satisfactory must effect an equal distribution of the heat throughout the car. Common experience has shown that



the ordinary coal stove cannot heat the further corners of a car without discomfort to the passengers in its vicinity. A certain amount of heat must be generated to produce a given heating effect, consequently if the heaters in a car be few in number and of limited heating surface, their individual temperatures must be high. The construction of the "H. W. J." heaters is radically different from any heretofore devised. The resistance

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wire, being effectually protected from the atmosphere by a covering of asbestos, is not liable to become oxidised. In the panel heaters the wire is first wound with asbestos thread, and



then woven into cloth or mat with an asbestos warp, consisting of asbestos cords. The advantage gained by the mat form of heater, is the ability to create a high resistance, and to provide



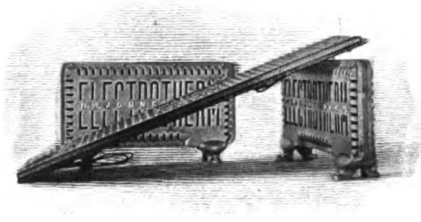
the largest possible radiating surface for the heat generated. The asbestos envelope prevents the sudden chilling of the resistance wires by the draughts from open doors, so as to ensure a more even temperature—freedom from such fluctuations which must take place in the operation of the heaters, if constructed with the wires bare and exposed. A piece of the cloth containing a certain quantity of wire is fastened by fireproof insulating cement to a sheet of asbestos millboard,

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which forms its support. The whole is then enclosed in a neat covering and perforated steel plate as shown in the illustration ; the steel covering being japanned with an insulating compound, or otherwise decorated.

The insulating wire folds back upon itself, forming a U-shaped loop ; there are no coils to short circuit when expanded by heat, nor to break when contracted by cold.

There is a free circulation of air through and under the perforated steel plate, which is so fixed that the back of the heater is about half an inch in front of the panels below the seat. Usually six heaters are placed on each side of the car, extending from end to end, thus ensuring a uniform temperature throughout, without requiring an excessively high local temperature in



the heaters themselves, which are so controlled by a patented knife switch that any intelligent person can regulate the heat, and due arrangements are made to prevent the over-heating of the car. The switch is simple and positive in its action, substantially constructed, with an ample space for breaking the arc in a 500 volt circuit. To meet the changing conditions of the atmosphere, the switch provides for three degrees of regulation.

Where the construction of a car does not permit the use of panel heaters, an upright heater, with ornamental cast-iron casing is recommended.

The construction of the electrotherm mat is similar to that of the panel heater, with the exception that the mat is attached to both sides of the millboard support. These heaters are

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intended to be placed under the cross seats, and secured to the floor of the car.

Vulcabeston.—This is a patented composition of asbestos, india-rubber, and other vulcanisable gums combined with materials for special requirements. It is exceedingly tough and strong, hence practically non-absorbent, resists great heat, possesses great mechanical resistance to blows and pressure, and is readily manufactured in the forms most useful for electrical purposes. It is greatly in use for steam packings, electrical insulators, etc., on account of its permanent resistance to heat and immunity from injury by acids, gases, moisture, etc. It can be made in any desired form, is indestructible, and will neither shrink, expand, nor warp. One of the forms is for electrical insulation and the other for steam packings.

Owing to its fibrous nature and the great pressure to which it is subjected in the process of manufacture, *Vulcabeston Insulation* possesses great strength. As it is composed almost entirely of asbestos, it possesses the property of great heat resistance, and as it can be made into any desired form, from the thinnest sheet to the largest insulating piece, it is suitable for all requirements.

Vulcabeston Packing is composed materially as above described, with the addition of lubricants which render it pliable and yielding. It can be moulded into any form of gasket, packing, etc., and can be used to advantage for steam, acid, and gas. This special packing is made to order, for use in salt, soda, alkali, and ammonia works.

On account of the indestructible nature of asbestos and the toughness and elasticity gained by the vulcanising process, vulcabeston is more durable and effective than any other material known for steam uses. It is made of any desired density, from soft (for rough joints), to very hard, and can be supplied in any form for special purposes.

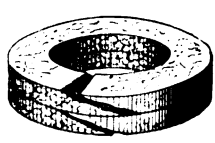
It is by no means to be said that all the varied applications of asbestos to engineering and electrical purposes have here been noted, but merely a selection of some of the most prominent. Indeed, it would be difficult to say for what special engineering

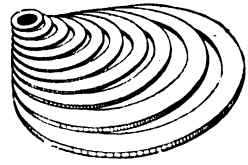
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or electrical purpose asbestos cannot be made available; an enlargement on this head would probably be considered of too technical a character to be of general interest, and enough has doubtless been said to show the great importance of the mineral in an engineering or electrical point of view.

Vulcabeston Packing Rings and Vulcabeston Moulded Union Washers.—There are numerous forms of plain concave-moulded packing rings for use in valve stems, piston rods, air





brake pumps, etc. Many of the large railroad systems have adopted these packing rings for steam and air ends of Westinghouse and New York air brake pumps, and for locomotive valve stems and piston rods. The use of these packings should be in sets of one concave and three convex rings, the outside convex rings tapering to fit the box and the intermediate rings pressing closely on rod and interior of stuffing box.

Moulded Mica.—In addition to the widespread use of moulded mica, in the insulation of trolley-lines during recent years, it has numerous applications in special form for the insulation of electrical apparatus. It is a hard, dense, waterproof compound, moulded under great pressure, and is intrinsically one of the best insulating compounds known for electrical purposes. It is also largely used for weather-proof sockets, switch bases, cut-outs, bases for instruments, and also for covering the handles of tools, such as screwdrivers and pliers, and many devices requiring durable and perfect insulation. Between a metal surface and one of asbestos, sufficient room is required to be left between the plug and the shell to allow for expansion.

"Monarch" Insulating Material.—The "Monarch" insulating material, like moulded mica, is made in moulds, under great pressure, and is suitable for similar purposes. It is a

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hard, black or red, material, composed largely of asbestos, and has been successfully used for the moulding of switch blocks, covers, sockets, bushings, thermostat bases, and special pieces requiring accuracy and permanency of dimension and finish. The material is not liable to warp, swell, or shrink with ordinary change of temperature.

Asbestos-packed Cocks.—Dewrance's asbestos-packed cocks are too well known to engineers to need more than reference.

Fox's Patent Asbestos-packed Side Bars.—The destruction of boiler furnaces, in course of time, by pitting and cracking, of which every practical steam user is fully aware, has proved a source not only of considerable difficulty, but of serious expense and delay in the renewal of the furnaces. The pitting in nearly all cases takes place some four or six inches above the line of fire-bars, in a longitudinal direction on the water side of the furnaces, in that position which careful observation has shown to be most affected by the variations of temperature, when the fuel is in direct contact with the sides of the surface. The most serious defects are usually found on a line with the surface of the fuel, or from one to three inches below the surface, depending upon the thickness of the fire, and are undoubtedly caused and developed, not only by the very high temperature of the fuel in contact with the plate, but more especially by the exceptional variations of temperature at this particular position. To prolong the life of the furnace, it is unquestionably necessary to equalise this range of temperature, and it is essential to success that any method adopted for this purpose shall be cheap, easy of application, and in no way interfere with the general arrangement of the fire-bars in ordinary use. Fox's Patent Asbestos-Packed Side Bars have been specially designed to meet the requirements set forth. The bar is made to fit the furnace side, and has a groove formed along its entire length for the reception of asbestos rope or packing, which, on the bar being secured to the furnace by studs or otherwise, makes an absolutely tight joint between the bar and the furnace, thus cutting off the air supply to the fuel in immediate contact with the furnace side, where by the

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dangerous inequality of the temperature of the furnace in contact with the fuel, which must result with ordinary fire-bars, is, by means of this air-tight joint, entirely avoided, as the sides of the furnace cannot be heated to excess, either locally or throughout their length, and destruction by pitting and cracking is prevented, and the life of the furnace proportionately prolonged. These bars have been fully tested under various conditions of forced and natural draught with most successful results, and are now being largely fitted.

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CHAPTER IX.

APPLICATIONS OF ASBESTOS TO MILITARY, BUILDING, AND FIRE PREVENTIVE PURPOSES.

Closing the Breeches of Big Guns—Miners' Safety Lamps—Torpedoes—Time Fuses—Dynamite Shells—Coating for Ironclads—Military Aëronautics—Stove-pipe Shield for Tents—Bâches—Safes and Deed Boxes—Carriage of Explosives—Lint—Hospital Purposes—Building Operations—Fire Protection—Patent Roofing—Building Laws in New York and Other Places—Fire-proof Curtains—Protection Shields—Fires in Theatres—Captain Shaw's Book—A Yankee Yarn—Fire Rugs—Accidents from Footlights—Chevalier Aldini—Firemen's Clothing—Protective Clothing in Ironworks—Appareil Aldini—Barnum's Show.

Military Purposes.

The bearings of asbestos on matters connected with the art of scientific warfare are numerous and important. We have the authority of Sir Frederick Abel for stating that asbestos is as effectual when used for closing the breeches of big guns, so as to prevent the passage of gas, as it is for ensuring safety (in a more peaceful application) in the same way for miners' lamps. In these last, it was for a long time found very difficult to get a good joint between the metallic and the glass parts of the safety-lamp, and a great many different materials were tried for filling these joints, in such a way that air should not be able to pass through. In many cases the air was contaminated with a certain amount of gaseous material, which would be likely to render the whole explosive, and if this got through the joint between the glass and the metal, there would be very serious risk of explosion. A great number of substances were tried, but found unsatis-

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factory, and after some hundreds of experiments had been made by Sir Frederick Abel and Sir Warington Smyth, with asbestos washers, these were ultimately found to maintain their condition most admirably.

With regard to closing the breeches of big guns, we are informed, also on the authority of Sir Frederick Abel, that the only contrivance which could be called an approach to a perfect arrangement, was one devised by a French artillery officer, M. Dubange, which consisted of a kind of pad of asbestos fibre attached to the breech-loading arrangement. This, from its mineral nature, was nearly indestructible, and consequently lasted, without material deterioration, for a great length of time, notwithstanding that it was subjected to the enormous pressures which are now developed in the bores of very heavy guns.

In connection with Whitehead torpedoes, we learn, from the same authority, that in these and other similar receptacles, within which charges of wet gun-cotton are enclosed, the use of asbestos was found to overcome a great difficulty. The vessels containing the damp cotton had to be soldered, in order to keep them perfectly air-tight, and thus prevent the water from escaping; and in order to do this, with anything approaching safety, the space between the gun-cotton and the metal surfaces which require to be soldered were formerly filled with damp felt wads or discs. This seemed to answer the purpose, but it was found, after they had been stored for some time, that the effect of the moisture on the felt was to cause it to undergo a kind of decay or fermentation, which resulted in the formation of gas to such an extent that the vessels were distended, and threatened to burst, and sometimes actually did burst, with considerable violence. But when asbestos millboard was substituted for the felt, the difficulty and danger were removed; gas was no longer evolved, whilst the operation of soldering could be performed with safety, the material remaining perfectly unaltered.

In the manufacture of time fuses, again, asbestos washers are found most valuable. Washers of indiarubber and wash-leather were formerly used, but these in time became hard,

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and acted on the metal surfaces, with which they came in contact, in such a manner as to cement them together, instead of keeping them mobile, and it was not until the introduction of asbestos washers that difficulties, in connection with the proper action of these ingenious contrivances for the explosion of shells in a given time after their discharge, were removed.* And experiments recently made with dynamite shells revealed certain defects in their construction which have been overcome by the use of asbestos, so that this terrible engine of warfare has been thereby in a great measure perfected.

Again, one of the uses to which asbestos has been proposed to be applied, in connection with warfare, is as a coating for ironclads. With the advent of rapid firing guns for naval use, it soon became evident that something more than water-tight compartments was required to protect a ship's side against shot holes, and the plan adopted was generally that of a double copper skin packed with some material which, after the passage of a projectile, would expand and seal up the hole against the influx of water. It was alleged by the inventor of the process that, if asbestos were packed between the armour-plates, it would arrest, or certainly minimise, the inflow of water after the penetration of a ship's side below the water-line. This was tried by the Admiralty, and an interesting account of the trial may be found in the *Army and Navy Gazette* Supplement (August, 1887). But although this first trial was decided to have been very successful, it does not seem to have been followed up; should, however, further experiments in this direction confirm its success, it is obvious that confidence would be raised in our fighting ships, by practically insuring them from becoming waterlogged in action. Many materials have been tried for this purpose, one of which was a mixture of cork and oakum. In the United States Navy, the same duty was for some time attempted to be fulfilled by the use of cellulose obtained from the husks of cocoanuts. More recently, a better material was alleged to have been found in the pith of cornstalks, granulated by machinery.

* "Jour. Soc. Arts.," No. 1743.

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Some of the uses to which asbestos is proposed to be applied are sufficiently astonishing. Who, for instance, could have imagined that a substance, of such specific gravity as crude asbestos, could have been manufactured into a cloth, available for aëronautical purposes, in which absence of weight is of such primary importance? Yet here it appears to be the one thing wanting to give success to that despair of aeronauts, military ballooning. Many years have now passed since scientific military men first turned their attention to aëronautics, and it is long since the War Department of the Government first authorised experiments to be made, with a view of utilising balloons in warfare; yet, notwithstanding all the time and money which has been expended, the result in the way of practical success has been nearly nil. Captain Baden Powell, of the Scots Guards, who is a well-known enthusiast on aërial navigation, warns us in the *United Service Magazine* for April, that we must not lag behind other nations in experiments if we do not wish to see a hostile navigable balloon some day floating over London. Such a balloon, he states, is now being made in Germany, and the Russians are still essaying the task, while two French inventors are trying thin metal as a material to enclose the lifting power, and it is said that the Aëronautical Establishment of Meudon has a large new balloon "which it is calculated will go twenty-five miles an hour through the air." This is said to have a gas engine of forty-five horse power, and engines can undoubtedly be made of no more than 10 lbs. weight per horse power. We seem, therefore, to be within measurable distance, not only of aërial navies, but of the uselessness of sea power, land fortifications, and all terrestrial armaments whatever, to be replaced by a universal empire ruled from cloudland.

The difficulties to be encountered in this direction are doubtless sufficiently formidable. Gas, it is clear, could not be carried into a hostile country or into remote and nearly inaccessible districts. Even if procurable at all, near the battle field, it could only be obtained by a long and difficult process of generation, at the very time when speed and

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simplicity would be the main factors of success. Gas, therefore, being practically out of the question, it seems to have occurred to Mr. Spencer, the well-known balloon manufacturer, that it would be better to revert to the original conception of Montgolfier. The old-fashioned fire ball, which acquired its power of ascension from rarefied air, produced by burning straw or something similar, was, of course, of far too dangerous a character, and had been productive of too many fatal accidents. It was necessary, therefore, to construct a balloon of some uninflammable material, and with the assistance of Mr. Fisher, the General Manager and Secretary of the United Asbestos Company of London, Mr. Spencer ultimately succeeded in finding the material he sought. A balloon was constructed, the whole of the lower part of which was formed of fine asbestos cloth, the remainder being of canvas, covered with a fire-proof solution. A trial took place in the grounds of the "Welsh Harp," at Hendon, which was afterwards repeated at Chatham, under the inspection of the Royal Engineers Committee, and on both occasions with success. The experimental balloon, about thirty feet high, was suspended between two uprights, from which it hung down like a limp rag. It was of a cylindrical shape, having a deep zone at the equator, and a containing capacity of about thirty thousand feet. A copper spirit lamp was attached to the neck, and no sooner was a light put to the spirit than the inflation commenced, the balloon being fully distended in a space of about five minutes. These trials have since been successfully continued in India, and the Russian Government has adopted the asbestos balloons for use in their army.

The immense advantage gained, by this method of inflation, over the tedious and difficult process of inflation by gas, is sufficiently obvious, whilst it is, at the same time, apparent that the quantity of spirit requisite for an endless number of ascents could be carried about with the greatest facility. Another advantage is that, whilst the large volume of gas required for an ordinary balloon is in itself both deleterious and a source of danger, the rarefied air in the new fire-proof balloon is perfectly

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innocuous. The balloon can be raised or lowered at will simply by turning the lamp a little up or down.

The Stove-pipe Shield is an invention patented by Lieutenant Brown, of the U. S. Army, which consists of an oval asbestos grommet or ring inserted in the roof of a wall tent or the night-cap of the conical wall or Sibley tent, through which the stove-pipe passes. Being composed entirely of asbestos, it insures the tent against danger of fire from the stove-pipe; and being soft and flexible, it easily folds with the tent. The unpleasant scratching, so noticeable in windy weather, when a tin shield is used, is avoided. The grommet fits the stove-pipe closely, and forms, therefore, a secure point of support for the pipe. It also prevents the escape of warm air through the stove-pipe hole.

In further continuance of this part of the subject, that is, the application of asbestos to matters connected with warfare, the particulars of a very interesting experiment, which may have an important bearing on the carriage of explosive material in the time of war, was given by Mr. Boyd, the late Manager of the United Asbestos Company's works at Harefield. In alluding to the value of asbestos millboard, as a lining for fire-proof cases and deed-boxes, so as to convert them into portable fire-proof safes, he said the matter was put to a practical test thus; two iron rails were supported on brickwork, at a height of about eighteen inches from the ground, and underneath them a strong fire of wood shavings and chips was made, and when this had well burnt up, a deed-box filled with papers was pushed along the rails to the centre of the fire, where it was completely enveloped in the flames, remaining there for a space of twenty minutes. The box on being withdrawn, was found to unlock easily, the papers were found in a state of perfect preservation, not even being in any way charred or discoloured.

On seeing this result, one of the gentlemen present asked if the boxes could not be used for transporting gunpowder, or other explosive substances. A quarter of a pound of powder was then put in a small bag, and placed inside another box,

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which was pushed along the rails into the centre of the fire, to which fresh fuel had been added; and after the box had been exposed to the fire for twenty minutes the question naturally arose how was it to be got off again? Mr. Boyd himself performed that operation, by means of a long iron rod and hook, after which the box was again opened and the powder found intact. The question was then asked by some one present who was not yet satisfied, "Why have the powder in a bag? Let it be laid on the bottom of the box loose." This was done, and the fire ordeal again repeated, with the same result.

La Société Française des Amiantes have recently announced as one of their specialities, the manufacture of bâches, or awnings, for military waggons.

Hospital Purposes.

And as yet another instance of its applicability to purposes connected with warfare, it may be interesting to mention that I have lately seen it stated that the fibre would be of great value for use as lint, in hospitals and on the battlefield. A paper on "Fire-proof Asbestos Surgical Dressing," was in 1895 read by Dr. Kane, before the McKean County Medical Society of Pennsylvania, in which the doctor exhibited a number of asbestos materials, such as are commonly used in the arts, to show how admirably fitted they are to serve as surgical dressings. Their softness to the touch and glistening silkiness of appearance, he says, commend them as being unirritating to the skin, and soft and cleanly as a covering. On account of their indestructibility when subjected to high temperatures they are the only materials which, as dressings, can be rendered absolutely antiseptic, while at the same time the variety of forms in which they can be manufactured enables them to fill all the requirements for which cotton fabrics are used in surgery, and with far more satisfactory results.

Appreciating the difficulty one is under in preparing dressings that shall be positively antiseptic, and of retaining them so for any length of time, the doctor says, it had always been his

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custom to have them all thoroughly impregnated with bichloride of mercury, iodoform, or boracic acid, as shortly as possible before using them. This procedure entailed much loss of valuable time when operating in accident cases, at a distance from his hospital, so that he was always in dread, lest, during his transportation to the scene of accident, or after being spread out among the flies and dirt upon the table of the farmhouse, or lumber shanty, or upon the cushions of a cabin-car, a new horde of germs should find entrance to them. His method, therefore, of only using fire-proof dressings, is, he says, the only safe one to pursue, and the results obtained since making use of them have been more than justified.

Asbestos dressings can be kept as if they were germ-proof. They may be carried in any parcel, handbag, or satchel, may be spattered with all sorts of filth, literally crawling with all sorts of germ life, yet in less than two minutes can be rendered absolutely pure by tossing them into the blaze of an ordinary kitchen stove or fireplace. When preparing for an operation, the necessary amount and sort of asbestos material wanted is laid out, and when the operation is completed and the dressings are ready to be applied, the assistant places them upon the coals, or in the flame of the nearest stove or fire, and allows them to remain until they assume a cherry-red, and, taking them out, places them on a clean napkin or piece of paper. Then the operator dusts them with iodoform, aristol, or other antiseptic powder, if desired, and as they cool rapidly, they can be applied at once to the wound. In the operating room there is a specially constructed receptacle of wire-netting, not unlike a griddle, in which the dressings are retained while being subjected to heat. When travelling over the country, a pair of tongs, or a toasting fork, will answer the same purpose.

The form mostly used as a dressing is the fibre, because it is most nearly like absorbent cotton. The only objection found is that it is not so long as the fibre of absorbent cotton, though sometimes this is an advantage. When thoroughly saturated with fluid the surface becomes as slippery as soap, and this

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enhances its value as an application to sensitive surfaces. It is the very best substance to employ as a first dressing after laparotomies, or as a covering to the stump after operations. And it can be also used as bandages in the form of paper cut in long strips. In all cases where purification by fire is mentioned, it must be noted that a wood fire is meant.

As at present manufactured, asbestos cloth is too coarse for surgical use, but there is no reason why it should not be made sufficiently fine to be used in this way.

Of the intrinsic value of asbestos in these cases, it is difficult to speak without full knowledge of the mode in which its otherwise non-absorbent character is proposed to be overcome; but if it be a fact that it can be so used, in favourable comparison with the best lint, as stated, it is certain that its imperishable quality would be of great advantage, seeing that it could be used over and over again, only needing purification by fire after each time of using. Although, as has been recently remarked by the editor of the *Engineer*, we may never reach the time when our under-garments shall be purified by fire, instead of by the laundress's art, yet, short of this, many uses now fulfilled by materials, the thorough cleansing of which cannot be secured without their destruction, may possibly be better served by asbestos.

Building Purposes.

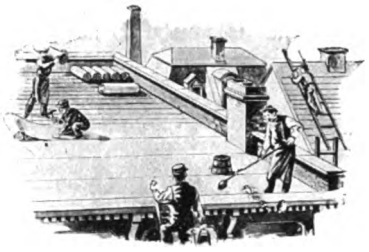
If we now turn from matters connected with warfare, to those relating to man's perpetual battle with fire, we shall find that, here also, asbestos stands him in good stead. Chemists are constantly bringing forward incombustible preparations of the various alkaline salts and other chemical combinations calculated to render textile fabrics and other materials fire-proof; but most of these salts evaporate, and in doing so, frequently damage the materials they are intended to preserve. It has, consequently, been imperative to find a material capable of opposing a negative action to the persistently devouring element, and up to the present time no

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substance has been found so efficacious in this respect as asbestos.

Probably its earliest use, for this purpose, in building operations, was in regard to roofing. The utilisation in Canada of the non-fibrous variety of asbestos has already been noticed; but the demand for the patent asbestos roofing is so great that an extensive factory has specially to be employed in its manufacture, by the H. W. Johns' Company, and when last going over this factory, and seeing the enormous piles of rolls of this commodity, I was informed that the quantity made by them



reached the enormous dimensions of from two to four miles a day.

This asbestos roofing is the product of new processes (for which patents have been granted in the United States, Canada, and Europe) by which the strength, durability, and uniformity of the material has been much increased. The specially prepared roofing material consists of a strong canvas, combined with a superior quality of felt, made expressly for the purpose, with a manilla lining or "backing." These materials are rendered water-proof and cemented together, with a special acid and water-proof composition, and compressed into a compact, flexible sheet, like leather.

It is easily applied by any intelligent workman, no heat or any special tools being required. The rolls each contain 200 square feet, and weigh, including packages, about 85 lbs. to 100 square feet. The following cut shows, on an enlarged

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scale, a cross section of the patent roofing, the thickness being about one tenth of an inch.



F, Felt; A A, Layers of Water-proof Composition; C, Canvas; M, Manilla lining.

Fire Protection Purposes.

It must be remembered that asbestos is used far more largely in America than it is here. It is brought into use there in a variety of ways for building purposes. In those Titanic structures which rise all about Chicago and New York, showing their metal skeletons when building, certain invitations to catastrophe are presented, even in their fire-proof state, which are



not found in more modest, even if more inflammable, dwellings. Costly experience has shown that the metal girders of a building, as yet unattacked by flame, will expand in response to the heat from a neighbouring conflagration, even across a tolerably wide street, to such an extent as to force apart the beams from their resting places, so as to cause a general collapse. Any one who saw the quick destruction of the Tuilleries,

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and other large buildings in Paris, at the time of the Commune, will remember how a fire, quickly generated by petroleum, naphtha, etc., in the centre of a room, caused the heavy iron girders to bend downwards by the heat, and as these gave way, they drew the sustaining pillars inward so as to cause immediate and total ruin. All this can now be obviated by the use of asbestic.

Asbestos Building Felt is a fire-proof sheathing or lining felt, which, on account of its non-conducting qualities, is largely used for lining weather-boards, floors, wood partitions, railway cars, etc. This is odourless, vermin-proof, and will not disintegrate by age. For fire-proof construction, several thicknesses require to be used.

Asbestos Sheathing.—This is a strictly fire-proof sheathing, composed of pure white, long-fibred asbestos. It is valuable for covering wood partitions, walls and ceilings, fire screens, and other surfaces, where there is any danger of fire.

Firemen also complain of the steam generated by water thrown on the vast system of iron beams, a result which may fatally impede their work—the evident remedy for which, in the monster steel structures, is to carefully sheath all metal supports with brick, covered with non-conducting asbestic cement or plaster.

In the building laws of New York, Philadelphia, Boston, and other cities, special insistence is placed on its use, and very material and expensive alterations are sometimes required, by the authorities, to be made in the fittings of public buildings, in regard to its more extended use for the protection of the public. This is in many ways rendered compulsory on every one desirous of obtaining a licence for the erection of a theatre, concert hall, library, or indeed any public building of a similar character. So carefully framed are these laws in the city of New York, that, in regard to such places as these, it is enacted that "all the shelving and cupboards in each and every dressing-room, property-room, and other storage-rooms, shall be constructed of metal, slate, or some fire-proof material. All stage scenery, curtains, and decorations, made of combus-

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tible material, and all woodwork on or about the stage, shall be saturated with some incombustible material, or otherwise rendered safe against fire, to the satisfaction of the Commissioners of the Fire Department of the city. The proscenium curtain shall be placed at least three feet distant from the footlights, and the proscenium opening shall be provided with a fire-proof metal curtain, or a curtain of asbestos, or similar fire-proof material; and said fire-proof curtain shall be raised at the commencement of each performance, and lowered at the close of said performance, and be operated by improved machinery for that purpose."

At the Academy of Music, in Philadelphia, the underwriters offered a reduction of 1 per cent. per annum provided an asbestos



curtain was placed in the house. The Fire Apparatus Committee then, it is reported, succeeded in perfecting "the only barrier of complete protection to an audience against fire in the world." This curtain, made of asbestos cloth (97 per cent. pure asbestos and 3 per cent. cotton), is 54 feet wide and 53 feet high. It is hung on wire lines, three-eighths of an inch thick, connected with a drum in the apex of the roof, and can be raised with ease by two men and lowered by one.

Again, after the disaster at the Ring Strasse Theatre, at Vienna, when attention was drawn to the great danger arising from the want of some certain and rapidly applicable means of separating the stage from the body of the theatre, the Roman Minister of Public Security issued an order that every theatre

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should be fitted with a fire-proof curtain, capable of entirely isolating the stage from the theatre, and he indicated an asbestos cloth curtain as one that would meet the case. All the principal Roman theatres are now supplied with these curtains, the material having been furnished by the United Asbestos Company of London.

The same company make Booth & Fisher's patent asbestos double iron-framed drop-curtains, and Marius's patent asbestos double act drop. The former of these they have erected in Manchester, Birmingham, Edinburgh, and other places, and the latter at one or two theatres in London. These curtains have an air space between the two thicknesses of cloth, and are specially recommended by theatrical architects. The price of extra strong metallic cloth is 6s. per lb. Special precautionary measures are adopted, by this company, for preventing the iron frame from bulging in case of fire or sudden alteration of temperature. The asbestos cloth can also be used as an ordinary drop curtain, worked on rollers, and can be coated with asbestos paint, if desired, which effectually closes the pores of the cloth, rendering the passage of smoke absolutely impossible.

Asbestos fire-proof curtains are also in use in most of the theatres in America, and are there made a speciality of by the H. W. Johns' Manufacturing Company, of New York, who furnish the curtains all ready to hang, made from the best quality of cloth and yarn, both manufactured from pure asbestos fibre. And as further illustrating the great importance attached to the extended use of asbestos in New York, for the purpose of preventing the spread of conflagrations, a company was some time ago established there, with the object of extending the use of asbestos in the shape of protection shields, either to be kept permanently fixed, or hung in such a way as to be capable of being promptly applied on sudden emergency. One of these shields was exhibited at a firemen's convention held at Rochester, New York. It consisted of a sheet of pure asbestos cloth about twenty feet square, supported on an iron frame; and for the purpose of testing it, a pile of pinewood, saturated

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with petroleum and tar, was built up on its windward side, and then fired. The heat from this fire was so intense that spectators could not approach within fifty feet of it, on the exposed side; on the side protected by the shield, the heat was so little felt that a construction of wood and glass placed close beside it suffered no injury at all.

One of the theatres at Brussels has been entirely coated with a composition largely made up of a mixture of asbestos and alum, in order to render it incombustible.

In France many of these shield curtains are now in use, and they are found to be as effectual in preventing asphyxiation, from the passage of the clouds of smoke, as in staying the spread of panic by a sight of the flames, which are not intercepted by the old-fashioned iron arrangements.

The terrible calamity which happened some years ago, at the Opera Comique in Paris, followed by that at Exeter, set men's minds running in the direction of providing greater security from fire in theatres. Several kinds of curtain, all involving the use of asbestos, were then contrived, the motive power being so arranged as to fully guard against the destructive force of a too rapid or unexpected fall, such as happened at Toulon.

The curtain made for Terry's Theatre, by the United Asbestos Company, is similar to that made by them for the Queen's Theatre in Manchester, its special qualifications being lightness, strength, and ease of manipulation. A special method of preventing the iron frame from "bulging" or altering its shape in case of fire, or sudden variations of temperature, is employed. By using weights not quite sufficient to counterpoise the curtain, the work of raising and lowering is very light. Combustible ropes may be employed, which, on being released by the action of fire or otherwise, will allow the curtain to descend of itself. Pockets are provided to catch the counterbalance weight in case of the breakage of the chain, so as to prevent personal injury, and friction rollers are put on the balance weights to ensure their free action. Similar rollers are also fitted on the curtain frame, to give freedom of action in raising and lowering. The hinging of the lower part

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of the frame, so as to admit of its being raised to the top of the proscenium opening when there is not sufficient room for a curtain of the ordinary make to be raised above the proscenium opening, is a valuable addition. The asbestos cloth is specially strengthened by a fine wire running through each asbestos strand, and is stretched across the whole of the framework, and fastened thereto by means of hoop iron bolts. A double thickness of asbestos cloth may be used, if thought necessary, one thickness on each side of the framework, with an air space between. This was accepted on all hands as far superior to the old-fashioned iron portcullis, which was an absolute nuisance from the harsh, grating sound it made when wound slowly up or down. The Queen's Theatre was burned to the ground on August 17th, 1890 ; but the curtain remained intact.

Sir Henry Irving, when bringing to the notice of the public his proposals for a "New Safety Theatre," laid special stress on the necessity of shutting off the stage from the auditorium by means of an asbestos curtain, so that in the event of fire, which generally originates on the stage, its perils should be confined to the stage itself; with the further necessity of providing an outlet for the smoke, which is sometimes even more disastrous in its effects than the flames.

Experiments were also about this time publicly made by Captain Heath, to prove the fire-resisting qualities of a new curtain invented by him, the proceedings taking place within a specially-built hoarding, in Oxford Street, within which was erected a large model of the Drury Lane proscenium. The curtain in this case was made of asbestos and canvas, and was rolled on a block of wood placed underneath the front part of the stage. The sides of the model were made of iron plates and the front of wood. When certain catches were released counterbalancing weights came into action, and the curtain was run rapidly up from below. On reaching the top, it pressed tightly and automatically against the back of the proscenium, turning on at the same time a supply of water from a perforated pipe, which ran along the whole length of the top of the curtain, so as to keep it constantly wet. The

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arrangement of the switch, for communicating action to the curtain, was such as to turn on the water and close the curtain at the sides at will. A very severe fire test was employed which was pronounced to be highly successful, the universal opinion of those present being that, in its construction, the curtain was as simple as it was effectual for the purpose intended.

Another novelty in this line was shown to the public on the opening night of the "Jodrell Theatre." In order to show their desire of doing everything possible for the safety of the audience, the lessees exhibited, after the evening's performance, a new "Niagara" or safety water curtain. On the drop being raised, an illuminated sheet of water was seen to be descending from the flies in such a way as completely to shut off the stage from the audience.

Since then the Baquet Theatre, in Oporto, has come to the apparently natural end of all such structures—namely, a fiery death. The calamity was caused by the wings catching fire from a gas jet, whereby the whole of the stage scenery was almost immediately afterwards enveloped in flames, the furious progress of which it was found impossible to arrest. Here, then, was a striking instance of a holocaust being caused, by the want of such a curtain as has been described ; for, had such a thing been available, the stage would have been at once shut off from the auditorium, and even if it had not been found possible to save the structure, the fire, at any rate, would have been localised for a sufficient length of time to have enabled the authorities to clear the building, and so to have prevented the panic and horror which ensued.

And again, the Communal Theatre at Amsterdam has since succumbed to the devouring element. Here, notwithstanding that, as is reported, the major portion of the scenery "was painted with asbestos," everything was destroyed, including the costumes of the actors, and a library of 8,000 volumes.

It is worth while, perhaps, recording the foregoing, because there can be very little doubt that something of this kind will

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Asbestos and Asbestic: Their Properties, Occurrence, and Use (1897) Published by AsbestosClaims.Law
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presently be made compulsory even in England, for use in theatres and music-halls generally. From the course matters are now taking in the United States, there is little doubt that the use of asbestos, in some form or other, will be made compulsory there for the shelvings and doors of public libraries and places for the custody of records, for sheathings between wooden floorings and below carpets, for hearthstones, for the linings of doors of elevators or lifts, for elevator shafts or stairways, and for the innumerable other places exposed to danger from flame or intense heat. The ease with which it can be applied, and the fact that it is absolutely impossible for flame to pass through it, makes it invaluable for purposes of this description. Where houses are constructed of wood, its non-conducting properties are found very useful, as it makes the house cooler in summer and warmer in winter than any other kind of sheathing.

In case of fire, in an adjoining house, it is quite possible the flames might destroy the outer covering; but even then, the frame and interior would be as safe as if built of stone.

Before concluding this part of the subject, which is of such vital interest to the community, it may be mentioned, as showing the extreme importance of the subject, that in Captain Shaw's book on "Fires in Theatres," a list is given of 112 theatres which had been destroyed by fire down to 1875. The loss of life is not mentioned in the aggregate, but, by the burning of only three of the buildings mentioned, no less than 800 lives were lost and 123 adjoining houses destroyed.

M. Mauret de Pourville, writing on the subject, says that in the years 1867 and 1868, fifteen theatres in Europe and America were destroyed by fire; the value of the property so destroyed, irrespective of loss of life, being placed at from £640,000 to £680,000; and this, Captain Shaw says, is well within the mark.

The following startling list will show what fearful calamities have taken place since 1876, by fires in theatres, and the imperious necessity which has constantly arisen of at once adopting effectual methods of protection:—

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Fires in Theatres, originating principally on the Stage, between the years 1876 and 1888.

Place.	Dates.	Lives Lost.
Théâtre des Arts, Rouen	April 25th, 1876	8
Chinese Theatre, San Francisco	October 30th, 1876	19
Circus Theatre, Madrid	November 13th, 1876	2
Mrs. Conway's Theatre, Brooklyn	December 5th, 1876	283
Cronstadt Theatre	January 9th, 1881	8
Opera House, Nice	March 23rd, 1881	150
Ring Strasse Theatre, Vienna (iron curtain not let down)	December 8th, 1881	794
Briggs' Theatre, Moscow	January 7th, 1883	300
Temporary Theatre, Dervio	June 24th, 1883	50
Theatre Govi Sanuke, Japan	August 28th, 1883	75
Tinnevelly, India	July 28th, 1886	100
Temple Theatre, Philadelphia	December 27th, 1886	2
Opera Comique, Paris (official report)	May 25th, 1887	77
Exeter Theatre	September 5th, 1887	188
Grand Theatre, Islington	January, 1888	—
Bolton Theatre	January, 1888	—
Varieties, Madrid	January, 1888	—
Theatre Royal, Blyth	February, 1888	—
Union Square Theatre, New York	February, 1888	—
Music Hall, Leith	March, 1888	—
Oporto Theatre	March, 1888	160
Total		2,216

During the three years preceding December, 1880, it is said that 252 theatres were wholly or partially destroyed by fire, resulting in 4,370 deaths, and no less than 3,400 persons being, more or less, injured.

It is calculated that during the past 11 years, 2,056 persons, or a yearly average of 184, have perished through fires in theatres, without taking into account the number of lives lost through panics.*

Almost at the very moment of concluding the foregoing comes the intelligence of the appalling calamity all but unexampled in its circumstances of horror, which happened

* "Jour. Soc. Arts," January, 1888.

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on the afternoon of the 4th of May. The catastrophe occurred while a bazaar was being held in a large wooden structure, built on some waste ground in the Rue Jean Goujon, leading from the Avenue d'Antin to the Place de l'Alma, in the Champs Elysées Quarter. The building being entirely of unprotected wood, was burned to the ground in about twenty minutes, and, being unprovided with proper exits, formed a perfect death-trap, horrifying to the imagination.

In London, no such structure as that in which this disaster took place can be used, unless its safety be certified by the architects' department of the County Council; in Paris such safeguards seem to be entirely absent.

An Extreme Case.—An extraordinary, or rather extreme, case of the use of asbestos as a protection from flames, was reported from Canada, an account of which appeared in the London *New York Herald*, 25th August, 1889, which is here given as narrated, without comment. It appears that a gas well, at Ruthven, having taken fire, the cap over the top of the pipe was so fixed that the escaping gas rushed out directly towards the ground, so as to make approach impossible, and consequently, also, the removal of the cap. All around the well the ground became so baked and heated, that when cooling was attempted, by a stream from a fire-engine, the water went up in a cloud of steam before it touched the ground. In this emergency the owners of the well offered a reward of $1,000 to any one who would remove the cap. A mining expert, named Marvin, undertook the job, and after many attempts to reach the well, made for himself a suit of asbestos clothing. In his first attempt, he had worn a heavy pair of cow-hide boots, covered with wet cloths; but, before he got to the flames, the cloth had dried and burned away, and his boots were half burned off. So great was his hurry to escape that he dropped his cutting contrivance, and was dismayed to see it get red-hot before his eyes. For his next trial he wore a pair of rubber boots, and inside these thrust his feet wound round with wet rags. Over these he put a heavy covering of asbestos. His asbestos coat was cone-shaped; his arms, sticking out through

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two holes in the cone, were wound round with several thicknesses of wet cloth, covered with a heavy coating of asbestos. His contrivance, for cutting the pipe, consisted of a very long and sharp chisel, fastened at right angles to an iron staff. His assistant, robed like himself, carried a long iron bar, on which was fastened a small farrier's hammer. His first stroke missed the chisel, and after two more unsuccessful attempts he had to get out for air. Two hours afterwards, when he had recovered, he made another attempt, and this time the roar of the well, which could be heard three miles off, changed to a shrill whistle, and the cap blew off 100 feet into the air. Marvin, the narrator adds, was much scorched, but not injured so seriously as his assistant. He afterwards succeeded in fixing on another cap so as to shut off the flow of gas.

Notwithstanding the Munchausen-like way in which this story is told, there seems to have been a substratum of truth in it. Similar feats have already been performed, to the astonishment of the multitude, by so-called fire-kings or human salamanders. M. Pouchet, Director of the Museum of Natural History at Rouen, mentions a case which he witnessed himself at Cremorne Gardens, where the man walked for several minutes in a long tunnel of fire, which looked, he says, like the most formidable flaming furnace one could imagine.* In this case the tunnel of fire was arranged in the form of a cross, with an opening at the end of each of its arms. This tunnel was formed of a trellis-work of iron, the roof of which rose a little above the head of the performer, and was covered with a heap of resinous wood. Then, at the time when the whole affair was a complete furnace, the man began his promenade, the flames rising to a considerable height above him, and the heat compelling the spectators to keep at some distance from the conflagration. The garments of this incombustible being, M. Pouchet says, seemed to be of coarse cloth, and at the time when he entered the furnace they showed a vermilion-red, but when he came out for the first time, to the surprise of every one, they

* "The Universe," 3rd ed., p. 33.

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had become as white as snow. The head of the experimenter was protected by a thick helmet furnished with glass eyes, and he seemed to carry in the folds of his dress an apparatus for yielding fresh air, by means of which he breathed in the midst of a combustion so intense that one entirely lost sight of him. Surprising as this exhibition then was, we should have little doubt now in what way the performer was protected by his skilfully made garments,* from the heat to which he was exposed in appearance only, and by which the change of colour is fully explained.

The American Watch-case Company, of Toronto, have their flooring protected by an asbestos covering, which recently saved their premises from destruction by fire. In connection with this part of the subject it may be added that various attempts have been made for the introduction of asbestos into the manufacture of lace curtains, dresses, etc., but I believe that the principal obstacle in the way of success in this line, lies in the fact that, in the shape of curtains, for instance, it is found to be an obstinate holder of dust. This objection will, no doubt, be presently got rid of; and soon we may hope to have heard the last of those fearful scenes which have at times occurred from the firing of ladies' dresses at the footlights in theatres.

In regard to accidents from the footlights by reason of the dancers' dresses coming into contact with gas, it might be supposed that, by the substitution of the electric light, this danger would be obviated; but even the electric light, protected as the incandescence is, has its own especial source of danger, not the least singular of which may be noted in the following instance. At the Berlin Opera House, one of the dancers, having inadvertently approached too near to a switchboard, her dress touched some metal parts between which a difference of potential existed. In the fabric of her dress metal threads had been interwoven, which, bridging these metal parts, formed a short circuit, and were heated by the current to such an extent as to set fire to the dress, whereby the dancer was much injured.

* *Ante*, page 14.

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The Chevalier Aldini's idea has been revived in Paris, the firemen there having been furnished with asbestos clothes. Immediately after this was done, it was reported in the papers that, on a conflagration occurring in the basement of a building there, the firemen arrived clad in their asbestos suits, and were thereby enabled to descend at once into the basement, where they extinguished the fire in a very short time, and so prevented what might have been a great calamity. The same course is now about to be taken in England, and the London firemen are to be protected in a similar manner; indeed, there can be little doubt that this course will presently be universally adopted for the protection of the men engaged in saving life and property from destruction by fire. Nothing has yet been discovered that will equal asbestos for this purpose, as it will neither burn nor smoulder, and is as impervious to fire as well-made mackintosh is to water.

In a recent number of the *Canadian Mining Review* we are informed that, in the museum attached to the offices of that journal, there was to be seen a complete suit of clothing from helmet to shoes, such as is used by the firemen of Paris, dressed in which a man can walk into the hottest flame with comparative impunity. This suit was made and presented to the museum, by Mr. Edward Wertheim, of the American Asbestos Company, Black Lake, and of Frankfort-on-the-Maine, Germany. And at a recent meeting of the National Association of Fire Engineers at Montreal, a representative of the Company, clad in a suit of fireman's clothing, entered a burning frame building, and remained in there for some minutes. His dress consisted of boots with iron soles, gaiters, pantaloons, jacket, apron, gloves, and helmet, the latter provided with mica eye-glasses. Under his jacket he carried a respirator for a purified supply of air, which permitted him to breathe with comparative impunity.

The following interesting description of the "Appareil Aldini" is taken, by his kind permission, from Captain Eyre M. Shaw's recent work on "Fire Protection," in which he gives it as his opinion that it is rather a matter of scientific interest than of practical usefulness. "In certain

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cases," Captain Shaw says, "it may be indispensable to traverse the flames in order to reach some particular spot, and it was for the purpose of preserving persons who find themselves in such circumstances that the Chevalier Aldini, an Italian physician, thought of the apparatus which bears his name.

"This preservative apparatus consists of two vestments, one composed of a thick tissue of asbestos (amianthus), or woollen stuff, made incombustible by means of a saline solution, the other of a metallic cloth of iron wire, covering the first garment, and mounted with a helmet on the upper part. A person enveloped in these two garments can withstand the action of flames for some minutes without experiencing any dangerous effects, for on the one hand the external metallic tissue cools the flames, and on the other hand the internal tissue transmits the heat very slowly, on account of the want of conductibility in the substances of which it is composed. Aldini's apparatus dates at least from the year 1825, but notwithstanding the good results which it has shown in the numerous experiments to which it has been submitted, it has never been adopted to any considerable extent, either because the circumstances in which it could be really of service are much too rare in comparison with the expense of its manufacture and maintenance, or because—as happens with a number of inventions—it presented, in serious practice, considerable inconveniences, such as rarely occur in experiments for mere show, where everything is generally arranged for the success of the operation."

The following is an account of one of the experiments made in Paris in 1829, by some *sapeurs pompiers*, or firemen, with Aldini's clothing on. Two piles were erected of thin wood, covered with straw, ten yards long, two yards high, and distant from each other about a yard and a half; two lateral openings allowed the firemen to go out from the flames, if they were compelled to do so, and in other ways facilitated the experiment, which consisted in traversing half the length of the burning heap, going out by one of the lateral openings, and entering again by the opposite end, and then repeating

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the same experiment from the other side of the heap. The four firemen who were to make this trial were clothed in the new garment of metallic tissue; two carried, in addition, a clothing of asbestos (amianthus) over a cloth garment, rendered incombustible by borax, alum, and phosphate of ammonia; the two others had a double clothing of prepared cloth; each man had boots of asbestos, and under the foot a piece of cardboard of that substance; and one of them carried on his back a child ten years of age, whose head was enveloped in a helmet of asbestos. The firemen penetrated together into the interior of the double pile of flames, and, walking slowly, traversed it several times. At the end of sixty seconds, the child enclosed in the basket cried out, so that the man who was carrying him was forced to retreat precipitately. They made haste to take out the child, who had in no way suffered; his skin was fresh, and his pulse, which beat eighty-four before the experiment, was only ninety-six after it. He could, without any doubt, have remained much longer in this wrapping, were it not for the fear which seized him, and which was caused by one of the straps supporting the basket, having slipped a little on the shoulder of the fireman who carried it. The child, at the sight of the flames, which roared below them, thought he had been thrown into them. A few minutes after, he was as merry as usual, and felt no uncomfortable sensation. The fireman who carried the child had, before the experiment, ninety-two pulsations a minute, and after it 116. The three others remained in the flames two minutes and forty-four seconds, and came out without having experienced anything except a sharp heat. The pulsations were before, eighty-eight, eighty-four, and seventy-two a minute; and after, 153, 138, and 124 a minute. The flame was continually fed with straw thrown upon that which was burning. There was very soon formed an enclosure of fire, in which the firemen were shut up, and as a portion of the straw scattered on the ground threw up a flame which at times enveloped their legs, it was certain that the bodies of the men were exposed to the direct action of the flames. At a distance of more than six yards from the focus of the fire, the heat was

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so intense that none of the numerous assembly could remain there. In other experiments the firemen were furnished with large shields, which they made use of to keep back the flames. It is obvious that such an apparatus as this could be of very little use for general work.

In the rolling mills of large iron factories, such as those where the Siemens, or Siemens-Martin process is either partially, or exclusively, used, the open hearth furnaces are arranged alongside, or on either side, of a casting-pit, which has yet a deeper deep, in the shape of a central pit, some thirty or forty feet below the ground, in which the largest ingots are manipulated, and it is a wonderful sight to see a huge ingot of steel taken out of the furnace, one glowing mass of a light primrose colour on a movable bogie, which itself forms the floor of the furnace, the ingot being seized in the powerful claws of a travelling crane, then conveyed along the iron travellers into the jaws of the rolling plate mill, which stand wide agape to meet it. In some of the rolling mills, the ingot is drawn from the furnace on to a bogie, and men have to stand quite close up to its glowing mouth to assist in the operation. The man who stands next to the mouth is shielded from the intense heat by garments made of asbestos, which cover him from head to foot, not unlike the robe and cowl of a monk. In his hands he holds a long wide piece of iron, for the purpose of protecting a man, who stands in front of him. Before the asbestos covering came into use, wet sacking was put on by the man who occupies the perilous position next the furnace, but it was found that no one could long stand this, the strain caused by the great heat, the steam, and the subsequent chill being deadly. A picture of this dress forms part of an interesting article on the "Terrible Trades of Sheffield," written by Robert Mackray, and published in No. 15, Vol. 3, of "Pearson's Magazine," and the actual process formed the principal sight shewn to Her Majesty on her recent visit to Sheffield.

In concluding this part of the subject, it may be worth remarking that in Barnum's Exhibition, in London, of the destruction of Rome by fire, surprise was constantly

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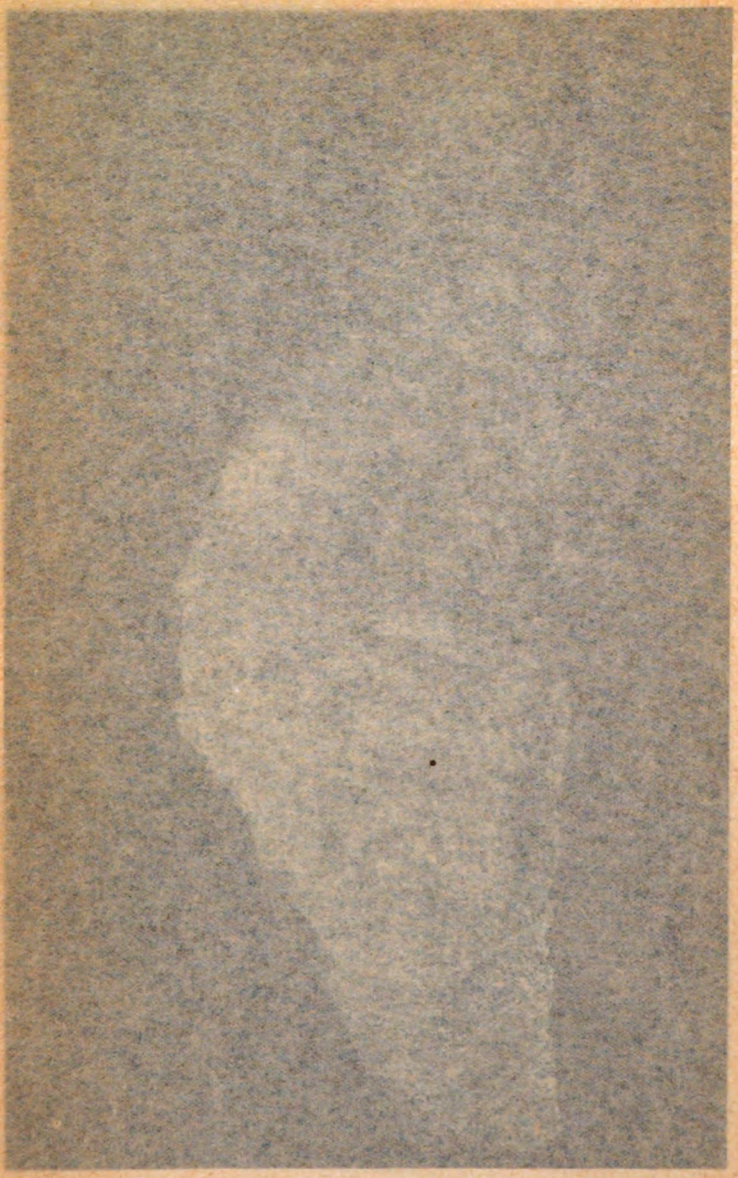
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expressed at the wonderfully realistic way in which such apparently substantial buildings, as those erected in the representation of the Eternal City, were slightly damaged in the conflagration. Here the whole secret lay in a liberal use of asbestos combined with a skilful construction of concealed effects.

When firebricks are made of clay and asbestos an intimate mixture of 75 per cent. asbestos and 25 per cent. plastic refractory clay are compressed in moulds. If this is ground up for firebrick, clay as pure as can be had, must be mixed with it, to make it adhere; then it must be burned as other bricks.

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expressed at the wonderfully realistic way in which such apparently substantial buildings, as those erected in the representation of the Eternal City, were nightly destroyed in the conflagration. Here the whole secret lay in a liberal use of asbestos combined with a skilful combination of chemical effects.

When firebricks are made of clay and asbestos, an intimate mixture of 75 per cent. asbestos, and 25 per cent. plastic refractory clay are compressed in moulds. If talc is ground up for firebrick, clay as pure as can be had, must be mixed with it, to make it adhere; then it must be burned as other bricks.

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CHAPTER X.

SOME MISCELLANEOUS APPLICATIONS OF ASBESTOS.

Asbestic, an Important Discovery—"The King of Wall-Plasters"—Its Use for Mural Decorations—For Paper-Making—For Cement and other Purposes—"Salamander" Decorations by the United Asbestos Company—Cold Storage—Meat Ships—Retention and Exclusion of Heat—Filtration Generally—Finely-Divided Asbestos—Viscid Liquids—Beet Sugar Factories—Maignen's "Filtre Rapide"—The Nibestos—Judson's Filter—Cresswell's Asbestos Carbon Filter—Chevrin's New Patent—Lipscombe's Moulded Asbestos Filter—Filtration of Sewage—Mineral Oils—Gas Stoves—The Leeds Stove—The Manhattan Gas Heating Company—Plastic Stove Lining—New Porcelain—Asbestos Paint—Fire-Proof Paint—Smoke-Stack Paint—Soapstone—Mr. Goodall's Experiments—Danger of Woodwork—Uninflammable Wood—Ransome's Siliceous Paint—Erichsen's Experiments—Mountford's Fire-Proof Paint—The H. W. Johns' Manufacturing Company's Paints—Asbestos Concrete Coating—Asbestos Building Felt—Insulation Purposes—Fire-Proof Paper—Talc Used in Paper-Making—Gas Shades—Wall Papers—Writing and Printing Papers—Asbestic Paper—Platinum Paper—Cardboard—Millboard—Ladewig's Process—Mail Bags—Fuses and Incandescent Circuits—Improved Stove-Piping—Ropes—Lamp Wicks—The Devonshire Everlasting Candle—Belting—Boots and Shoes—Type Founding—Jeweller's Moulds—Minor Household Articles—Fireplace Curtain Blower—Stove Polisher—Stove Mat—Knitting Yarn—Flat Iron-Holder—Flat Iron Rest—Baking Paper—Asbestolic—Baby Incubators—Cigarette Papers—Tobacco Pipes—Tobacco Paper and Tobacco Mixture—Waterproofing.

Asbestic.

This is the new mineral production recently discovered by Mr. Boas at Danville, which has caused such intense excitement throughout Canada and the United States, and has so completely revolutionised the industry of the asbestos district in the important Province of Quebec. Knowing that the mineral

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was only another form of asbestos, the discoverer gave it the name of ASBESTIC. His first idea of its use was that it would be a famous material for the manufacture of a new kind of plaster or cement, and, with that object in view, he sent over a trial sample to the H. W. Johns' Manufacturing Company, of New York. These gentlemen having tested it in every possible way, found that its qualifications for this special purpose were so exceptionally great, that they at once named it "THE KING OF WALL PLASTERS;" and as it was made known, the demand for it became so great that an immediate duplication of the whole of the Danville machinery was found to be imperative, notwithstanding that this was already of such a magnitude and quality as was then unknown in any similar works. During the short time that has elapsed since its discovery, although the number of men engaged in its production is unusually large and the machinery employed entirely automatic, it is found to be quite unable to meet the demand for it in anything like the quantity required.

This new and invaluable wall-plaster is composed entirely of asbestos and is consequently incombustible, fire-proof, and practically indestructible under any degree of heat. Its value, therefore, as a protection against fire, when used for plastering walls and ceilings is undeniable. It is invaluable also for protecting the beams, posts, walls, and ceilings, especially of hotel and restaurant kitchens, bakeries, and every place which it is desired to preserve by preventing the transmission of heat to the adjoining rooms.

The asbestic plaster, as furnished to customers, is prepared in two qualities, namely, "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 feltboard, which is now so much in use in America and Canada. This coating must then be surfaced with a layer of the "finish," which is a carefully prepared, pure, asbestos fibre of remarkable fineness, and, after this has dried, it will present a beautiful surface, as hard as marble and as smooth

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as glass. It is so adherent, that it will stick to metal, or even to pipes, showing no crack or split when bent round a pipe, and when covered with it, near the ceiling or floor, all danger of fire from this source will be entirely avoided. When the walls are covered with asbestic, the papering or painting may be proceeded with immediately the walls are dry, without the least fear of having to do it over again, after the building shall have become settled. And more than this, the covering capacity of this asbestic wall-plaster greatly exceeds that of any ordinary plaster; the mixing is so simple and the application so easy, that the asbestic is thus rendered cheaper than any known plaster in existence. Moreover it can be applied to the lightest structure and the thinnest of partitions. Taking all these points into consideration, it can easily be understood how it is that this "king of wall-plasters" has so completely revolutionised the plastering trade, that every form of lime and sand mortar, plaster, or cement is entirely superseded.

There is a special danger to be feared in the lofty buildings, now so much the fashion over yonder, specially arising from their framework. Iron and steel are so much affected by heat that, if a conflagration should occur near to one of these Babel-like buildings, the girders would be so quickly affected that they would be likely to bend downwards, in doing which they would draw the uprights towards them, and cause a general collapse of the whole structure. I saw the action of this immediately after the destruction of the Tuilleries and other large buildings in Paris at the time of the Commune. The plan there adopted was to pile up the furniture and such other combustible matter as was at hand in the centre of the principal room, pour petroleum over the heap and then set fire to it. The great heat soon caused the metal girders to sag downwards, which drew the sustaining walls inwards, causing speedy and irretrievable ruin. In the case of any of the monster buildings alluded to, if the metal skeleton were protected by brick, and the brick plastered with asbestic, all danger from the source indicated would be avoided. This

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is the plan which was adopted at the Waldorf Hotel, in the Fifth Avenue, and many of those great buildings in New York.

In mural decorations also, especially for ceiling and other ornamental purposes, there is absolutely nothing which can compare with asbestic. Being so perfectly plastic and adhesive, it can be moulded or embossed into any shape required. It dries with a soft grey tone, far more pleasing to the eye than the usual cold white finish. It can be washed down when required, and being of such a marble-like surface, it can be used for any ornamental purpose, offering a splendid surface for painting with oil, water colours, lacquering, or gilding. It will take the richest tints and colours, and when its own is retained, exhibits a pure, transparent greyish-white tone. Even false beams can be made to represent old wood, and the splendour of some of the decorations in many of the new hotels, saloons, restaurants, and similar buildings, in New York and other large cities, is incomparably beautiful, many being of a charming delicacy, showing how it lends itself to the highest artistic treatment. Composition mouldings, in imitation of stone, wood, metal, or bronze, old oak, or other carvings in relief, formed of asbestic, look remarkably well, and, if treated with dark distemper oak-stain and oiled, singularly resemble the genuine carved oak, whilst possessing the enormous additional advantage of being fire-proof.

It may be exposed to the direct action of flames or drenched with water without injury, and may be dried by artificial heat at any temperature which may be thought desirable. It is of a peculiarly tough, elastic and fibrous nature. Frost does not affect it, and it can be left to stand for any length of time after mixing without deterioration, nor need it be kept dry when in bags, as it is in no way injured or affected by damp or wet, nor does any waste of the material occur by keeping or in application.

The writer has recently seen something similar, the work of the United Asbestos Company, in what they term their patent "Salamander" decorations. The decorative materials supplied by them are singularly effective and artistic. Many other companies also supply excellent decorative wall coverings,

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but all of these labour under the disadvantage that their productions are combustible, which naturally proves a hindrance to their general adoption, especially where the building materials employed are also inflammable, such as wood, lath and plaster, canvas, and similar partitions, ceilings, etc.

The United Asbestos Company have in their "Salamander" decorations produced from their Italian asbestos a high class of artistic uninflammable, decorative papers, which are applicable to every branch of the decorative art. In the course of their experiments, the company state that they tried all kinds of asbestos, but none of them met with such unqualified success as the fine qualities obtained from their own mines in Italy. This particular asbestos (which has a light grey tint) after being subjected to special treatment, retains the hard firm impression made upon its surface by their special process of embossing, whether in high or low relief, so that the character of the design is not impaired. They show a book of artistic designs from which we extract a design for an Italian frieze and a couple of panels.

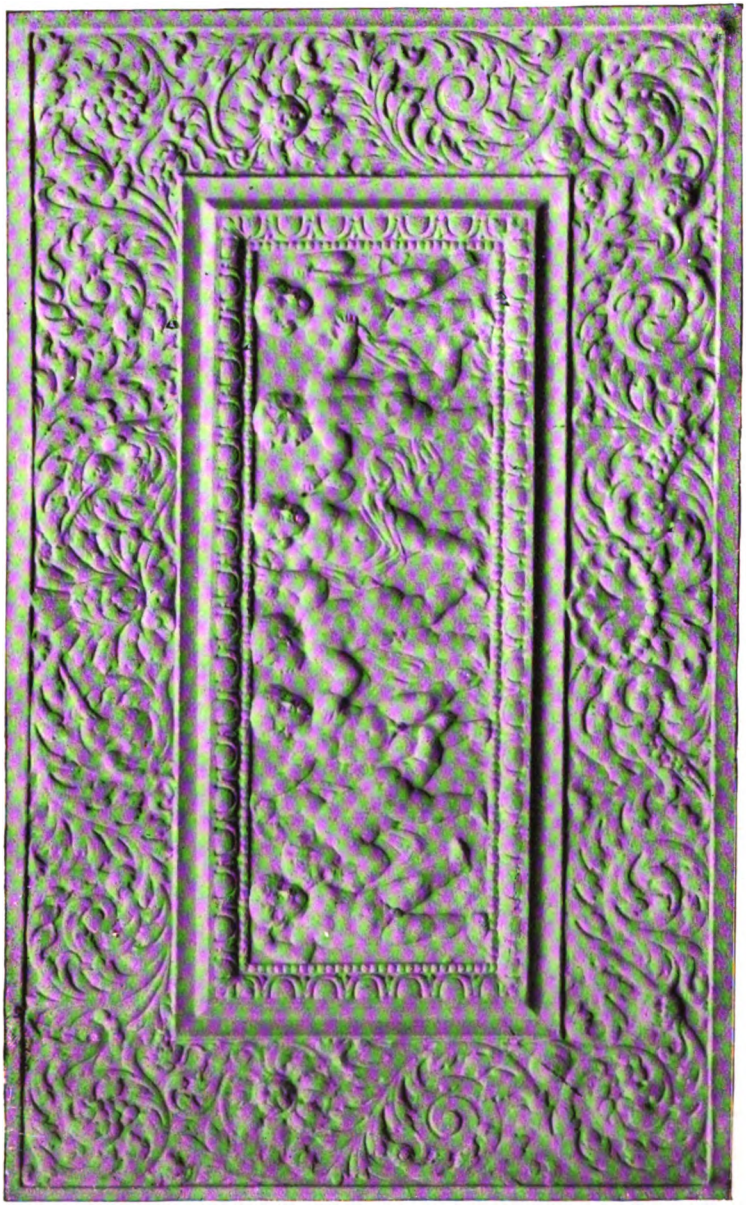
The "Salamander" is said to be less heavy and more easily hung than other embossed decorations, and owing to the fibrous nature of the asbestos, it grips walls and ceilings with great tenacity and power. The material employed by them is capable of any special decoration that may be desired, and can be altered at any time. Particular attention is also called to the extremely high relief friezes and ceilings, which are indistinguishable from plaster mouldings. All these decorations are now extensively used where it is desired to combine economical, effective, and sanitary decoration with security from fire, as in public buildings, museums, picture galleries, theatres, hospitals, asylums, etc., as well as all kinds of wooden structures. The Lords of the Admiralty, we learn, have adopted its use in H.M. Navy, and the battleships now building are being fitted with it. The White Star Steamship Company also selected it for the decoration of the walls and ceilings of their special building at the Chicago Exhibition, representing the smoking saloons and state rooms of their splendid steamers *Majestic* and *Teutonic*.

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"Salamander" Frieze. [*To face p. 273.*

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The "Architect," "The Journal of Decorative Art," and other similar papers, speak very highly of these decorations; the former stating that one cannot over-estimate the importance





of a fire-proof covering to walls and ceilings. Many a fire has been materially assisted in its progress by wall-paper, so that a substance capable of being adapted to such uses and of an ultra-fire-proof nature has long been sought. They also

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specially refer to the suitableness of the "Salamander" panels, etc., being well aware how often yacht architects have been puzzled to know what they could use to vary the monotony of mahogany and birds'-eye maple in their cabin decorations.

Cold Storage.—For cold storage buildings and refrigerating chambers, such as are now in use in every populous place, the non-conducting properties of asbestos render it absolutely indispensable. For the preservation of meat, and all kinds of provisions brought from distant lands, specially-constructed ships, containing the necessary refrigerating apparatus and chambers, are in universal use; as are also buildings of considerable size. In London most of these places are fitted up in underground chambers, but in New York and other places, large buildings have been specially erected for the purpose. Nearly all of these have double walls surrounding the cold chambers, with some kind of non-conducting material rammed in between by way of lining. For this purpose, asbestos has been largely used, but now this filling material can be most advantageously dispensed with. Nothing more is necessary from this time than to have the walls of the chambers coated with asbestic, which while leaving them perfectly clean, will keep them cool and sweet.

In order to show the value of asbestos and, better still, asbestic in the exclusion of heat, we may cite the case of a Channel steamer, the owners of which wished to have the boiler covered with asbestos composition. The engineer's berth, being quite close to the boiler, was unpleasantly warm even in winter; but, after the boiler had been covered in with an application of the composition, two inches thick, that functionary had a different tale to tell, the heat being so effectually confined to the boiler that the change made his berth unpleasantly cold. Again, in the case of the re-building of a seamen's floating chapel at Genoa, the old chapel, having been erected on the deck of a hulk, was found to be too expensive on account of the reparations frequently rendered necessary by the extremely high summer temperature. It was desired that the new chapel should be built of iron; but fears were expressed that, when exposed to the summer's sun, the roof and sides would get so hot as to

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make the temperature inside unbearable. The engineer, therefore, suggested that the space between the outer skin and the inner boarding should be filled with pulverised asbestos. Accordingly, this space of about one and a quarter inches, up the sides and over the ceiling, was tightly rammed with asbestos powder; and the result was that, while the outside temperature stood at 100°, the inside temperature, the doors and windows being kept shut, did not reach 70°, and was, therefore, in comparison, deliciously cool. But now such a proceeding as this is quite unnecessary, a coating of asbestic being all that is required.

In consequence of the above, it has been suggested that the deck cabins of steamers passing through the Suez Canal, or navigating the Red Sea, should by similar means be made more comfortable for the passengers, more especially as asbestic is vermin-proof.

Now there is no longer any need to use asbestos powder, or any other matter whatever in the way suggested, because a thin coating of asbestic is, as we have said, all that can be required in any such case.

Beetroot Sugar Refineries.—In the beetroot sugar refineries of France, Germany, and Austria, fine asbestos cloth is in universal use for filtering the saccharine juices. It is used also in chemical laboratories for straining and filtering acids and alkalies, which would quickly destroy any ordinary filtering paper; and it is specially useful when the liquid to be filtered is of a caustic or strongly acid nature, or where it may be desirable that the filter, with residue, should be ignited without consuming the filter, or where the residuum is to be dissolved off the filter by acids or other solvents. Asbestos filter bags are better fitted for this purpose than those made of any other material, they last longer, retain the heat better, and are more easily purified.

Finely-divided Asbestos.—In cases where a very finely-divided asbestos is desirable, it can be accomplished by a process patented in Germany by Fr. Breyer, of Vienna. The asbestos is first coarsely ground, and then mixed with some granular crystalline carbonate, which must be soluble in acids. The carbonate should possess a hardness between 3 and 4, 5, according to the mineralogical scale. After the mixture is ground

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Asbestos and Asbestic: Their Properties, Occurrence, and Use (1897) Published by AsbestosClaims.Law
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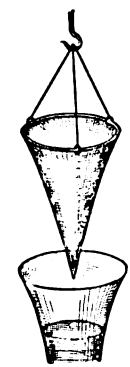
in a mill, the mass is treated with an acid until the carbonate has been dissolved out. The escaping carbonic gas causes the asbestos fibres to be loosened and disintegrated from each other so as to make the mass porous. It must be thoroughly washed with water before being used.

For filtration purposes generally, asbestos has proved to be so eminently adapted, by reason of its peculiar properties enabling it to resist the action of alkalies and acids, that, either in the form of cloth, or finely-carded fibre which, when fouled, can be easily cleaned by hot water or steam, it forms a material adjunct to the filtering media in all the more important filters now used. All filters are modifications of the simple principle here shown, the object being the purification, by separation of liquids from the substances held in suspension in them, through the pores of the media used, which must be sufficiently fine to retain or keep back the solid matter. The filtering medium may be any substance of a sufficiently spongy or porous nature to allow of the free percolation of the liquid, the pores at the same time being sufficiently small to render it limpid or transparent.



Filter.

In other forms, rapidity of filtration is the point aimed at. To secure this, regard must be had to the porosity of the filtering medium, the extent of the filtering surface, the relative viscidity or mobility of the filtering liquid, the pressure or force with which the liquid is impelled through the pores of the filter, and the porosity and fineness of the substances it holds in suspension.



Asbestos Cloth Filter Suspended.

After straining and filtering acids and alkaloids in chemical laboratories, the filter can be thrown into the fire, and when the residual matter has been consumed, the web will be found as good as ever.

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Viscid Liquids.—If a large quantity of liquid has to be filtered, or if the substance is too viscid, a funnel of asbestos cloth suspended by a hook is found useful.

The various filtering media now commonly used, with the mode of applying the asbestos, will be sufficiently seen from the following examples :—

Maignen's "Filtre Rapide."—In M. Maignen's "Filtre Rapide" the apparatus consists of a hollow perforated cone of earthenware over which a specially woven asbestos cloth is stretched. Canvas or felt an inch thick was at first used for this purpose, but it was found that with soft rain water, containing ammonia, this felt became as rotten as wet blotting paper. Asbestos was accordingly suggested, but it was at first supposed that this would be too expensive, and it was some considerable time before a pure asbestos cloth could be made, of exactly the right porosity, to arrest the fine filtering medium which is used in this apparatus to purify the water chemically; but so successfully has this at length been accomplished, that M. Maignen anticipates that presently asbestos cloth will take the place of sand in the purification of the water supply of London. In this filter a layer of finely-powdered carbo-calcis is automatically deposited on the outside of the asbestos cloth (which is stretched over an earthenware cone), by being mixed with the water first put in; and to cleanse the filter all that is required is to deposit a fresh supply on the asbestos cloth.

The Nibestos.—The Nibestos filter is specially prepared for cleansing water from all chemical impurities. It consists of upper and lower earthenware vessels, divided by a strainer of the same material, and upon this is fixed a sheet of specially prepared asbestos cloth, and above this again, another sheet of the same material of much finer texture. In percolating through this filtering medium the water is deprived of all suspended matter, including any organic germs that may be present. When the medium becomes clogged with impurities it at once ceases to act, and will allow nothing to pass through. The asbestos cloth is then renewed and another fitted into its place.

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Judson's Filter.—In Judson's filter the medium employed is said to give off minute particles of oxide of iron, which necessitates the use of a straining apparatus. To effect the required object, porous blocks or slabs of carbon, or silicates of various kinds, are used ; but as these sooner or later get clogged, they have to be cleaned by brushing or scraping, or by replacing the block by a fresh one, in doing which it is difficult to prevent particles from passing round the joint. This difficulty is surmounted and perfect mechanical straining effected by substituting a layer of carded asbestos fibre for the block.

Creswell's Asbestos Carbon Filter.—In Creswell's asbestos carbon filter (Parker's patent Niagara) the inside is quite plain, except for three or four projections, which are rounded below but shouldered on the top. These projections support a perforated stoneware tray, which carries the filter bed and unfiltered water ; any number of which trays may be used by placing them one above the other. The edges of the trays and the sides of the cistern are rendered water-proof by a flexible closely-fitting ring, so as to prevent the water, running between, carrying with it small particles of the filtering material. Whilst the upper bed detains the rougher particles of dirt and any organic matter, the water is effectually purified by the asbestos tray and the lower bed.

Cheavin's New Patent. — In Cheavin's "New Patent Removable Plater Filter," the construction is of so simple a character that the whole can be taken to pieces and the purifying medium renewed within a few minutes, whilst nothing comes in contact with the water but the stoneware, the "idiocathartes," and the asbestos cloth. The shape of this filter enables a large amount of the purifying medium to be used, over which is spread a screen of asbestos cloth, which arrests all the impurities before they are brought into contact with the idiocathartes.

Lipscombe's Filter.—Lipscombe's filter is noticeable for the simplicity with which the filtering material can be renewed. The construction is very simple, being one perforated earthenware cylinder within another, each covered with the United

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Asbestos Company's special asbestos cloth, with the filtering material in the intervening space.

Moulded Asbestos Filter. — The moulded asbestos water filter, manufactured by the Bühring Water Purifying Company, of Broadway, New York, has been in use for many years, and is said to answer its purpose well.

Filtration of Sewage.—In the filtration of sewage, and in the purification of foul gas in connection with sewer traps, and for ventilating and deodorising manholes for cesspools and sewers, the asbestos fibre is saturated with deodorising liquids which render the escaping gases harmless. The system of deodorising sewer gas, formerly adopted, was to cause the gas to rise through charcoal, but the impurities soon clogged this up and prevented the passage of the gas. Messrs. Adams & Co., of York, suggested a new mode, by placing over the opening rising from the sewer a hood of galvanised wire interlaced with asbestos yarn, spun in such a way as to have good capillary action, the ends of the yarn being dipped into a liquid disinfectant. When the fibres are saturated, a disinfecting screen is formed, through the meshes of which the gases rise, and in their passage through they become purified and rendered innocuous.

Mineral Oils.—Dark mineral oils, dissolved in benzine, are apt after some time to deposit fine precipitates. The filtration of these precipitates is difficult; but good results can be obtained by using filter paper containing asbestos. After washing the precipitates and drying them at 100° to 110°C., it was found by weighing that the quantities of the insoluble substances contained in three different mineral oils were 1·8, 2·0, and 1·8 per cent. respectively. The precipitates consisted of a fine powder, resembling dark brown coal, having a slight bituminous smell and a higher specific gravity than water.

Viscid liquids, such as are obtained in processes of artificial digestion, may be filtered in much the same way by the aid of finely-picked asbestos fibre. The filtration of such liquids is exceedingly slow, and the filtrate often passes turbid even through paper of the closest texture. In order to filter such a fluid, Fresenius advises that it be diluted with water and

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some recently ignited asbestos added, and the mixture vigorously shaken up. After about twelve hours, the suspended matters will have subsided, leaving the supernatant liquid perfectly clear. This can then be syphoned off, and the residue washed once or twice by decantation, and afterwards passed through a glass funnel, the neck of which contains a pellet of asbestos.

Gas Stoves.—Perhaps the most popular conception of the use of asbestos is that in which it figures in gas stoves, where the gas is made to rise through asbestos and is then lit. While the gas is burning, the fibres glow brightly, showing the flame of the gas, which not only spreads the heat, by expanding it, but gives somewhat of the appearance of an open fire. There are so many varieties of these stoves, all of which are so well known, that little need be said about them here.

From an Englishman's point of view, engendered by long habit and the damp and chilly nature of the climate in which he lives, there is nothing to which he attaches so much importance as the luxury of a visible, pokeable fire. The stoves and warming apparatus mostly in vogue elsewhere, excellent as they are in their way, are simply nothing to him in comparison with the comfort and cheerful appearance of his open fire, even when, as is only too frequently the case, the unscientific construction of his fireplace causes nine-tenths of the heat from the fuel to be lost in the chimney. When living in Canada, in rooms comfortably warmed by the stoves in use there, on re-entering from the keen air outside, I always felt an irresistible desire to kick open the stove door and revel in the cheerful blaze, so as to enjoy the sight of the flames rippling over the logs. It is only by very slow degrees that a more scientific manner of warming houses or rooms in England can make its way, such is the conservative nature of the people and their disinclination to move out of the old-fashioned ways of their fathers. For some time past, however, practical men have been drawing attention to this subject, with the praiseworthy object of showing how to obtain the maximum of heat from a minimum of fuel, reserving at the same time the luxury of the visible fire. There is more than fancy in this, because heat, radiating directly from the glowing

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coal, passes through the air without modifying its temperature in any important degree; consequently, coming in contact with the person, it imparts warmth to the body, whilst leaving the air comparatively cool. For public rooms, or places which people simply pass through, warm-air stoves are both economical and satisfactory, but for places where people remain seated for any length of time, the comparatively low temperature of the floor and walls, which always occurs when warm air alone is used, combined with the effect of the warm air on the lungs, causes an unpleasant feeling, which is not felt when moving about. Unless, therefore, the difference between radiant heat and warm air be taken into consideration, it is not possible properly to appreciate the comparative value of the different systems. Registration by thermometer is no guide to comfort, and is useless in estimating the value of radiant heat. Acting on these principles, Messrs. Fletcher, of Warrington, have produced an asbestos gas-fire respecting which the committee of the Gas Institute state, in a report issued by them, that in regard to floor temperature, the highest recorded at the floor level, which may be taken as synonymous with comfort of body and warm feet, was obtained by it. Gas used in this way costs less than coal for making a room comfortably warm.

Professor Tyndall explains that the transmission of heat is powerfully influenced by the mechanical state of the body through which it passes. Pure silica, in the state of hard rock crystal, is a better conductor than bismuth or lead, but if the crystal be reduced to powder, the propagation of heat is exceedingly slow. Through transparent rock-salt, heat is copiously conducted, but through common table salt very feebly. Asbestos, he explains, is composed of certain silicates in a fibrous condition; and he could place some asbestos in his hand, and in it a red-hot iron ball, which he could hold without inconvenience. That the division of the substance should interfere with the transmission might be reasonably inferred, for heat being motion, anything which disturbs the continuity of the molecular chain, along which the motion is conveyed, must affect the transmission. In the case of asbestos, the fibres

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are separated from each other by spaces of air ; the motion has, therefore, to pass from solid to air, and from air to solid, and it is easy, consequently, to see that the transmission of vibratory motion through this composite texture must be very imperfect.*

The "Leeds" Stove.—Another good stove is the "Leeds," which was shown at the Brussels Exhibition. Here the flame is made to impinge on an asbestos block, which it brings to a white heat, insuring complete combustion and the total absence of noxious vapours. In this case the heat is thrown, by direct radiation, on to the floor, which is undoubtedly the most hygienic way of heating rooms.

The Manhattan Gas Heater.—The Manhattan Gas Heating Company, of 903, Seventh Avenue, New York, show many excellent open grate fireplaces, so made as to combine the gas heating style with the luxury of an open grate fireplace, and which do away entirely with the objectionable features which are common to many gas stoves. The principal advantages of a chamber gas burner are, that the gas and air are thoroughly mixed and superheated in the chamber before coming in contact with the flame in front of the burner, thereby producing a brilliant fire, perfect combustion, and an intense heat. Their medium size heaters consume from fifteen to twenty feet of gas per hour. Some of their designs are remarkably elegant, and all are economical and practical. One of these combines an asbestos fire back and a basket grate ; the back being the regular Manhattan chamber gas burner, and the basket grate being filled with porous artificial coal, so arranged that the gas may be turned into one or both, at the same time giving a remarkably pleasant fire. The combination gas heater is expressly fitted for the use of andirons, and has a singularly handsome appearance. In their illustrated catalogue they show some very ornamental forms of grates and stoves of their special manufacture, which is a great improvement upon the general run of gas stoves.

Plastic Stove Lining.—"Plastic stove lining" was formerly

* Tyndall on "Heat."

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composed of asbestos or other fire-proof material prepared in the form of a cement, so that it can be used for the lining of cooking and heating stoves, as well as the fire doors of boiler furnaces, etc., but this now will be entirely done away with, as no material can compete with asbestic in plasticity, or as a fire-proof form of cement.

In regard to the fibre used in gas fires, the best long silky fibre is worth 10s. per lb.; 2nd quality, 3s. 6d.; and the asbestos fuel 6d. per lb., or 32s. 6d. per cwt.

New Porcelain.—A new porcelain is spoken of, which is made by grinding asbestos to a fine powder, and then dissolving out all insoluble matters with hydrochloric acid, making the powder into a paste with water, and afterwards baking in a porcelain furnace for eighteen hours at 1,200°.

Asbestos Paint.—The demand for asbestos paint is continually increasing. It is used largely in the Houses of Parliament and other public buildings, as it was at the several Exhibitions at South Kensington. The whole of the buildings at the "Healtheries" were coated with asbestos paint supplied by the United Asbestos Company; and, in his presidential address to the Institute of Civil Engineers, Sir Frederick Bramwell stated that these buildings owed their escape, during an outbreak of fire, to the fact that their walls were covered with asbestos paint. At the "Fisheries," in 1883, the Prince of Wales, as chairman of the general committee, announced that, owing to the use of asbestos paint, they had been enabled to insure the buildings and contents at 50 per cent. less than usual.

Fifty pounds' weight of asbestos paint is sufficient to coat about one hundred square yards of wrought timber primed in the usual way; for unwrought timber the quantity must be increased according to the condition of the wood. On rough wood one coat will offer great resistance to flame.

Fire-Proof Paint.—A fire-proof paint or varnish without asbestos, it is said, can be made as follows:—Finely-powdered glass twenty parts, porcelain twenty parts, any kind of stone twenty parts, calcined lime ten parts, mixed to a proper consistency with water-glass, *i.e.*, silicate of soda. The first

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coat of this paint will harden in a few hours, after which another coat can be applied, when the wood, or other inflammable substance so treated, may be considered fully protected.*

Danger of Woodwork.—The woodwork in buildings constitutes, of course, the greatest danger from fire. Every one knows the difficulty of lighting a fire without wood; neither paper nor shavings are of any use, as these will only blaze up brightly and then burn out without firing the coal, though they will readily light up the wood which will inflame the coal. When, therefore, the woodwork of a building catches fire there is great danger, because the flame emitted is a clear flame of great penetrative power, which is the cause of the rapid spread of the fire from the starting point to staircases and passages affording communication from room to room. If all wooden fittings could be replaced by iron, many a fire would burn itself out, and ample time would be afforded for the engines to arrive before the conflagration could assume unmanageable proportions. But in the great majority of cases iron fittings are an impossibility, and there is no alternative to the use of wood.

In the United States especially, attempts are being continually made for the preparation of some kind of uninflammable wood. In order to accomplish this, and to make timber fireproof, the air and the natural juices of the wood must first of all be removed from its pores and cells, and the places of these be filled in with a solution of fire-resisting salts and other chemicals. This operation can only be carried out under great pressure, steam being first used to open the cells; and by means of this new process, it is said that wood of all kinds can be rendered absolutely uninflammable, *i.e.*, incapable either of supporting or conveying flame. Under the fiercest heat there occurs merely slow carbonisation of the part actually in contact with the fire. There is no spreading of flame by the so treated material. The process is not limited to timber of any particular size—boards, planks, joists, wood of all dimensions and of any shape can be prepared with equal success. Although

* "Chambers' Journal," April 28th, 1883.

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it is scarcely two years since wood thus specially prepared has been offered to the public in the United States, it has already been adopted by the Navy Department of that country for exclusive use in all its ships of every description. All the timber needed for the thirty or more ships, torpedo boats, etc., now under construction for the United States Navy, is officially required to be treated by this process. More recently the United States Treasury Department adopted this plan in respect of all timber to be employed in the new Appraiser's Stores, in New York City, and other principal buildings of that Department. The Post Office Department, also, has ordered the exclusive use of the process in the construction of the new buildings in Washington, Denver, Buffalo, and elsewhere. Later still, it has been decided by the United States War Department to apply the protective method in the construction of ammunition stores, forts, barracks, etc.

A trial of this prepared wood is reported to have taken place on the 17th May, 1897, on the site of the old Millbank Prison, in the presence of H.R.H. the Prince of Wales, and a number of distinguished persons who had been invited to see it. Two cottages, thirty feet in height, had been built, similar in all respects save one, the wood of the edifice nearest to the royal pavilion having been treated with a fluid said to render it proof against the fiercest flames. Piled up against these two little houses, on all sides, were heaps of billets of wood and shavings, whilst the odour of petroleum showed clearly enough that the company furnishing the test had no fear of submitting their product to a severe trial. After the Prince had inspected the two buildings the torch was applied. A strong wind swept across the wide, open space, and the flames danced and crackled in a way that would have made any but an enthusiast step back. In twenty minutes the house that had not been treated was enveloped in flames mounting high in the air, and formed a fine subject for the cameras levelled upon it from all points. The other structure was charred and the window-panes in it melted like so much pewter, but that was all. A mass of inflammable materials in the inside had not even

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caught light. Ten minutes more and the unprotected cottage fell in. In the middle of the pile in the protected cottage was a box made with the uninflammable wood containing souvenirs. Smoke and flames poured up the chimney, but when the mass had burned itself out, the box was recovered, charred, but unharmed, from the ashes, and the contents distributed.

It is said that the Japanese Government is also employing the fire-proof wood on the two new cruisers now being built for that country in the United States. All the latest and largest office buildings in New York City are now constructed on the newly-discovered plan. The American architects, Messrs. Gooch and Harding, who designed Holland House, the Gerkin Building, the Queen's Insurance Building, the Postal Telegraph Building, and many other of the finest structures in New York, have declared their intention to specify this uninflammable timber for all their future buildings.

Ransome's Siliceous Paint.—Many attempts have also here been made to render wood uninflammable. So long ago as July, 1871, Mr. Frederick Ransome experimented in a wooden shed partly painted with siliceous paint, which was set on fire. The unpainted portion was completely destroyed, while that which was protected by the siliceous covering escaped ignition, and although deeply charred never took fire at all. The composition of the paint was analogous to that of Ransome's patent stone; it consisted principally of a mixture of pure silex and soluble silica, converted into an insoluble siliceous covering by an outer coating of chloride of calcium. Although this invention promised well at the time it never came into extended use. But the idea of covering wood with a fire-resisting surface having been published, it was taken up and improved upon by others. The refractory quality of asbestos being well known, Mr. Thaddeus Hyatt, who had already spent much pains upon developing the industrial uses of asbestos, endeavoured to turn it to account in the protection of buildings against fire in the form of a coating of cement. He ground the shorter and less valuable fibres into a slip or paste, analogous to

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porcelain slip, and combined it with gelatinous silica, either alone or in conjunction with magnesia, baryta, alumina, or lime.

Erichsen's Experiments.—In 1881, Mr. E. G. Erichsen, of Copenhagen, who had been connected with the earlier experiments at the works of Mr. Ransome, brought out a new protective composition in which there is likewise a large percentage of asbestos. When intended for use as a paint or enamel it is composed of a siliceous solution, pulverised asbestos, metallic oxides and chalk, the asbestos forming 10 to 20 per cent. of the whole. Applied as a paint, it forms a fire-proof enamel, capable of resisting a white heat. It is worked, upon brickwork and woodwork, with an iron trowel or wood plate covered with felt; it can be laid on in a thicker or thinner coat as may be desired, and can be cleaned from time to time with hot water.

Mountford's Fire-Proof Paint.—The latest fire-proof paint is the invention of Mr. C. J. Mountford, of Birmingham, whose patents have been acquired by the United Asbestos Company. This is simpler in its composition than the last, and consists of asbestos ground and re-ground in water, aluminate of potash or soda, and silicate of potash and soda. When it is to be exposed to the weather it is combined with oil, driers, and gummy matters, and in some cases with zinc oxide or barytes. But by far the best material for a fire-proof paint is steatite, which, like asbestos, is a silicate of magnesia.

The H. W. Johns' Company's Paints.—In 1858, this well-known company commenced the manufacture of paints and coatings for roofs and the preservation of wood, metals, etc., and ten years afterwards made known the results of their long continued experiments with asbestos, which was then comparatively unknown; they then commenced the manufacture of numerous specialities composed wholly or in part of this indestructible fibrous mineral which have now become recognised standing articles for mechanical, structural, electrical and almost every other purpose. In 1874, they commenced the manufacture of liquid paints, their success in which has been

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unparalleled. The fire-proof paints specially prepared by this company are ready for immediate use. They are prepared in white and in various light colours and tints, especially for the inside rough woodwork of factories, boiler-rooms, theatres, stables, etc., so as to form a valuable protection against sparks, cinders, or light flames. One U.S. gallon of this paint is sufficient for two coats to cover as much as 275 to 300 square feet without thinning, and can be thinned with half a gallon of pure raw linseed oil to one gallon of paint for first coat. For outside work, these paints afford a reliable protection, not



only against sparks and cinders, but also against the action of the weather. They are claimed to be in every respect first-class paints, being composed of pure linseed oil and the highest grade of pigments, combined by processes exclusively original and unequalled in richness and permanency of colour, and as in addition to the ordinary grinding, they are re-ground, while in the liquid state, they are claimed to be far superior to ordinary paints in their covering properties, which are said to be from 15 to 20 per cent. of the usual cost of painting.

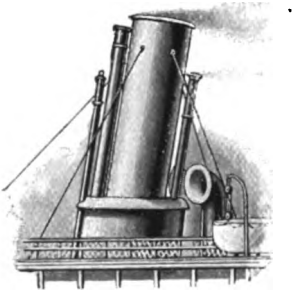
Smoke-Stack Paint.—Their "smoke-stack paint" is specially adapted for smoke-stacks, boiler fronts, and all heated iron-work. Attention is also called to their roof and railway

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paints, which are specially adapted for iron and other roofs, railroad buildings, bridges, freight cars, steamboat decks, boats, outbuildings, fences, gas holders, etc., and for coach colours for re-painting carriages, wagons, buggies, etc., for which their application is easy, as they dry rapidly with a firm, hard gloss, and require neither rubbing nor varnishing.

Soapstone.—In the manufacture of pigments, soapstone is simply invaluable. When it is remembered that one of the main causes affecting the durability of iron bridges, and metallic structures generally, is the tendency to oxidation, arising from the humidity of the atmosphere, it will be at



once understood that if proper precautions were not taken to obviate this element of danger, by finding some means of lessening the corrosion which is so constantly taking place, very serious results might ensue. This liability to corrosion is still more persistent in ships, built of iron or steel, in the latter especially, because of the difficulty of finding some kind of pigment capable of taking a firm hold of the fine fibres of the steel plates. Many modes of overcoming this difficulty, such as rough-rolling the steel, have from time to time been tried, and experiments are constantly being made in this direction, but mostly without successful result.

Mr. Goodall's Experiments.*—Some time ago, Mr. Goodall, Surveyor of Shipping to the Trinity House, spent a considerable time in the endeavour to find some material possessed of the

* See page 329.

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necessary power of taking hold of the fine fibres of steel, and in the end gave the result of his experiments to the public. In doing this he strongly urged on paint manufacturers the desirability of trying soapstone as an ingredient in any paint designed to be employed in the protection of iron and steel ships, especially in the coal bunkers, as he had found nothing so suitable for accomplishing this object. The chief difficulty met with in carrying out his ideas was that steatite when mixed as an ordinary paint, that is, with raw or boiled linseed oil, driers, turpentine, terebine, etc., the steatite forming the basis, would neither mix properly nor dry hard, and was quite useless as a protective paint; but with quick-drying varnish it was a success.

When ground into an impalpable powder, the grain of soapstone is of such an extreme fineness as to be all but infinitesimal, and this quality, coupled with its imperishability, endows it with extraordinary qualities. It is, moreover, lighter than any metallic pigment, is not liable to be thrown off by vibration, and will cover a much larger surface than zinc white, red lead, or oxide of iron; all of which, especially the latter, are very difficult to obtain free from adulteration. The red oxide of iron being the pigment generally in use for iron structures can, according to Professor Lewes, be easily tested for soluble sulphates, by warming a little of it with pure water, filtering, and then adding to the clear solution a few drops of pure hydrochloric acid, with a little chloride of barium solution. If a white sediment is formed in the solution, the sample should be at once rejected.

When soapstone, reduced to a fine impalpable powder, is mixed with a quick-drying, hard-setting varnish, it furnishes a paint superior to asbestos, not only of great covering capacity and firmness, but of an even, enamel-like surface. When ground by itself pure soapstone is transparent, the added colour alone, therefore, is shown in the pigment. Its remarkable smoothness is due to the extreme minuteness of the atoms of which it is composed, and to which it may be reduced. Its extraordinary fineness and adhesive nature is shown by the

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fact that you may write with it on plate-glass, the steatite finding a ready hold on its highly-polished surface. It consequently finds perfect and permanent adhesion to the surface of the smoothest steel.

Oxide paints mixed with boiled oil are now regarded as failures; naphtha is a far better combination, corrosion resulting from the oxygen contained in the oil.

Asbestos Concrete Coating.—The H. W. Johns' Manufacturing Company's asbestos concrete coating, being strictly fire-proof, is made either thick or thin, and of the proper consistency for application, either with a trowel or a brush. It forms a durable surface on beams, posts, partitions, roof boards, and other inside rough woodwork exposed to flames or intense heat. One hundred pounds of this coating will cover about 200 square feet $\frac{1}{16}$ of an inch thick.

Asbestos Building Felt.—This fire-proof sheathing or lining felt, on account of its non-conducting qualities, is in special use for lining weather-boards, floors, partitions, railway cars, etc. It will not disintegrate by age, and is, moreover, both odourless and vermin-proof.

Insulation Purposes.—For insulation purposes asbestos is much in use by electrical engineers, in the form of millboard, in the construction of dynamos; and cables and leads, covered with plaited yarn, have been adopted in several installations. It is also made into tubes, fitted into sockets, for joining the lengths, and with elbows for turning corners. The advantage of an insulator, formed from a material unaffected by heat or damp, speaks for itself. Cheapness of production, however, is very essential, for this class of work as asbestos is here brought into competition with other materials, which, though not possessing all its advantages, are more easily procurable and require less special adaptation in their manufacture.

A special quality of asbestos paper is made for wrapping battery plates in; and gloves of asbestos cloth for holding red-hot crucibles;* others of a lighter make, lined with rubber, enable the engineer to handle the wires with comparative

* Watt's "Dic. Chem." Art. Asbestos.

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impunity. Another non-conducting material is supplied for the wires, which, whilst preserving their perfect insulation, guards them equally against risk from fire and damage from contact with water. Tubes are made for providing a non-conducting covering for electric wires, both fire and water-proof, which preserve a perfect insulation.

Fuses and Incandescent Circuits.—For the special class of work which relates to fuses and incandescent circuits there seems, at present, to be some difficulty, brought about by the contact of asbestos with copper; the former, for some unexplained reason, appearing to exercise an injurious effect upon the latter. The fuses for high tension currents used for transformers are made of copper wire, passed through sheets of asbestos, so as to break the arc when the fuse goes. In this application it may be that asbestos exerts some peculiar corrosive action on the copper wire, as, at the points of contact, the wire turns green, and soon eats away.

Fire-Proof Papers.—An excellent fire-proof paper has been made by a combination of asbestos with infusorial earth. About forty parts of fine disintegrated asbestos fibre and sixty of infusorial earth, are put in a dry state in an ordinary beating engine, sufficient water being added while the machine is in operation, to beat the mass into a pulp, just thin enough to form upon an ordinary cylinder. The web is taken from the cylinder and finished in the usual manner. This forms a flexible paper, which can be used, whenever ordinary paper is employed, but it differs from ordinary board in being fire-proof.

Another fire-proof paper might also be made from a pulp consisting of one part vegetable fibre, two parts asbestos, one-sixteenth of borax, and one-fifth of alum. The ink for this was made from 65 parts of graphite, 0·8 parts of copal varnish, 7·5 parts copperas, 30 parts tincture of nutgalls, and a sufficient quantity of indigo-carmine.

Talc.—Professor Macadam describes a sample of talc, obtained from New Jersey, which he states to be very largely used in paper-making in place of kaolin or china clay, which is the

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felspar of decomposed granite washed from the rocks. This talc is of such a fibrous nature that it readily attaches itself to the smaller particles of paper, and causes them to be retained, instead of being washed away. It is said that the beautiful quality and smooth glaze of American papers is primarily due to the use of this mineral.

Paper for Writing and Printing.—Asbestos papers for writing and printing have always been a great desideratum. We have already referred to the Norwegian attempts in this direction, as recounted by Pontoppidan, Bruckmann's book, and the Italian experiments of Perpenti, Aldini, and others. But actual experiment in paper-making has always hitherto been greatly thwarted by the natural affinity of asbestos for water. Few kinds of asbestos are suited for paper-making, and, even when the right quality is obtained, special treatment is necessary. A patent for asbestos paper-making was granted in 1853, and in this case the pulp was mixed with alum, with the object of producing a fairly indestructible paper. The low price of some descriptions of the mineral, coupled with its heat-resisting and low heat-conducting powers, have led to constant experiments in America for its use for this purpose. Most of the papers so made contain only about one-third of their weight of asbestos. Some of them will burn with a flame, leaving a white residue which, if the sheet be carefully handled, will retain its shape, the writing, with common ink, being perceptible even after the organic substance of the paper is consumed.

A very good class of asbestos paper was some time ago manufactured 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. What is required is the discovery of a method of furnishing to the paper a sufficiently hard and smooth glossy surface, to enable the pen to glide smoothly over it and prevent the running tendency of the ink. It will be readily seen that, when the difficulties incident to its manufacture are successfully overcome, how invaluable such papers would be for bankers' and merchants' books, registers, deeds, and permanent records of all kinds. A good deal of the

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inherent difficulty has now been surmounted, but still the best writing paper produced is too tender, and any writing upon it is apt to disappear if the paper be subjected to a red heat.

Professor Silvanus P. Thompson, F.R.S., remarks that it is no exaggeration to say that the introduction of wood pulp for paper has degenerated that manufacture to such an extent that nine-tenths of all the books now being printed would certainly in a hundred years have disappeared into powder. The books of William Morris, printed at the Kelmscott Press, and a few others, would probably survive, and a hundred years hence people would say what splendid fellows there were in the 19th century; they produced admirable literature, and beautiful paper and printing. They would give us credit for being great masters of the art of printing, simply because all the inferior stuff had perished. Now they had a new material, more imperishable than the best linen paper, and probably the next great printer would use imperishable paper made from asbestos, and perhaps print it with platinum black, so that the ink as well as the paper should be fire-proof.*

Asbestic Paper.—Now, however, the introduction of the Danville asbestic has completely revolutionised all previous attempts at paper-making, and this mineral product has entered as an important factor into the paper trade. In the form of pulp, it can be furnished much superior in quality and cheaper in price than any kind of wood or straw pulp, so that among paper manufacturers its use, as it becomes known, is likely to be universal. The material is of a pure white colour, of remarkable fineness, produced in enormous quantities, and can be sold to paper manufacturers at a price below that of any material now in use by them. Contracts of such an extent have been made by the H. W. Johns' Company, who have secured the practical control of the produce of these mines, that in order to meet current demands they have been compelled to erect an immense building for the special manufacture of asbestic paper at Brooklyn, adjoining their other works.

* Discussion on Asbestos and Asbestic.—"Journ. Soc. Arts," No. 2,319, vol. xlv.

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When looking over this building in November last, I was informed that the firm's consumption of asbestos during the past year was at least three or four times greater than that of any former period, which was mainly occasioned by the demand for asbestic paper, and that not a day passes without some new development of their special manufactures and new uses for asbestos, and in particular of asbestic, being brought under their notice. For builders' purposes alone, about 1,500 tons are made yearly for placing between layers of boards, and covering ceilings, walls, and partitions, in accordance with the laws of New York.

Gas Shades.—Incombustible and non-arsenical asbestos gas shades are naturally much less risky than the ordinary paper shades. These are largely in use in the General Post Office and elsewhere in London.

Wall Papers.—Asbestos is also manufactured into wall and ornamental papers of every description ; coloured wall papers, practically indestructible by fire, can also be had in great variety. After severe heat tests, these are found to retain their colourings and letterings as clearly impressed and as plainly visible as before. They show up colours in a brighter fashion than ordinary paper, and are therefore specially useful for theatrical side scenes, and similar purposes.

Jagnaux (p. 552) speaks of its use in a similar way in France, saying :—"On prépare avec les débris d'amiante, ainsi qu'avec une variété cotonneuse de cette matière, une pâte avec de l'eau et du silicate du soude, et cette mixtion peut remplacer la couleur à la céruse ou au blanc de Meudon pour la peinture des châssés employés pour les décors du théâtre."

Some time ago the H. W. Johns' Manufacturing Company, of New York, had its price lists printed on asbestos paper, and at the present time they produce a class of paper as capable of receiving good impressions from type as any in use in modern books.

Platinum Paper.—In preparing platinum paper for printing potassium chlorate is sometimes used. Paper that is coated with the sensitive mixture must be kept dry—not ordinarily

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dry, but chemically dry—for otherwise, even in the absence of light, it appears that the iron salt is partially reduced by the paper in the matter used to size it, and the effect is a general fog and loss of brilliancy. The sensitive paper must, therefore, be kept in an artificially dried atmosphere; and this is most conveniently done by storing it in a canister that has a perforated false bottom, below which is anhydrous calcium chloride. It is customary to prepare the calcium chloride by pouring a solution of it over asbestos, then drying and strongly heating the residue. The asbestos being fibrous, the mixture is more coherent, and less liable to allow dust to escape from it. It is, however, necessary to periodically heat this mixture to rid it of the moisture that it has absorbed.*

Cardboard.—In order to manufacture a solid cardboard from asbestos which shall be proof against fire and water, and capable also of serving as a roofing material, sheets of common cardboard, tarred or otherwise prepared, are covered with the pulp. The application is made in a paper machine, the pulp being allowed to flow over the cardboard.

Millboards.—Boards can be made in any thickness from that of the thinnest card to heavy shelving, fit either for partitions in safes, or for use in large libraries. I have been informed by a Canadian manufacturer that, in his early attempts to manufacture millboard, he could not get it stiff enough. He tried a mixture of cotton fibre, but, after exposure to fire, the board again became limp, and he was ultimately successful only by the use of potato starch (mixed to about the consistency of that used by laundresses), which he stirred up with the pulp, when, after the application of fire to the finished board, it remained sufficiently firm and stiff.

The millboards manufactured by the H. W. Johns' Company are both fire- and acid-proof, and are consequently specially valuable for packing joints in contact with fire, oils, etc., as well as for fire-screens, partitions, linings for ranges, stoves, grates, etc.

Ladewig's Process.—In a former number of *L'Industrie*

* Jones' "Science and Practice of Photography," 1881, page 23.

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Moderne there appeared an account of a new process, invented by a Mr. Ladewig, for manufacturing pulp and paper from asbestos fibre, which he asserts will not only resist the action of both fire and water, but will absorb no moisture ; this pulp, he says, may also be used as a stuffing and for the joints of engines. He further proposes to use it, in the form of a solid cardboard, as a roofing material for light structures. The process of manufacture consists in mixing about 25 per cent. of asbestos fibre with about 25 or 35 per cent. of powdered sulphate of alumina. The mixture is moistened with an aqueous solution of chloride of zinc, and is then washed with water, and afterwards treated with an aqueous solution of ammoniacal gas. The mixture is again washed, and then treated with a solution composed of one part of resin soap and eight or ten parts of water mixed with an equal bulk of sulphate of alumina, which should be as pure as possible. The result thus obtained should have a slightly pulpy consistency. Finally, there is added to it 35 per cent. of powdered asbestos, and 5 to 8 per cent. of white barytes. This pulp is then treated with water in an ordinary paper machine, and worked just like paper pulp.

Mail-bags.—The H. W. Johns' Manufacturing Company of New York have recently obtained a large contract for the supply of mail-bags made of asbestos cloth.

Again, the non-conducting and fire-resisting properties of asbestic render it invaluable to iron and steel manufacturers for lining or covering the tubes employed to convey hot air from the stoves to the furnaces or cupola.

Its usefulness also for firemen's and stokers' aprons, or, indeed, for any one working in dangerous proximity to fire or sparks, as well as for salvage blankets, needs no comment.

Improved Stove-piping.—An improved stove-piping is also made by the H. W. Johns' Manufacturing Company from asbestos, which in appearance exactly resembles cast-iron. These pipes have the additional valuable properties of extreme lightness, combined with great strength and a capability of

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ornamentation unobtainable with the cast-iron pipes mostly in use; paint, in the case of the asbestos pipes, not scaling off under heat as it will do in the case of ordinary iron pipes, nor will it even blister under the most trying circumstances. The manufacturers of these pipes claim for them that they combine the strength of steel with the lightness of paper.

Capability of ornamentation is a noteworthy feature in all these cases, as well as in floor-cloths, panellings, and similar goods, which are all capable of being made ornamental and of being coloured and brought out in shades and patterns so as to be made to harmonise with their surroundings.

Ropes.—Possessing great tensile strength, and, as we have seen, being entirely unaffected by heat, asbestos rope at once asserts its applicability for a great variety of purposes, such as sash-lines and ropes for fire-escapes. A ladder of asbestos, fitted with gun-metal heart thimbles, to attach to hooks or fasteners, will sustain the weight of two or three men with perfect impunity. The weight of a fifty-foot ladder of this description is about sixteen pounds only. It is related in the history of a man of fashion, a millionaire who died not long since, that he was accustomed to say when speaking of danger from fire, that he would never go to bed in a strange house without having an apparatus of knotted rope affixed to a ring in the wall, so that he might lower himself to the ground on an emergency. On one occasion when asserting this, he was asked, What if the rope itself took fire? Had he known of its existence, he might have replied, "Let it then be an asbestos rope."

The H. W. Johns' Company manufacture a special class of asbestos fire-proof rope for fire-escapes, ladders, etc., from half an inch to two inches in diameter.

In dyeing and printing cloth it is frequently necessary to hang the fabric in loops from parallel rods for exposure to steam, air, or ammonia. In order that it should hold upon the rods, without straining, or slipping, rope or strips of cloth are usually bound around the poles. This, however, does not remove, although

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it mitigates, the difficulty, because the heat and corrosive action of the vapours will rot any covering, the first notice of the deterioration being generally the appearance of small pieces of rod-covering among the cloth which is in process of finishing. Asbestos rope and cloth are, therefore, now largely used for this purpose in the United States, with very beneficial results.

Lamp Wicks.— Indestructible wicks are used in some forms of safety lamps, their cost being slightly above that of ordinary wicks. These are specially useful to all who make use of mineral or heavy oils, as they obviate the disagreeable task of daily trimming; an asbestos wick can be used for twelve months without any trimming at all.* A fine asbestos yarn is run through a cotton lamp wick, after which the cotton is carbonised. The asbestos gives strength to the wick, which otherwise would fall to pieces. Manufacturers in the United States use asbestos wick for wrapping round wire when galvanised. This wick is composed of the finest asbestos fibre, made in the form of a strong soft wick, which can be used, if desired, as a packing, wound or packed round small steam or other valve stems, and for many other purposes. Alcohol lamps used under teapots and chafing dishes are filled with asbestos fibre, on which the alcohol is poured. A special form of asbestos wick for general purposes is now being manufactured for the Standard Oil Company.

Devonshire Everlasting Candle.—A lamp which can be used as a night lamp, fire lighter, or for cooking, has been recently patented as "The Devonshire Everlasting Candle." It consists of an outer casing of metal, glass, or other material, with a perforated bottom. This is nearly filled with a porous earthy substance, which the inventor calls "Egyptian clay," by which the oil is absorbed. The indestructible wick is made of slag-wool and asbestos fibre. To charge the lamp it is placed on a saucer or plate containing the oil, which is drawn up and absorbed by the porous material within.

Belting.—Asbestos belting is now said to be coming into use, instead of leather, cotton, or rubber belts, in all places which are exposed to the action of heat or acids.

* *Ante*, page 8.

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In my last edition, asbestos was proposed by me as a fitting substance to be used as an inner sole or lining for boots and shoes, with the object of keeping the feet warm in winter and cool in summer, the material possessing the double advantage of being at once a preserver of heat and a protector from cold. Patents have since been taken out for this, and I have now a pair of asbestos socks in my possession. They are formed of a thin sheet of asbestos paper enclosed in a calico cover, and are intended to be used by slipping the so-called sock into the boot, like an ordinary cork sole, but the idea not being properly carried out, soon proved unsuccessful. Another case is the "Cavendish Sole," in which the general idea is caught, but this also being wanting in one important particular, will probably not be permanently successful. The Laplanders carry out this principle by using a vegetable fibre called "Lapp shoe-grass," of which there are two varieties, the *Carex ampullarea* and the *Carex vesicaria*, both of which grow, like other sedges, near pools. This substance they stuff into their shoes, knowing that its peculiarity is the retention of heat, and consequently it keeps the feet so warm that by its use cold feet can be effectually defied. Nansen, in his "Eskimo Life," says that the Greenland Eskimo also use a lining of bladder-grass (*Norske, sennegræs*) between the interior sock of skin with the fur turned inwards, and an exterior shoe of hairless water-tight hide, into which the naked foot is thrust. They use it also in their summer shoes, as a protection from the stony ground. There are some other materials which are also used in this way—for instance, the interior fibre of *Luffa*, or *Loopah*, which is converted into an inner sole for boots, for much the same reason. This has the singular property of attracting damp and moisture to itself and thereby keeping the feet dry and warm. Their *Kamiks*, or shoes, are made of seal skin; in the sole of which, between the sock and the outer shoe, they place a layer of straw, or the bladder-grass sedge.

Type Founding.—Respecting the use of asbestos in type foundries in France, Jagnaux says (p. 552): "On se serte dans l'imprimerie du papier d'amiante pour la confection de certaines

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moules dans lesquelles on coule les caractères typographiques. Ces moules ou flans se font tout simplement en encrustant le cliché dans un papier compressible. Lorsqu'on emploie le papier d'amiante, on peut se servir une vingtaine de fois du même moule, tandisque ceux qui sont faits en papier ordinaire sont carbonisées après la deuxième ou troisième opération. Le papier d'amiante, sert aussi à doubler les decors de théatre (marouflage) qu'il met aussi à l'abri de l'incendie. On emploi également l'amiante pour envelopper les cables télégraphiques ; en effet, il presente sur la gutta percha l'avantage d'être infusible, tandisque cette dernière substance commence à fondre vers 50°, c'est-à-dire à une température qu'on observe fréquemment dans le sol, en Algérie par example ; aussi notre armée d'Afrique a-t-elle adopté ces enveloppes d'amiante."

Jewellers' Moulds.—Special asbestos moulds are manufactured for a variety of purposes by the H. W. Johns' Manufacturing Company, a few of which are mentioned here, as specimens of the adaptation of asbestos to this particular class of manufacture. One of them is a patent watch case and jewellery soldering block. This is a homogeneous body of porous asbestos, which will neither break, crack, nor disintegrate under the most intense blowpipe heat, and is at the same time of such a refractory nature that the block may be held in the hand with perfect safety while one end is in the blowpipe flame. It is also of so porous a character that binding wires or pins can be readily inserted, whereby small objects of jewellery can be easily and quickly secured to its surface ; whilst being indestructible, the block can be used over and over again.

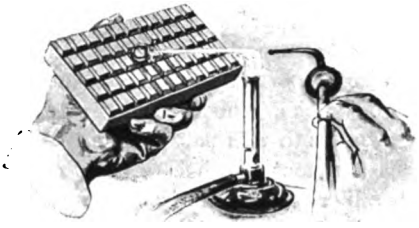
The block specially made for watch-case manufacturers is in cup form and of the proper size to hold a watch-case. With the cup, but separate from it, is a handle provided with a metal frame or socket, on which the cup is placed when ready for use ; and with each block a box of asbestos paste and a piece of asbestos rope is furnished for protecting the delicate parts of fine work, in using which the fibre is moistened, and the jewel or case embedded in the paste.

Among the soldering blocks specially prepared for jewellers,

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silversmiths, dentists, and others, is a patent ingot block for soldering, melting, and moulding ingots; this is provided with a basin and mould, and the metal being placed in the mould and covered with a piece of charcoal to confine the heat, is quickly melted. An asbestos lid is held over the block and the melted metal allowed to run from the channel into the mould where the ingot is formed. These blocks are homogeneous pieces of porous asbestos, which will not flake up under heat, and can be used over and over again, outlasting all blocks made from charcoal or other perishable materials, while the refractory nature of asbestos admits of the block being held in the hand while in use.



There are many other blocks of various descriptions manufactured by them, all of an exceedingly useful character. The patent ring block, for instance, for soldering stone-set rings, is manufactured in cup form containing an asbestos paste and a piece of asbestos rope. The ring being partially buried, with its stone embedded in the paste, and further protected by the shield of asbestos rope, an asbestos braid is passed through the ring as a shield, and the exposed portion can then be soldered without the slightest danger of injury to the stone.

A spectacle and eye-glass block is made, on one side of which is a mould for holding spectacles, and on the reverse is one for eye-glasses. The moulds hold the articles firmly in position and obviate the necessity of binding wires. A little asbestos paste, which can be re-moistened to use over again, is sent with each mould.

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A new form of block is now made for small articles, plain on one side and corrugated on the other; the corrugation allowing the heat to pass round the work quickly, and render binding unnecessary, as the articles retain their position while being soldered.

Tapestry.—A kind of tapestry is manufactured in France out of pulverised asbestos. The asbestos is reduced to powder in such a way as to preserve the short fibres, which are bound together by means of a cement. This product, which is about one half asbestos, is stretched over a wire gauze, and when finished will take a fine polish. Woodwork covered in this way is rendered fire-proof, and can be used for the interior lining of



safes or wooden cupboards containing deeds or other articles necessary to be preserved. Chloride of zinc, which is used in the manufacture of a certain class of incombustible cloths, is volatile at a high temperature, and its vapours then become so dangerous that it is impossible to enter a room the woodwork of which has been protected by this salt, when exposed to a temperature at which ordinary wood will take fire.

Asbestos is also used in America in the manufacture of fireside rugs, which are woven in plain colours, for after decoration, and are naturally preventive of any sparks or flying cinders.

Household Articles.—Fireplace Curtain Blower.—Among the smaller goods are a great number of articles specially prepared for household use, among which is a patent asbestos

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fireplace curtain blower. This is attached to an automatic spring roller in the frame or inside of the fireplace opening. It entirely takes the place of the unsightly and unmanageable sheet-iron blower which was always getting out of order, and the noise made by the use of which was so unpleasant. The draught is regulated by raising or lowering the curtain. When not in use, this asbestos curtain blower is rolled up out of sight, and when drawn down, serves as an ornamental summer front, which can be decorated in any pleasing way required.

Stove Polisher.—This is an ordinary brush back with a face



of asbestos cloth instead of bristles. The cloth is backed by a soft asbestos pad, and may be used on the hottest stove without harm or the production of any unpleasant odour.

Stove Mat.—This mat is a disc of asbestos, bound by a metal rim. It prevents food from scorching while being cooked, especially such articles as milk, oatmeal, preserves, etc.



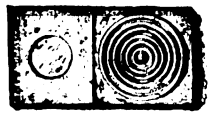
Knitting Yarn.—This yarn is about the thickness of ordinary knitting yarn, and may be knitted, crocheted, or otherwise made into fire-proof lace work and fancy designs for lamp hangings, fire screens, radiator covers, etc.

Flat-Iron Holder.—This is a soft heat-insulating pad faced with asbestos cloth. It will not burn, but keeps the hand cool, and is indispensable to those who have occasion to handle hot dishes, implements, etc.

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Flat-Iron Rest.—A hard slab of asbestos, 9½ by 5½ inches, having on one end a place for the iron and on the other a wax receptacle. It smooths the surface of the iron, and, being a non-conductor, does not abstract its heat, while preventing the charring of the ironing board or table.



Baking Paper.—For regulating the browning of bread, cake, roasts, etc. When the article to be baked is sufficiently browned on top, place the asbestos sheet loosely over it, after which it may be left in the oven until done without danger of burning. If the oven bakes too rapidly on the bottom, place an asbestos stove mat under the baking pan.

Any number of similar small articles can be had, such as articles in cloth, gloves, etc., etc., the enumeration of which would be endless.

Asbestolio.—Asbestos soap is manufactured by the United Asbestos Company, who put it forward as one of the great labour-saving agencies of the day, for the cleaning and polishing of all kinds of metal, wood, paint, marble, mirrors, reflectors, etc., as it will not scratch the surface of the most delicate articles.

Cigarette Papers.—Among the many curious novelties occasionally introduced, cigarettes were recently sold in London having a case of asbestos paper, the object apparently being to get rid of the objectionable burnt paper in ordinary cigarettes. In this case the tobacco burnt out, leaving the paper intact; but as these cigarettes have now disappeared it is presumed they met with no success.

Tobacco Pipes.—Asbestos tobacco pipes, Jackson's patent, had a considerable sale when first brought out. Their principal merit lay in their lightness, but after a while, when the novelty had worn off, it was found that the composition, whatever it was, caused the pipe to become objectionably hot, and then the sale fell off.

Tobacco Paper and Tobacco Mixture.—Again, in this line, we have a "tobacco paper and compound tobacco asbestos

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Asbestos and Asbestic: Their Properties, Occurrence, and Use (1897) Published by AsbestosClaims.Law
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mixture." The inventor makes a paper from tobacco, rendering it more fibrous by adding a percentage of asbestos. The paper is cut up like cigarette paper, and a number of these leaflets are put up together in book form. To use it, you take out a leaf and roll it up between your fingers, and it is then ready for smoking. As asbestos has neither taste nor smell, it does not interfere with the flavour of the tobacco, whilst the evil effects of smoking paper are obviated. The mixture is so made up that the asbestos is not observable in it. It is said to be very cool to smoke, and consumes the nicotine in the tobacco, whilst it burns right down to the bottom of the pipe. A pipe smoked with this tobacco asbestos is said to be always dry, and to leave no filthy moisture in the stem, but we are not told what becomes of the asbestos.

Waterproofing.—Many asbestos articles require to be waterproofed, for which the following may be useful. Dr. J. Holfert, of Berlin, has patented the following process, which is prepared by making use of the fact that gum and gelatine undergo a change by treatment with *formaldehyde*, losing their adhesive property and becoming insoluble in water. This treatment renders the material waterproof, and in all probability air-tight as well; but if so, its desirability for clothing would be lessened, though its usefulness for many other purposes would be enhanced. The well-known antiseptic properties of formaldehyde would point to its special usefulness for medical purposes. The fabric is steeped in a solution of gum or gelatine, and is then subjected to the action of gaseous formaldehyde or its solution in water, when the preparation is completed.

Baby Incubators.—Apparently there is a good time coming for mothers and babies. A chicken incubator is now no novelty. It simply consists of an asbestos lining to prevent the effect of radiating heat, to make it, when desired, air-tight. The novelty in the present case is to apply the machine to human chickens. It was, I believe, first tried at Cincinnati, and the following was the first account of it, which appeared in the *Cincinnati Enquirer*:—

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A Novel Experiment being tried in Cincinnati.

"A wee bit of a seven-months baby, weighing between three "and four pounds, is now at the Cincinnati Hospital, being "raised in an incubator.

"The wee thing has no finger-nails, its eyelids are open, and "every hour a drop or two of digested milk is dropped into its "tiny mouth.

"Chickens have had woollen rugs for mothers, ducks have "been hatched by hens, and alligator's eggs warmed to life in "the sand, but incubating babyhood into successful existence "has at least the merit of novelty.

"The incubator looks like an unpainted family ice chest. "It is thirty inches high, twenty inches wide, and contains "two compartments, an upper and lower.

"The inside of the chest is lined with asbestos to prevent "the effect of radiating heat as well as to make it air-tight. "In the lower compartment is a galvanised iron tank filled "with water. The tank does not fit tightly into the chest, "there being an inch space for the air to circulate. Holes in "the bottom allow the escape of foul air, while on a shelf, "resting on slats that divide the two compartments, lay a "basket containing the baby. The skin of the tiny thing is "covered with an unctuous sebaceous matter. The bones "of the head do not set closely together, and the process of "ossification is slowly going on."

The foregoing comprise some only of the very numerous and diverse applications of asbestos which might be referred to or described, so this part of the subject must necessarily be far from complete; indeed, it would be impossible to make it so, without adding to it, day by day, as the constantly increasing items of special usefulness are brought forward. The writer trusts, however, that the matters described are sufficient, not only to indicate the almost universal use of this singular mineral, but to confirm the statement with which he started, that asbestos is one of Nature's most marvellous productions.

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CHAPTER XI.

SUBSTITUTES AND SIMILARITIES.

Slag Wool and its Manufacture—Origin of—Pélé's Hair—Properties of Slag Wool—Defects—Rock Wool—Patent Fire-Proof Plastering—Infusorial Earth—Dynamite—Asbestonit—Spun Glass—Woodite—Whalcite—Wood Pulp—The Monier System of Construction—Wood Wool.

Among the numerous materials and compounds put forward as substitutes for asbestos, Slag Wool possesses very high qualifications as a non-conductor and a fire resister. It is applicable to many of the same uses as asbestos, and as to some of the purposes to which it is applied, it presents by no means insignificant qualities as a competitor.

Its history is very singular. That curious natural production of the lava beds of Hawaii, called by the natives Pélé's hair, —Rauoho o Pélé,—this being the name of the goddess who is supposed to dwell in the crater of Kilauea, holding her court at the volcano called *Hale-mau-mau*, or the "House of Everlasting Fire," and which doubtless originally suggested the manufacture of this curious fire-proof material.

Miss C. F. Gordon Cumming, in her "Fire Fountains of Hawaii," speaks of this material as "filaments of stringy brown lava, like spun glass, which lie scattered here and there, having been caught by the wind (when thrown up) in mid-air, in a state of perfect fusion, forming fine lava drops, a rain of liquid rock, and so drawn out in silky threads like fine silky hair." This, in reality, is a silky volcanic hair, like the byssus of certain shells, concerning which she says that handfuls of it can occasionally be collected from the rocks to which it has

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drifted, most of it having a sort of pear-shaped drop attached to one end.

This material which is called Pélé's hair is really a basic glass, a filamentary variety of obsidian, containing long cylindrical cavities, its production being brought about by gusts of wind crossing the viscid lava, at the moment of its projection into the air, by the steam escaping from the surface of the lava lake, its action in this way forming a kind of natural spun glass.* "It "is of a rich olive-green or yellowish-brown colour—a hint for "æsthetic fashions—and is glossy, like the byssus of certain "shells, but very brittle to handle. Sometimes when the great "fire-fountains toss their spray so high that it flies above the level "of the cliffs, the breeze catches it sportively, and carries it far "away over the island; and the birds line their nests with it. "Sometimes you can collect handfuls clinging to the rocks to "which it has drifted, generally with a pear-shaped drop "attached to it." This, it is evident, would crumble and break off short in the fingers, and the mineral wool, when handled, has just the same gritty, brittle feeling one can imagine Pélé's hair to have.

Its composition, which is as follows, will sufficiently account for the brittleness:—

Silica	51·19
Magnesia	18·16
Peroxide of iron	30·26
	99·61

The formation of this volcanic hair was very carefully watched by Professor Dana, the celebrated American geologist, one of the scientific party sent out by the United States Government in 1836-42, as a Government Exploring Expedition, and he has given the following interesting account of the process, as it was carried out under his eyes.†

* "Some very fine glutinous lavas are drawn out into fine filaments as portions are tossed into the air by the escaping steam."—Geikie, "Geol."

† "U.S. Geological Exploring Expedition," 179.

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"At one of the pools of the crater by which he stood, the "formation of this capillary volcanic glass was going on ; and, as "it was carried away by the wind, it thickly covered the surface "of the rocks to leeward, where it lay like mown grass, its threads "lying parallel, and pointing away from the pool. It soon became "apparent, as he watched the operation, that it proceeded from "jets of liquid lava, thrown up by the process of boiling. The "currents of air blowing across these jets bore off small points "and drew out a glassy fibre, such as is produced in the common "mode of working glass. This delicate fibre floated on till the "heavier end brought it down, and then the wind carried over "the lighter capillary extremity. Each fibre was usually ballasted "with the small knob which was borne off from the lava jet by "the wind." Mark Twain, who witnessed the scene by night, says that through their glasses the little fountains scattered about looked very beautiful. "They boiled and coughed and "spluttered, and discharged sprays of stringy red fire, of about "the consistency of mush, from ten to fifteen feet in the air, "along with a shower of brilliant white sparks—a quaint and "unnatural mingling of gouts of blood and snowflakes."*

The scoria from which the fibre is made, or rather the lava that would have constituted scoria, had it cooled upon a floating stream, is mostly glassy in texture, a kind of ferruginous black, basaltic, obsidian, the result of rapid cooling. This scoria has the following composition :—

Silica	50·00
Protoxide of iron	28·72
Lime	7·40
Alumina	6·16
Potash	6·00
Soda	2·00
	100·28

Professor Dana's description was very suggestive, but the time was not quite ripe for any practical result. A year or two passed on, and then Percy, the metallurgist, whilst on a visit

* "The Innocents at Home."

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to Dowlais, was struck by the formation of a hair-like form of slag, bearing a strongly marked semblance to Pélé's hair, which he thus describes.* "A little slag was seen to be leaking out "through the clay-stopping, which was placed round one of the "twyers at the back of the hot-blast furnace, and as it was in "the act of escaping it was caught by the regurgitating blast, "and blown out into fine threads, intermingled with minute "adherent globules of glassy slag, which so exactly resembles "Pélé's hair, in everything but colour, that one cannot be "distinguished from the other."

The mode of manufacture of this slag fibre, and its usefulness for a variety of purposes, was now very quickly seen; it was not to be supposed that the method of its production having once been pointed out, it would long remain without some attempt at utilisation. The form was singularly suggestive, especially when the composition of the slags produced in metallurgical operations is considered; these being essentially compounds of silica with earths, chiefly lime, magnesia, and alumina, or with metallic oxides, such as protoxides of iron or manganese;† the three principal constituents being silica, lime, and alumina, the silica being the acid which neutralises the other two bases.

The way was now clear for the introduction of a new material to compete with asbestos which, although rapidly growing in favour, especially for engineering purposes, was too dear. The brittleness and glassy texture of the slag fibre was certainly against it, as were also the small metallic pellicles, which it was found could not be entirely eliminated; still, if birds could utilise it for lining their nests, it was manifest that there were many useful purposes to which it could be applied; and these have, on continued experience of its qualities, so multiplied, that the material is now in considerable demand.

Attention was early directed to this substance by Mr. Charles Wood, of Middlesborough, in a paper read by him before the

* Percy on "Metallurgy," Art., "Slags."

† "The Useful Metals and their Alloys," Pickett, 623.

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Society of Arts, some time back, and to whom we are indebted for so many improved methods of dealing with slag that he is termed by Mr. Gilbert Redgrave "the pioneer of slag utilisation."

Commonly spoken of as "slag wool," this refuse production of the blast-furnace, which has hitherto so detrimentally encumbered the ground, and disfigured the country around all the seats of the iron industry, offers a notable example of the utilisation of waste products. If we take Mr. Redgrave's estimate of the annual production of cast-iron in the United Kingdom alone at 13,600,000 tons, and the weight of the refuse slag at $1\frac{3}{4}$ tons, per ton of pig iron, it will be seen that the vast heaps of this refuse by-product are increasing at the rate of upwards of 18,000,000 tons annually. This enormous mass of refuse, therefore, encumbers the ground to such an extent that, irrespective of any profit to be derived from its utilisation, it is manifest what enormous advantages would be gained by its dispersion.

In America slag wool, which is there termed "mineral wool," is manufactured by the "Western Mineral Wool Company," of Cleveland, in the State of Ohio. In England it also goes by the name of "silicate cotton;" and although the use of it here does not progress in anything like an equal ratio with its advance in estimation in the States, it is manufactured on a considerable scale at Middlesborough for Messrs. Frederick Jones & Co., of Kentish Town, and their agents, Messrs. D. Anderson & Co., of Bow.

The process of manufacture consists in subjecting a small stream of molten slag to the impelling force of a strong blast of steam or compressed air, which divides it into innumerable small spherules, forming a spray of spark-like objects; the slag being dispersed, or broken up, by the jet of steam into countless small bead or shot-like particles, each of which, as it is blown away, carries behind it a thread of finely drawn-out slag in extremely delicate filaments, resembling the fine glass thread made by the glass blower, and called spun-glass. The shot, being

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heavy, drops to the ground, whilst the fine woolly fibre is sucked into a large tube and discharged into a chamber. This process is aptly compared by Mr. Redgrave to that of the production of the threads which are drawn out from sealing-wax when the latter is hastily withdrawn from the paper. These fine threads are sometimes two or three feet in length, and occasionally much longer; which readily break up into much smaller ones, in bulk looking like a mass of cotton of a somewhat dingy white colour, the length and fineness of the threads being dependent upon the fluidity and composition of the material under treatment. When the slag is of the proper consistency, the shot are small at the outset, and to some extent are absorbed into the fibre; but in no case will they entirely disappear; it accordingly becomes necessary either to separate the two, by strong currents while still in mid-air, or else to put the bulk through a riddling machine. The finer and lighter threads are carried away from the shot, the heavier fibres making a gradual separation between the extreme fine and the coarse. In order to collect the fibres and separate them from the beads, or heavier portion of the slag, the jet is now arranged at the open mouth of a cylinder of sheet iron, in which a strong air current is induced, by means of additional jets of steam. This tube or shaft is furnished with a shield or striking plate, which detains the heavier particles, the lighter slag wool being carried by the draught, upwards and onwards, into a large chamber, constructed like a gigantic meat safe, having its walls formed of wire-netting with about sixteen meshes to the square inch. Here the steam condenses and escapes, and the slag wool, which may be aptly compared to flakes of snow, is deposited on the floor and round the sides, the lighter portions being carried to the greater distances, some flakes even attaching themselves to the ironwork of the roof. The filaments of slag formed in this way, though of considerable length, are of such delicacy and fineness that they are broken up into numberless fragments and felted together into a substance much resembling cotton-wool.*

* "Jour. Soc. Arts," No. 1,941.

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After each blowing, it is selected and taken up with forks and put into large casks or bags for shipment, or as may be wanted.

The product of the blast is divided into two classes :—

The Ordinary, which includes all the fibre weighing over 14 lbs. and less than 24 lbs. to the foot cube ; and

The Extraordinary, which comprises all that comes under 14 lbs. to the foot cube.

Mr. Charles Wood found the product to possess the following valuable qualities :—

1. Extreme lightness and absolute fire-proofness (to which the American manufacturers add that it is also frost-proof, vermin-proof, sound-proof, indestructible, and odourless).

2. Marvellous powers as a non-conductor of heat and sound.

3. So great an amount of porosity that it will absorb large quantities of water, and readily retain it for a considerable time.

Although the resemblance of this material, so far as its outward appearance is concerned, to wool and cotton is so close as to have given rise to the names mineral wool and silicate cotton, by which it is known in America and England respectively, yet this is as far as the comparison can be followed. The hollow-jointed structure of the organic fibre, which gives it its flexibility and spinning and felting qualities, is altogether wanting in slag wool ; which, as already shown, is simply spun-glass of irregular thickness, without elasticity or any such features as the imbrications or spicules of wool or cotton, necessary for facilitating the weaving process. There are, indeed, certain rough surfaces and markings on the fibre incident to its make, but these are only visible under a strong lens. The drawing out of the fibres is a purely mechanical operation, and is a remarkable illustration of some of the various forms which mineral substances will assume under different conditions of cooling.

One cubic foot of slag will weigh 192 lbs., and the same weight of ordinary mineral wool measures eight cubic feet ; the

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wool fibres, therefore, encase eight times the quantity of air which is contained in the slag. In other words, the cubic foot before conversion contains 100 per cent. of material and after conversion only 12 per cent.; the product consequently contains 88 per cent. of its volume of air. The extra grade has 92 per cent. of its volume of air, and is consequently much superior to the ordinary as a non-conductor; but even in the finest product there is a great dissimilarity in the shape and thickness of the fibres. Slag wool, therefore, consists essentially of fine interlocking mineral fibres, forming a mass of minute air-cells which give it its property of a non-conductor; air, when unconfined, being so subtle and rapid in movement, and so slow to convey heat, except by its own motion, that mineral wool forms a good distributer of heat, and at the same time presents the greatest barrier to its transmission, according to whether it has, or has not, freedom to circulate. If the air-confining substance is not very loose and porous, it will be found to transmit heat, and the reduction of the percentage of volume of air, by making the material more compact, develops its capacity for conducting heat.

As illustrating this view, the following tables have been published, by the Western Mineral Wool Company, which are worth quoting here for several reasons applicable to the subject generally. No. 1 was prepared by Mr. J. J. Coleman, and read by him before the Philadelphia Society of Glasgow, and No. 2 was compiled in order to show the non-conducting properties of different materials at even thickness :—

No. 1. Relative heat-conducting power of various materials used as boiler coverings :—

Mineral wool	100
Hair felt	117
Cotton-wool	122
Sheep's wool	136
Infusorial earth	136
Charcoal	140
Sawdust	163
Gasworks breeze	230
Wood and air space	280

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No. 2. Non-conducting property of various materials at even thickness :—

Black slate	100
Sandstone	71–95
Firebrick	61–70
Asphaltum and soft chalk	45–56
Oak, pine, and wood and plaster	25–66
Sulphate of lime and sand	18–70
Sawdust and tan bark	17–20
Asbestos cemented	18–20
Fine asbestos in thread	13–15
Extra mineral wool, ordinary mineral wool, raw silk	8–13
Ice	0

Recently a very important step in advance in the manufacture of mineral wool was taken by the Western Mineral Wool Company. The production of mineral wool by the method long in vogue, is to utilise the molten slag as taken from a blast furnace in the usual course of furnace work. This plan necessarily depends upon the operation of the blast furnace ; and when, for any reason, the blast furnace fails to supply the molten slag the manufacture of the mineral wool must stop. Another objection is that only a single carload of slag can be done from one run or flush of the furnace, which fact shows that the supply of material is necessarily limited. A third objection is the unevenness of the slag as it comes from the blast furnace. Much of the slag drawn fails entirely to make mineral wool, or results in a product of inferior quality. The suitability of the molten slag can be often only determined by the results of the blowing, and when the operations have been defective it can only be disposed of as waste. Accordingly, the run of the furnace is lost, and time and labour are expended in disposing of the useless slag. Again, the entire slag product of some blast furnace, by reason of the nature of the ore used, is wholly unfit for the manufacture of mineral wool. And a fourth objection is that even where the slag is of correct quality, a large portion of each carload becomes cool before it can be used, and the cool portion is lost. The inventor of the improvement mentioned that, by

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mixing lime or silica, or silica-bearing stone, with the ordinary slag, and fusing the mixture in a cupola, a constant supply of re-melted slag could be obtained from which a mineral wool can be produced of better and more uniform quality than is produced by the slag drawn direct from a blast furnace. In short, the general improved process of manufacture may be thus described. The material is melted in a large vessel, and is drawn off by means of a tap from which it flows in a sluggish stream, and as it comes out, steam under high pressure is blown through it, which has the effect of at once converting it into soft, fleecy clouds, which sink to the ground in accordance with their own weight, and thus offer a natural and simple method of differentiating its various qualities. At the same time, each of the several objections above mentioned is overcome. Whether silica, or lime, or both, shall be used depends entirely upon the nature of the slag. This, he explains, is readily determined by one or two inexpensive trials, and accordingly it is in the power of the manufacturer to arrange this mixture to produce a perfect article at all times. At the works of the Western Mineral Wool Company, Cleveland, Ohio, two cupolas are at present in use. It is found, by trial, that about twelve hours' run can be obtained from a cupola before the lining gives out. With two cupolas working alternately night and day, a continuous run is obtained, and upon this plan the company are at present proceeding. In 1885, the first year of the company's business, 300,000 lbs. of mineral wool were produced and sold. In 1890, no less than 9,000,000 lbs. were manufactured and sold, while for the current year the output will probably, it is said, be considerably greater.

Among the many comparative tests that have been, from time to time, made with the view of determining the most efficient covering for boilers, steampipes, etc., the following may be instanced as authentic and suggestive: —

At the Paris Exhibition of 1878, some experiments were made to determine the relative value of different kinds of pipe-covering materials. The experiments were made by

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MM. Geneste, Herscher, & Co., with twelve vertical steam pipes, all of the same dimensions, and charged simultaneously from one boiler, so that the action of the steam was precisely the same in each case. Some of the tubes were bare, and the others were covered with different non-conducting materials. The following are some of the results arrived at, as published in the "*Moniteur des Fils et Tissus*":—

Description of the covering, or the state of the surface of the pipes.	Thickness of covering.	Pressure of steam absolute.	Temperature of the air around the pipes.	Quantity of water condensed per hour per sq. ft.
	Inches.	lbs.		lbs.
Pipe of polished brass (bare) .	—	54	77·9	0·50
Pipe of galvanised iron (bare) .	—	54	78·2	0·81
Covered with plaited straw .	2·00	54	76·7	0·37
Composition A . . .	1·58	54	77·0	0·41
Composition B . . .	1·58	54	77·3	0·41
Composition C . . .	1·58	54	77·3	0·54
Asbestos	1·38	54	76·0	0·37
Asbestos	3·15	54	77·9	0·31
Silicate cotton . . .	2·36	54	76·7	0·27
Wood	0·71	54	76·7	0·35
Felt	2 thicknesses	54	76 8	0·37

The materials, A, B, and C, representing three approved boiler cements or non-conducting compositions, ranked last, showing a result very little better than that of a bare tube, polished. Taking into consideration its incombustible and indestructible properties, the silicate cotton proved to be by far the most preferable substance as a non-conductor; whilst its cost is much less than asbestos.*

A wrought-iron tank six feet in diameter and twelve feet high containing steam under 354 lbs. pressure, condensed 16 lbs. of steam per hour. Now 146 lbs. of steam represent, at the rate of $7\frac{1}{2}$ lbs. to 1 lb. of coal, the combustion of $19\frac{3}{5}$ lbs. of coal per hour, or 460 lbs. per day of twenty-four hours. Allowing $3.00 per ton for coal $460 \div 2000 \times 300 = 69$, which is the loss

* "The Engineer," March 12th, 1880.

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in cents per day from condensation; in a year of 309 days the loss would be $213.21; the exposed surface of the tank was 225 square feet. Figuring from this data, together with the known value of mineral wool, it may be stated that at a cost of 15 cents per square foot, or $33.75 for the whole job, this tank could be so protected by a covering of mineral wool that the loss would only be 10 per cent. of the above, or, say, $21.32 per year.*

For ordinary fire-proofing purposes the slag wool is enclosed between two thicknesses of galvanised wire-netting, which netting is kept at proper distance apart by loops of wire passing from front to back, and the layer of slag wool of a suitable thickness, (an inch has been found sufficient for any purpose,) is compactly felted between these two sheets of netting. Prepared in this way, very tough, light, and flexible sheets of "silicate cotton wire-net felting" are obtained. It has been found that in the thickness of an inch, one ton of slag wool will cover 1,800 square feet, say 1¼ lb. to the square foot. It is employed, therefore, in this form under joists, instead of pugging, as a lining for corrugated iron buildings, sheds, etc., and for many other structural purposes.

As a non-radiator of heat and cold, it appears to be well adapted as a lining for temporary buildings either in extremely hot or very cold climates. It can also be advantageously employed as a lining for refrigerating chambers. In 1885 Mr. T. B. Lightfoot, C.E., tested it thus: Two blocks of ice, weighing 30 lbs. each, were placed in separate boxes, one of them being surrounded by two inches of slag wool and the other with six inches of charcoal. Three days afterwards these boxes were opened and the unmelted ice weighed: the ice block in the box surrounded by slag wool was then found to weigh 13 lbs., and the other 5½ lbs. only; showing that two inches of slag wool form a better non-conducting lining than six inches of charcoal.

As an insulator it also takes high rank. It is said to be liable to become pulverised, if used on board ship, on account of the

* "The American Engineer," November 19th, 1885.

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incessant vibration and the motion of the vessel at sea. Yet it does not seem to be so objectionable on locomotives, although the vibration in that case is necessarily severe. It has been used for many years by the Chicago, Milwaukee, and St. Paul Railway Company for jacketing locomotives, and the passenger cars of the Pennsylvanian Railway also are lined with it.*

As lubricators, mineral oils are fast replacing animal and vegetable oils in the woollen industry. Their superiority consists in oxidation, and the deposition of resinous substances



English make. ½-inch objective.

being prevented in the staple. The fibrous material, therefore, is unchanged, and they are not liable to saponification, and resist the action of lyes.

It forms also a good filling material, where the object is to prevent the transmission of sound, on account of the vast number of minute air-cells distributed through it, which endow it with astonishing properties as a non-conductor of heat and sound.

The result of practical experiments with slag wool, packed round joists, or employed in a loose state as a backing for fire

* "Canadian Mining Review," vol. i., No. 4.

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grates, shows that the heating power of a fire is greatly enhanced by compelling the radiation from a stove to take an outward direction, and the combustion of the fuel is so thorough when a grate is packed all round with it, that, as soon as the fire gets under weigh, little or no smoke will rise, and, even after burning all day, if the fire be allowed to go out gradually, the residuum of ash will be surprisingly small.

It is now used largely for covering boilers, steam and water pipes. For boiler and pipe coverings slag wool mainly relies,



American make. ½-inch objective.

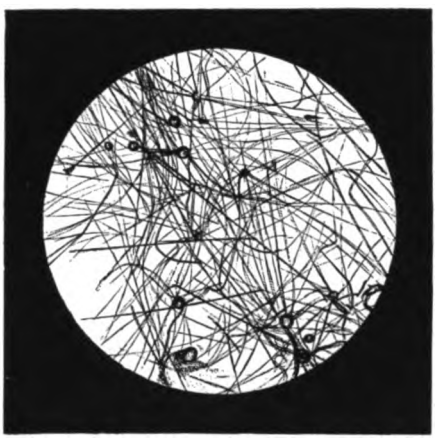
in its competition with asbestos, on its comparative cheapness, and, as asserted by the manufacturers, on the fact of its being a better non-conductor. But, however that may be, its most manifest inferiority in this respect lies in its want of elasticity and lubricity. Even when most carefully prepared it has a harsh, gritty, metallic feel when crushed between the fingers, altogether unlike the soft silkiness and unctuosity of asbestos. The cause of this is at once apparent even on examination with the naked eye, but, when placed under the lens, its sharp, acicular fibres, studded with minute metallic grains or pellicles, are brought out into strong relief, these last being globules or

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pear-shaped drops of basic glass, precisely such as are seen in Pélé's hair, being the points first blown off from the liquid slag. In the two first diagrams these pellicles are exaggerated in size, by manipulation of the fibre, so as to bring out clearly their peculiar form.

From the peculiar formation of the material as it comes from the factory, it is very difficult to obtain a satisfactory microphotograph of it; the fibres being so crushed and closely compacted that it is not practicable to draw out so clear a fibre, as can



No. 1.—Silicate Cotton. Manufactured by Frederick Jones & Co., Kentish Town.

be done with some amount of care with asbestos: but the two following diagrams will give a general idea of the construction.

In No. 1, the brittle, glassy filaments are seen to be exceedingly fine, and the bulbs both small in size and few in number. Owing to the transparency of the filaments this was difficult to photograph; its extreme fineness can be best judged by comparing this with the equally magnified sample of American make; respecting which last, the irregular character of the glassy fibre shows the artificial nature of the wool; the filaments are much coarser and the bulbous ends larger. It is

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quite possible, however, that an injustice has been inadvertently done to the American make by difference of sample, that of No. 1 being a fine, picked specimen, and No. 2 being the ordinary first quality sample, sent over from the works at Cleveland.

Another very important property of slag wool is its power of absorption, which makes it capable of holding water to the extent of its own volume. Thus, when water is pumped into a burning building, instead of running through into the street



No. 2.—Mineral Wool. Manufactured by the Western Mineral Wool Company, Cleveland, Ohio.

and being wasted, as in the case of an ordinary iron and concrete construction, the water is held by the slag wool, as in a vast sponge, and will, owing to the surrounding heat, evolve sufficient steam to extinguish the flames, or at any rate to powerfully assist in so doing.

Being vermin-proof, it is additionally valuable as a lining for wainscots, passages, pantries, dining-rooms, and ceilings; its glass-like fibres causing great irritation to rats and other vermin, as well as such insect pests as may come in contact with it.

It is also said to be antiseptic, and this property, taken in

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Asbestos and Asbestic: Their Properties, Occurrence, and Use (1897)
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conjunction with its great porosity, adapts it to some medical purposes; such as for cholera belts, for use in hot climates, chest protectors, etc. Moreover, these antiseptic qualities can be specially utilised in the construction of hospitals, infirmaries, etc.

There are many other uses which might be enumerated, all tending to show the value of slag wool for certain purposes, and the many points in which it can compete with asbestos. Its main feature, of course, is its comparative cheapness; but it is to be remarked that there is scarcely one point of value cited which does not carry with it a corresponding disadvantage. For instance, when its vermin-proof character is mentioned, the warnings of Percy and Bloxam at once occur to the mind. The former specially cautions his readers that these slag fibres have to be handled with care, because the fine short threads, being very brittle, easily penetrate the skin and cause irritation; and Bloxam says, the fine filaments, being so exceedingly brittle, and the material itself so light, the needle-like particles are liable to become diffused in the air of a room, and pass into the lungs and eyes, and so become the source of serious mischief. *Rock wool* can be made of melted glass, but is chiefly derived from sandstone, and consequently, the fibres being harder and sharper, are the more likely to produce greater injury.

Again, its power of absorbing water is doubtless a valuable quality in case of fire, but it has one corresponding disadvantage, and that a by no means unimportant one, as a boiler and pipe coverer, inasmuch as if a leak should occur, or exterior damp penetrate it, it at once becomes the cause of corrosion. Although water is the primary cause of rusting, the percentage of sulphur contained in the slag becomes dissolved in the water, and, in the form of sulphuric acid, will attack the surfaces, unless they are kept dry by radiated heat. This particular defect, however, is now in some measure overcome by entirely manufacturing the article from non-sulphur-bearing rocks, so as to render it absolutely free from sulphur and its compounds. It is then called *Rock wool*, and although it is more costly than slag wool, the difference in

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weight reduces the cost of transport so much that it is claimed to be rather in favour of the former.

Practically the main objections to its use are its glass-like texture and the grittiness caused by the minute pellicles, which cannot be entirely eliminated, together with its liability to pulverise under vibration, and its water retention.

In its normal condition a cubic foot weighs 12 lbs., and its cost, as applied to steampipes, is 2*d.* per square foot for each inch in thickness.

The Canadian Mineral Wool Company, of Toronto, formed for the manufacture of and dealing in mineral wool, asbestos, etc., was incorporated in 1892, with a capital of $40,000, divided into 400 shares of $100 each.

There are many other uses which might be enumerated, all tending to show the value of slag wool for certain purposes, and the many points in which it can compete with asbestos.

The Patent Fire and Sound Proof Plasterings (W. Hitchins' patents), purchased by Messrs. F. Jones & Co., made in many ingenious ways with a backing of silicate cotton, have proved their value. The same manufacturers furnish a variety of fibrous wire-netting, and fibre-ligneous slabs and compounds, which are rapidly making their way in the estimation of architects, builders, and all others who are desirous (as who are not?) of ensuring perfect immunity in their habitations from damp, for preventing the transmission of sound, and the spread of fire in the case of conflagration. In this plastering, no lathing, lime or hair is required; there is no annoyance from dirt or rubbish, and the walls and ceilings can be painted or decorated the same day that they are put up. Cornices and enrichments, prepared in long lengths, are fixed dry, and buildings thus treated are rendered fit for habitation or decoration at once. The same firm's Salamander compound is composed of silicate cotton and prepared plaster, and when set, this is not only a fire-proof non-conductor, but possesses sufficient elasticity to prevent cracking under even extreme heat.

A cottage residence has been specially designed by Messrs.

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Frederick Jones & Co., to illustrate their method of isolating such a structure, with a view to rendering it at the same time fire, frost, sound, and vermin-proof, perfectly cool in summer and comparatively warm in winter. The ceilings and walls can be fitted with Hitchins' patent fire and sound-proof plaster slabs, which have a lining of slag wool between the plaster and the wall or ceiling. These slabs are made specially to suit the building; they can be of any size and ornamented in any way desired, either by moulding, painting, or gilding; they can be fitted with the greatest ease and simplicity, and without dirt or mess of any kind.

The same firm manufacture patent portable anti-thermal and antiseptic huts, which they claim to be impervious to external climatic influences and to be so constructed that they can be readily put together or taken to pieces by any ordinary workman in a couple of hours. As these huts are not only fire, heat, frost, and sound-proof, but give an entire freedom from insect pests, which wooden houses or huts are especially liable to, they are undoubtedly a great step in advance. Soldiers' huts, gentlemen's fishing boxes, and other buildings of a similar or temporary character can be fitted in a precisely similar way if constructed of wood or other similar material. Apparently this would be a great boon to troops in camp, who, in such huts as these, would enjoy complete immunity from the annoyances caused by the all too friendly disposition of the insect inhabitants of the present huts, whilst they could at the same time depend on a tolerably equable temperature, cooler in summer and warmer in winter, than that offered by any other system at present devised for ordinary camp-dwellings, excepting only the newly discovered Danville asbestic. In the wooden houses of Canada and Norway, it is a common practice to ram in sawdust between the outer timbers and the match-board lining; and although this makes the house undoubtedly warm, it forms a delightful harbourage and breeding ground for all insect pests. In Russia, where things in this respect are much worse, but much less regarded, it

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is almost needless to say that the Government has at once adopted the idea, and it is anticipated that a large order will be at once given for these portable huts for housing the troops in camp.

Soapstone.—This soft magnesian mineral frequently occurs in association with serpentine, and possesses many of the valuable properties of asbestos. Mainly composed of two of the most durable substances known for exposure to fire or atmospheric influences, it is often used in competition with asbestos, or enlisted as a valuable auxiliary, in certain forms of manufacture.

Technically called Steatite (Ger., *Speckstein*), it is also occasionally termed *Synophite*, as being an associate of ophite. The word *Steatitis*, used by Pliny, is the name of a stone resembling fat. Like asbestos, soapstone is a hydrated silicate of magnesia, a more or less pure and compact talc, generally of a grey or greyish-green colour; it occurs in massive form-crystalline, granular, or impalpable, and is very greasy to the touch. Sometimes it is found in a fine granular, or crypto-crystalline form, of a milk-white colour and pearly lustre, soft enough to be used as chalk (*craie de Briançon*); it is then called Venetian or French chalk, and is the substance used by tailors and others for marking cloth and removing grease and other stains.

Analyses of two samples give the following:—

Silica	62·8	63·49
Magnesia	33·5	31·75
Water	3·7	4·76
	100·00	100·00

A little iron is occasionally found replacing magnesia. Sometimes it appears as a pseudomorph, taking the form of apatite as at St. Just in Cornwall; or of arragonite in Bohemia.

Soapstone occurs abundantly in many parts of the world. In the United States and in Canada it can be had in large quantities, and sometimes of remarkably pure quality. Large deposits have been found in several districts in California. In Arkansas a fine quality occurs in Saline County, where it is

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worked by the Arkansas Soapstone Manufacturing Company. The deposits are mixed up here in an unusual way with slates and serpentine, but are considered to be very pure, the general average being about 62 per cent. of silica and 34 of magnesia.

In the Eastern Townships of Quebec it is abundant. The quality is not always good, but a considerable quantity can be had in a comparatively pure state. Deposits exist at East Broughton, Lake Nicolet, Hatley, Potton, and Wolfestown. At the last-named place it is found in a bed from one to two feet thick in black and grey talcose schist; this is mostly pure and occasionally translucent. Excepting at Wolfestown, where a factory has been established for working it, and where slabs of a fine quality can be had, not much use is made of it in Canada. Possibly the high prices now realised for asbestos will cause greater attention to be given to the valuable properties of this refractory mineral.

In England, a company, operating at Newcastle-on-Tyne, imports it in bulk from China, mostly for use in the manufacture of pigments; the peculiarity of the Chinese soapstone consisting in the large proportion of potash it contains, amounting occasionally to as much as 60 per cent.

The following are some of its most important properties, which serve to explain the estimation in which it is held for manufacturing purposes. It is not liable to corrosion, is without expansion or contraction, and is unaffected by moisture, atmospheric influences, or chemical fumes. It will not discolour with age, and is a better radiator than any metal. When pure, and of a hard nature, it may be sawn into slabs, or made into knife-edged bricks, and, being a non-absorbent, may be washed without injurious effect. Its refractory nature naturally adapts it for use as firestones and as a lining for furnaces and fireplaces, especially those designed for anthracite, as well as for the manufacture of crucibles. When highly heated it loses the small proportion of contained water, and then, becoming much harder, assumes a dark-green colour, and is susceptible of a fine polish; in this state it is used by the Chinese for the manufacture of images, especially of their household gods: hence its name of

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figure-stone. The minerals *pagodite* and *lardite** also are simply soapstone. In the churchyard of Lom, in Norway, tombstones are formed of soapstone (*Klæbersten*) in the shape of crosses, encircled with rings.

Possessing unusual powers of withstanding atmospheric and chemical influences, it has long been used, in China and Japan, as a preserving medium for woodwork, and buildings or monuments erected with any stone liable to disintegration, the powdered soapstone being put on in the form of paint.

The causes of rusting in ships are contact with sea water, and the various acids it may contain, atmospheric influences, or electric or galvanic action. The first two can be cured by preventing the sea water and the atmosphere from coming into contact with the steel, but in order to do this, it is necessary to have a paint which will adhere to the fibre of the steel, and while being perfectly air and water tight, will have sufficient elasticity not to crack with the vibration of the vessel or the contraction and expansion of the steel. This elasticity, Mr. Goodall says, may be obtained in steatite by using a suitable varnish to convey it to the steel in the form of paint, which varnish should contain evaporating spirits, combined with a certain proportion of slow-drying oils, in order that the paint may dry and at the same time keep its elasticity. Varnish alone is porous, and admits the atmosphere and moisture to the body coated with it, but when mixed with steatite, owing to the minute atoms of which that mineral is composed, the fine pores are completely closed, and the paint becomes air and water tight. The third cause of rusting is due to electric or galvanic actions. The gums of which varnishes are made are, like steatite, isolators of electricity or galvanism; consequently, if a vessel's iron or steel plates, inside and out, together with all iron or steel attached thereto, are properly coated with steatite paint they are completely isolated, and unable to set up electricity or galvanism from the

* "C'est à la steatite que doivent êtres rapportées une partie des substances pagodite, lardite, etc., avec lesquelles les chinois sculptent des figurines."—De Lapparent, 376.

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atmosphere, sea water, etc., as they certainly will do if coated with paint made from metallic pigments.*

Generally it may be said that it possesses properties which adapt it to a great variety of economical uses. Slabs of it are used as firestones in hearths, stoves, and for register borders and for gas jets. In the manufacture of soap it is used as a filler and as possessing cleansing properties of its own. It is the base of all face and tooth-powders, the cost being scarcely anything, while it can be sold for high prices. It makes dustless crayons, and is far superior to ordinary chalk where a fine line is wanted. It writes readily on glass, and is therefore used by glaziers before cutting with the diamond. It is so absorbent of oil and grease that it is used in powder for extracting stains from silk and woollen goods. It is used in dressing skins and leather in boots, and forms a large percentage of various patent greases. It is used in imitating engraved stones, being easily cut and then hardened by heat, any desired colour being given by metallic solution. It is very largely used as an adulterant, being an inert, harmless material. It is eaten by many savage tribes, and is used in the manufacture of candy. It is also added to flour and pulverised sugar, baking powder, etc., as a make-weight and diluent, doing no more harm, it is said, to the consumer than it does to his pocket-book.

Professor McCandless gives the following as its chemical composition :—

Silica	63·70
Magnesia	33·75
Protoxide of Iron	1·46
Alumina	·42
Moisture	·48
Loss	·19
	100·00

The best Italian tales differ but little from this.

Lapis Ollaris (potstone ; Ger., *Topfstein*) is an impure steatite of a greyish-green colour and slaty structure (*Vide ante*, p. 48).

**Invention*, May 10th, 1890.

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Pyrallolite, very similar to steatite in chemical composition, softness, and refractory properties. It is often met with in the Laurentian series of rocks. In colour, it is generally of a greenish-white, or sea-green, and some varieties, nearly white, have the translucency of porcelain.

Bamboo Fibre.—As a packing, bamboo fibre has certain elastic incompressible properties, in which it is claimed to be without a rival. It is formed into packing for the boxes of the wheels of railway carriages, where it holds oil like a sponge, never hardens, and never wears out.

Infusorial Earth, Earth Meal, Fossil Meal, Kieselghur, is also now much brought into use, either as a composition in conjunction with asbestos, or in competition with it. It is a siliceous mealy earth, composed of the flinty shields or skeletons of infusorial animalculæ; the infusoria found in the mineral called tripoli and in bog iron ore being mostly of vegetable origin.

It is a white, greyish-white, or brown chalk-like earth, which occurs in deposits, often many miles in extent and either uncompacted as a fine earth, or compacted and moderately hard. The infusoria of which it is composed abound in moist earth, in which they have been found alive at sixty feet below the surface, in both fresh and salt water, often covering leagues of the ocean and giving a beautiful tinge to it from their vivid hue, occasioned by the mud, of which they have been brought up from a depth of 1,600 feet; and occasionally under peat. The infusorial beds of Virginia, a vast accumulation of these microscopic organisms, are of tertiary age, and underlie the City of Richmond. A bed also occurs in Monterey, in California, fifty feet in depth. In some parts of northern Germany deposits occur of more than sixty feet thick; the minute organised specks of matter requiring the aid of a microscope, even to discover the fact of their existence, many of them being less than the three-thousandth part of an inch in length, of which it would require thirty-five thousand millions to fill the space of a cubic inch.

Near the mouths of the great rivers which flow into the Baltic Sea large banks, islands, and very broad tracts on the coast are known to be derived from this source.

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In Nova Scotia and New Brunswick it is found in the bottoms of lakes in much greater purity than in Germany or America, and the writer found a deep bed of it near Romaine's Brook, at the Gravels, Port-au-Port, Newfoundland, in which some of the shells mixed with it were of comparatively large size and very perfect, the material here partaking somewhat of the nature of shell marl. It is found also in Scotland, and to a very great extent in Norway, where it forms the beds of a large series of lakes, as also in Hanover and Italy. It is nearly pure silica, being composed in part of the siliceous shells of diatomaceous plants.* Nobel experimented with charcoal, sawdust, brickdust, paper, rags, and many other materials, for the manufacture of dynamite; but finally selected kieselghur as the most suitable material, and this was generally used until wood pulp began to compete with it. It is also formed occasionally from the mineral remainder of a kind of moss which grows in stagnant waters. The stem consists mainly of silica, and when the organic substance of the plant decays, the siliceous part remains, retaining the shape it had as a plant—namely, that of a kind of tube. It contains a little iron, which accounts for the reddish tinge observable in dynamite. These remains are discovered in all climes, and have been found in almost infinite abundance in flint and opal, in the latter of which they encase the solid and translucent interior.

The composition of this fossil earth was first made known by Ehrenberg, who discovered 100 different species of diatoms under the City of Richmond, U.S.A.

A large manufactory is carried on by the company owning the United Kieselguhr mines at Chelle, who claim to be the largest producers of the meal; the English agent is Mr. F. E. Clotten, of 23, Leadenhall Street, London.

The non-conducting qualities of the meal indicate its usefulness for the coverings of boilers and steam pipes, for the isolation of engine-rooms, for protection against heat and cold, for refrigerating-rooms and ice manufactories, for rendering floors, walls, and ceilings fire-proof and rot-proof, as a filling material for

* Spicules of sponges, diatoms, etc.

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use in the manufacture of fire-proof safes, strong rooms, and ice boxes, for the protection in transit of dangerous, explosive, or easily damaged goods, and for a variety of other purposes. It is extensively used in the manufacture of water-glass or soluble silica, and for the coverings of boilers and steam pipes, for polishing powder, and the linings of safes.

It is sold in many forms, such as pure fossil-meal, fossil-meal composition (containing a mixture of asbestos), patent removable fossil-meal plates, specially adapted for isolating engine-rooms and as roofing for use in tropical climates, removable coverings, packing and boiler coverings, and for many other purposes for which asbestos is generally used. As an indication of its value as a boiler and steam pipe covering, it is now used for that purpose on some of the vessels of the Peninsula and Oriental, White Star, Inman, and Orient lines. It is also used in the manufacture of firebricks, and as a polishing powder, and when mixed with nitro-glycerine as an absorbent it makes dynamite; but for this last purpose it is now in a great measure being superseded by wood pulp.

Although dynamite has been in use for some considerable time, inquiries are still often made as to its explosive force, and how best to handle it with safety. Moreover, the users of this explosive, in the asbestos mines, from their carelessness in handling, which grows from familiarity with its use, so often ignore its power that the following information, taken from the *Indian Engineer*, published at Calcutta, may not perhaps be considered out of place :—

Dynamite consists of some porous absorbent mineral saturated with nitro-glycerine. Several substances have been tried as absorbents of the glycerine, but the most satisfactory is the *kieselguhr*, an infusorial earth, composed of the siliceous shells of extremely small vegetable organisms, and it is of this that Nobel's dynamite is made. It absorbs about three times its weight of the glycerine, and resembles putty in appearance. Thus, a given quantity will contain 75 per cent. of the real explosive, and its blasting power compared with pure nitro-glycerine is, of course, represented by the same ratio. In order

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to explode it, it is necessary to obtain the temperature of 360° Fahrenheit. It freezes in the same way as glycerine, and when in this state must be carefully handled. Nitro-glycerine has an expansive force ten times that of an equal weight of powder. It is highly dangerous to place dynamite on or near fire stoves, steam pipes, or any highly heated metal. Dynamite must never be put into warm water to thaw it, as the water would free the nitro-glycerine, when it is most dangerous. It ought always to be put into a water-tight vessel, and then have the vessel put into warm water. It should never be exposed to the direct rays of a tropical sun. When loading it, a wooden rod or squeezer should be used to push home the cartridge, *never a metal one*, and the charge should gently and firmly be pushed down, and not rammed or pounded.

If dynamite has to be loaded into tins, the miner or workman should avoid smelling it, as it gives a sickly, nervous headache for several days. He should also never squeeze the primer containing the detonator, but lower or push it gently till it rests on the charge. For tampings, sand, dry earth, or water should be used; and in the event of a misfire, one should never attempt to draw the tamping. If water tamping has been used, put a fresh primer and detonator on top of the charge. If other than water tamping has been used, bore a fresh hole. The detonator must be very carefully handled, because if one exploded in the hand, the hand would be shattered. When putting in the fuse, cut off the end of it square, and put it in firmly, but gently. Dynamite can be burnt with safety, and simply fizzes up harmlessly. It exercises its force in the direction of most resistance. A single cartridge attached to a rail will break it; a 4 oz. cartridge will break a 35 lb. railway rail in two. The charge varies from a few cartridges to as much as may be necessary.

Dynamite is generally packed up in deal wood boxes containing 50 lbs. Each box contains five separate packages of 10 lbs., and in the package $\frac{1}{2}$ oz. and 2 oz. cartridges are mixed. They are all the same power, but the $\frac{1}{2}$ oz. cartridges are called primers, and used for exploding charges. The detonators are long

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copper caps, filled with a heavy charge of chloride of mercury. They must be kept quite dry, and always separate from the dynamite. These are sold in boxes of two hundred caps. The fuse used is of various sorts. The most useful is the black fuse sold in coils of twenty-four feet, which burns at the rate of a yard a minute.

Asbestonit is a patent compound of asbestos and some other material, manufactured by Messrs. Ladewig & Co.,* of Rathenow. It is a form of millboard recommended for packing, jointing, roofing, and many other purposes for which similar substances are available and useful. The same firm also make an asbestonit sheeting and wire-wove cloth, which is used for a great variety of purposes, including the protection of timber or wooden posts when such are required to be fixed below ground or in water.

Spun Glass.—Mr. Reed, an American citizen, has recently applied this to the insulation of copper wires for electrical purposes. The wire is first wound round with woollen or cotton yarn, twisted slackly, and this is then overlaid with longitudinal strands of spun glass; above which another strand of silk and spun glass is wound in close spiral form, over which is then placed a braid of either cotton, hemp, flax, or silk. The whole covering is then well saturated with paraffin or varnish to exclude damp.

Woodite is a patented article which takes its name from that of the patentee, and not from the substance of which it is composed. It is an elastic rubber compound, said to possess properties which enable it to compete with goods formed of rubber, gutta-percha, leather, etc., owing to its being able to resist the action of heat, oil, steam, and some acids. An asbestos and woodite packing is made to supersede the asbestos packing with india-rubber core, which, under high-pressure steam and heat, has a tendency to become viscous and to lose its elasticity; to obviate which the asbestos woodite packing is formed of asbestos with a woodite core. It is also put forward as a competitor with asbestos for protecting the sides of war-

* *Ante*, page 289.

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ships, and on precisely similar grounds, the inventor claiming that if the blocks of woodite fixed on the sides of war-vessels were to be riddled by projectiles, the only effect would be that the perforations would instantly close up again and prevent the influx of water.*

Whaleite is another form of the same material, in which whalebone cuttings are intermixed with woodite, in order to give it the rough, frictional quality requisite in water-proof mats, floor coverings, etc.

Wood Pulp and terra cotta lumber are also useful non-conductors of heat and sound. The latter is a mixture of clay and sawdust made into the form of bricks. It possesses great lightness, and, being both fire and sound-proof, is well fitted for all interior work, such as division walls. Among the innumerable uses of wood pulp is that, if mixed with colouring matter, it forms an excellent basis for paint suitable for use on metallic surfaces. It can easily be made insoluble and impervious to heat and moisture, and would therefore be of special use on steel ships. A New York journal says that paper pulp is a most useful article, which should be within reach of every householder; and it would certainly seem from the list of virtues with which it is credited that it would be well to be able to obtain it retail. Mixed with glue and plaster of Paris, or Portland cement, it is said to be the best thing to stop cracks and breaks in wood. The pulp should be kept in a closely-stoppered bottle, and thinned to the consistency of thin gruel with hot water just before use, when the plaster or other material is added to bring it into a pasty condition. A water-pipe broken by the frost can be readily mended by wrapping round the fracture with cheese-cloth, and dressing the joint outside the cloth with the pulp compound. When once thoroughly hardened, the strength of this cement is enormous. Sawdust boiled with paper pulp, with glue and linseed-oil added, makes a good fitting for cracks in floors, and there are many other uses for which pulp in some form or other would be found valuable in the household.

* *Army and Navy Gazette*, October, 1886.

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A new industry seems to be foreshadowed in the production of artificial cotton yarn from wood pulp, the finished article imitating the genuine product closely with regard to softness, lustre, and strength. The wood of the spruce, or the pine, is preferred for the purpose, which after being defibrated, is bleached in the usual manner. The product is next treated with a mixture of zinc chloride, castor-oil, gelatine, reduced to strands and rubbed into threads, when it assumes much the appearance of cotton yarn.

A paper on "The Monier System of Construction" was recently read by Mr. Walter Beer, at the Institution of Civil Engineers. The system originated in the attempts of a Parisian florist, named Monier, to obtain large vessels of a material more durable than wood and lighter than concrete. The principle of the system is the combination of Portland cement concrete with iron or steel in such a manner as to develop in the same material the high resistance to compression and binding of the former, and the great tensile strength of the latter. It has been found that in such a combination the good qualities of both materials are retained, and no chemical action occurs between the iron and the moisture in the concrete. The latter adheres firmly to the smooth surface of the metal; and the co-efficients of expansion of the two constituents are, for all practical purposes, identical. The economy of the system in the construction of girders and arches is considerable, owing to the great strength and compactness obtained, and further, the material is absolutely fire-proof. Large spans may be used for floors, and the small amount of headroom required is a factor often of great value. The system can also be used in situations where brick and stone would be impossible. There can be no doubt of the usefulness of this material, though one fails to see in what manner it can equal asbestic.

With **Wood Wool** we have here nothing to do, its manufacture being for sanitary purposes only.

It may, however, be mentioned that a German manufacturer has recently patented a wood fibre for spinning purposes.

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Here the wood is first boiled in a chemical solution, as sulphurous acid or bisulphide of carbon, the fibres being afterwards dried and softened in water, and then subjected to repeated mechanical pinchings.

In addition to the foregoing there are many combinations of asbestos and rubber, and similar compounds, which are used as packings, many of them possessing good qualities of their own, to supplement the main feature of cheapness.

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CHAPTER XII.

Fibre Spinning—Initial Difficulties—Organic and Inorganic Fibres—Powers Employed in their Examination—The Fibre of Wool—Of Cotton—Silk—Spider Web—Radial Thread of a Garden Spider—Spun Glass—Quartz Fibres—Mr. Boys' Experiments—Chrysotile Fibre—Fibres from Thetford Ore Magnified—Various Italian Fibres—Corsican Fibres—Delicacy and Strength of some Mineral Fibres.

The difficulty experienced in the early attempts to spin and weave asbestos fibre was purely structural, and in order the better to explain this we will contrast the peculiar form of some mineral fibres with others of organic origin. These structural differences between organic and inorganic fibres can be at once perceived when such fibres are placed under a lens.

One main difficulty in spinning the asbestos fibres was caused by the want of means of getting them to adhere together. A strand of asbestos fibre is unlike that of any fibre of organic origin, in that it is smooth even beyond that of spun glass, and when perfectly cleared, on being placed under the lens, it is as smooth and rigid as a bar of steel. Nothing but continuous study of the special nature of this, could enable manufacturers to overcome the difficulty. Now, however, they are able to turn out a single thread of so delicate a character that a hundred yards of it shall weigh no more than an ounce, yet still possess comparative tensile strength. For ordinary purposes of examination and comparison, their distinguishing characteristics can be sufficiently well seen with a moderate power, but very high powers are sometimes employed in investigations of a scientific character. Dr. Bowman, for instance, when engaged in the examination of the structural peculiarities of wool fibres

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Asbestos and Asbestic: Their Properties, Occurrence, and Use (1897)
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for his well-known series of lectures on the subject,* occasionally employed powers as high as 8,000 diameters, or such as would magnify 64,000,000 times. A power such as this would give to a single fibre of Leicester wool the appearance of a tube 2,000 feet long and 10 in. in diameter, the dimension of which will be better understood when it is stated that if this represented an actual metal tube, such as a gas main, for instance, its size would be sufficiently large to supply all the gas requirements for a small town.

Wool.—The first fibre selected for examination is a hair of sheep's wool, as this affords the aptest illustration of a spinning or felting fibre. In the cut this is magnified 600 diameters only, that power being amply sufficient to show its peculiar notched or serrated character, or what is technically termed its imbrications,† those irregularly shaped cylindrical scales, or plates, which form its outer structure. These overlap each other after the manner of house tiles, the effect being to give rise to very minute projections all along the surface or line of the fibre, which act like spikes or teeth, and so cause wool fibres to cling together when twisted. The imbrications thus being the cause of the felting property inherent in wool, it follows that the more numerous these imbrications are in the fibre of any particular wool, the more valuable that special variety becomes in the eyes of the manufacturer. In fine Saxon wool there are no less than 2,720 of these imbrications within the length of an inch, in Southdown there are 2,080, whilst in Leicester we find only 1,850. Thus we have no difficulty (other circumstances being identical) in assigning to each variety its relative value for



FIG. 1.
Fibre of Sheep's Wool. Magnified 600 diameters.

* "Lectures on the Structure of Wool Fibres," by Dr. Bowman.

† Deriv.: *imber, imbris*, rain; *imbrex, imbricis*, a roof-tile; *imbrico*, I cover with tiles.

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manufacturing purposes. It must not be forgotten, however, that wool, being a part of the skin of the animal on which it grows, is capable of being modified to a very great extent by change of climate, food, and other surroundings, as well as by judicious breeding; but there can be no doubt that practically we now possess the best breeds of sheep possible both for wool-producing and food-producing purposes.*

Cotton.—In cotton, the fibres become twisted during its growth, and although not so strong as linen or silk, its irregular surfaces adapt it for being spun into a strong yarn, from which all cotton fabrics are made. Its peculiarity as a fibre has been thus described by Mr. Thompson :†—"The filaments of "cotton are transparent glassy tubes, "flattened and twisted round their "own axis. A section of the filament "resembles a figure of **8**, the tube, "originally cylindrical, having col-"lapsed most in the middle, forming "semi-tubes on each side, which give "to the fibre when viewed in certain "lights the appearance of a flat ribbon "with a hem or border on each side. "The twisted and corkscrew form of "the filament of cotton distinguishes "it from all other vegetable fibres."

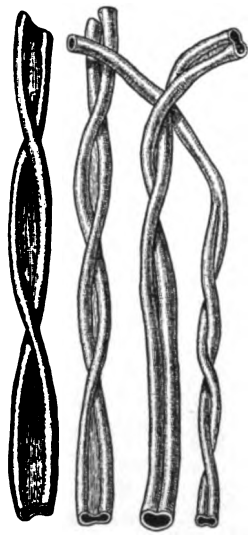


FIG. 2.
Filaments of Raw Cotton.

When it is important to know from what material a fabric has been constructed, it can sometimes only be discovered by the use of a microscope. It was by this means that the discovery was made that the cere-cloths in which the Egyptian mummies are wrapped were made of linen, the Peruvians alone using cotton for this purpose. Much has been said about the "parallelism" of cotton fibre in

* Dr. Bowman's "Lectures," *ubi supra.*

† James Thompson, Esq., F.R.S., on "Mummy Cloths."

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manufactured goods, but if a bit of one of the best grades of cotton cloth be examined under the lens, it will be seen that there is no such thing as parallelism among them. In a lecture on cotton fibres delivered before the Franklin Institute, Mr. Thomas Gray, Jun., suggested that the usual method of determining the quality of cotton fibre, by feeling it with the fingers, was an exceedingly crude one, inasmuch as these fibres vary from $\frac{1}{9000}$ of an inch in thickness for the coarsest "upland" quality, to $\frac{1}{20000}$ for the best sea island.* The finest cotton raised from any of the cotton fields of the world comes from the Mississippi delta. Under the microscope this presents a beautiful structure and a perfect development; it is seen to be full of oil deposit, and has nearly 400 spirals to an inch. The form of the spiral is seen on p. 335.



Fig. 3. Fibre of Raw Silk.

The actual length of the fibres shown in the drawing was $\frac{1}{100}$ of an inch; the thickness of cotton fibres varies from $\frac{1}{800}$ to $\frac{1}{86000}$ of an inch. There are from 300 to 800 twists of the cylindrical tubes in an inch in length of cotton fibre.

Silk.—Then if a fibre of silk be drawn out from the cocoon, we shall see (Fig. 3) that the construction of silk is entirely different. Whilst not of a perfect smoothness, it is in no sense imbricated or twisted spirally; consequently although the fibre of the silkworm lends itself readily enough to the spinning process, it cannot be felted unless mixed with some foreign material. The fibre of silk is, in reality, nothing more than a slender rod of consolidated flexible gum, secreted from a pair of long tubes which end in a pore of the underlip of the silkworm; which explains the peculiar appearance of the silk fibre when examined under the lens. Each thread of silk is then seen to be composed of two separate filaments. These issue from the pores, and are cemented together longitudinally by the secretion from a small gland

* "Popular Science Monthly" (New York), vol. xxxvi., No. 4.

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situated near the pores, the quality of the silk being dependent on the character and difference of the two secretions. The form of the fibre, as disclosed by the microscope, shows no sign whatever of structural markings; on the contrary, it bears some resemblance to a polished metal rod, the line of junction being made perceptible by a slight groove, which gives it the appearance of two somewhat irregular lines, longitudinally attached together by the glutinous matter; each of the lines being about the two-thousandth part of an inch in diameter.

The enormous comparative tensile strength possessed by silk fibre was shown by Mr. C. V. Boys, in a paper read by him at the Royal Institution in June, 1889,* in which he states that, when the two filaments had been separated and washed, they were each capable of sustaining a weight of 60 grains before breaking, and each could be safely loaded with 15 grains; the carrying power, therefore, being equivalent to from 10 to 20 tons per square inch. Consequently, when we read of the successful manufacture of artificial silk, which rivals the natural product in lustre, elasticity and touch, while only costing a quarter of the price, we are now quite prepared to hear the addendum, "but it is not so strong."

Some few weeks ago, I copied from a paper, the name of which I have lost, an account of the very remarkable discovery of the means whereby silk is produced artificially, so that it may equal the natural product in every essential particular. Consequently, I looked particularly to the question of strength, without finding any remark at all on that point.

I reproduce my notes, so far as I can read them, on account of their great interest, and so far as I have been able to decipher them, they read as follows:—

Count Hilaire de Chardonnet, of the Polytechnic School, is the inventor, and his process is a triumph. It is the result of a patent of ingenious mechanical contrivances, by means of which Nature's methods are so closely copied that, from a substance so refractory as wood, a silk is made, which excels the product of the worm. In the natural process, the silkworm

* "Quartz Fibres," by Mr. C. V. Boys, F.R.S.

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goes to the leaf, in the artificial, the operator goes to the tree, both of them in search of cellulose. When once this is metamorphosed into collodion, the process is said to be easy.

In the processes of spinning and twisting, the artificial silk has a manifest advantage, because it can be spun to any desired thickness. It is exquisitely soft to the touch, and as a material for underwear must meet with unusual approval.

The silk obtained from the cocoons collected in the woods and forests cannot be compared with that produced artificially by the new process. The outer part is exposed to dirt, is deteriorated by exposure, and has no uniformity of texture. In fine weather, the coat of the wild silkworm is thin, in cold weather it is thick, and in wet weather flat.

Three or four years ago, Dr. Lehner's process for manufacturing silk was tested at Bradford. The foundation is waste cotton, jute, or similar material, which is treated with a mixture of sulphuric and nitric acid, so as to form a kind of liquid collodion. The liquid is then formed into threads by being forced into glass tubes with extremely small outlets, and the thread then wound upon bobbins. It is afterwards rendered uninflammable, and then it very closely resembles the real article.

At Nicosia, in Cyprus, a sericultural school is now opened for gratuitous teaching. No climate in the world is believed to be better adapted than that of Cyprus for this purpose, whence come the largest and finest cocoons ever seen; but the industry suffered from ignorance and neglect, until this school was established for its revival. Sericulture also constitutes one of the oldest industries of Japan, where its authentic history dates back to the early part of the third century, when silk fabrics were extensively employed for the payment of taxes.

Spider's Web.—Now, if we turn to the somewhat analogous case of the delicate radial thread of the common garden spider, which in its gossamer fineness is of so slender a quality as frequently to be invisible to the naked eye until washed

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with dew or exposed by a shower, we shall be better able to understand how this great tensile strength is obtained. The filamentary secretions exist in the spider's body in a semi-fluid state, and are secreted by glands which end in four or six teat-like organs called spinnerets, minute conical projections situated near the abdomen of the insect, towards the posterior end where, when at rest, they present a bluntly conical appearance. Each of these is composed of a multitude of fine hair-like tubes opening at the top of the spinneret, which thus forms the spinning apparatus. The narrow space which intervenes between the basis of the anterior spinnerets is filled by a tongue-like process. The silky matter or secretion, so long as it remains in the spider's body, is in a semi-fluid state, and issues thence by a sieve-like apparatus; each sieve, according to Bonnet, containing more than 1,000 punctured holes. When the filaments are projected from these holes, they agglutinate together in such a manner, that each thread is composed of from 4,000 to 6,000 fibres, but yet is of so slender a character that, according to Leuwenhoek, it would take 4,000,000 of them to make a thread as thick as a hair from a man's beard; the thread holes being so fine and so crowded together that 1,000 of them would be covered by the point of a needle; but after the thread is woven, Meckel could not recognise it as consisting of more than eight to ten strands. When this silky fluid is exposed to the air it congeals rapidly, becoming of a tenacious consistence, and is then capable of being drawn out into a fine thread. This will be better understood by thrusting a piece of stick into a glue-pot and drawing it out again, when it will be seen that the adhering glue, so long as it retains sufficient heat, will remain fluid, but no sooner does it cool than it will harden, and then it can be drawn out



FIG. 4.
Radial Thread of Garden Spider.

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into a fine hairlike thread, precisely as is sometimes the case with sealing-wax. The single threads, therefore, with which the spinning is accomplished are, in reality, each of them composed of a multitude of strands issuing from the spinnerets and consolidated into a single fibre; so that actually the fine, gossamer thread, which has become typical of the utmost tenuity, is composed of a vast number of different threads invisible to the naked eye, and even when magnified, as we see it in Fig. 4, representing only a single line.* A rope of many strands will have fewer flaws than a solid rope of the same thickness, and is therefore much stronger. Enormous strength in the fibre is necessary, as not only must the orb web be able to sustain the weight of the evening dews but also of summer showers, which occasionally fall heavily, and are also sometimes driven before a strong wind. Indeed, as a matter of fact, silk is, size for size, stronger than a bar of steel. An ordinary spider's thread is capable of sustaining a weight of three grains, while a steel thread of the same thickness will not quite bear two. A celebrated microscopist has estimated that the threads of the minutest spiders, some of which are not larger than a grain of sand, are so fine that four millions of them would not equal in thickness one of the hairs of his beard.

An interesting example of the use of the spider web by scientists, is the following: Professor Mitchell, wanting a clock to record its beat telegraphically as well as to perform in a perfect manner its work as a timekeeper, found the required makes and breaks in the battery could be effected by means of a cross of delicate wire and a mercury cup, the difficulty arising of procuring a fibre sufficiently minute and elastic to constitute the physical union between the top stem of the cross and the clock pendulum. A fine human hair was found to be too coarse and stiff, and, after many fruitless attempts, the assistance of a spider was invoked, and his web, perfectly elastic and pliable, proved to be exactly what was required.†

It may be within remembrance that the Creoles of the

* C. V. Boys, *ubi supra*. Wilson's "Science Jottings."

† "Popular Science Monthly," May, 1890.

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Mauritius presented to the Empress Eugenie a pair of mittens made of the Madagascar spiders' threads, which were so fine that they could be scarcely seen when on her hands, being almost transparent and nearly colourless. A French naturalist has recently ascertained that the Madagascar spider produces at the beginning of its work more than 100 yards of thread per hour, increasing in quantity until it produces more than



FIG. 5.—Spun Glass.



FIG. 6.—Quartz Fibre.

150 yards per hour. A newly-constructed little machine which winds the thread on bobbins automatically immediately from the spider is to be employed in Madagascar. The spiders themselves are to be raised systematically in enormous numbers, and although the fabrics made from the new material may be stupendously costly at first, it is not unlikely that the present generation will live to see dresses made of spider web.

Now, if we turn to inorganic fibres, it is well known that

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physicists, in their endeavour to find a really delicate torsion thread, have usually turned their attention to spun glass, which is about the thousandth part of an inch in diameter, and would appear to be an ideal torsion thread, its great strength enabling it to carry heavier loads than would be expected of it; but Mr. Boys confesses that he used it only to be disappointed—although apparently possessing every good quality, it is deficient in the important one of elasticity. So great had been his difficulty in finding a fine torsion thread that the attempt had practically been given up, and in all the more exact instruments he had been compelled to use silk. The torsion of silk, however, though exceedingly small, he found to be quite sufficient to upset the working of any delicate instrument, for the simple reason that it is never constant; at one time the fibre twists in one way and at another in another, this evil effect being only capable of mitigation by using large apparatus in which strong forces are developed, the result usually being that the smallness, the length of period, and therefore delicacy, of the instruments at the physicist's disposal had, until lately, been simply limited to this behaviour of silk. When, therefore, Mr. Boys was engaged in making some improvements in an instrument for measuring radiant heat, his experiment came to a deadlock; he would not use silk, and could find nothing else. Spun glass being far too coarse and a thousand times too stiff, he was driven to try by experiment to find a new material, and he explains in the paper from which we are quoting, how he managed to draw out fibres from a fine rod of quartz which had been melted and drawn out in the oxyhydrogen jet. In this way he produced threads of great length, of almost any degree of fineness, of extraordinary uniformity, and of enormous strength. One fibre, of the five-thousandth part of an inch in diameter, he had in constant use in an instrument loaded with about thirty grains. It had a section of only one-sixth of a single line of silk, and was just as strong, while, not being organic, it was in no way affected by changes of moisture or temperature. The piece he used in the instrument was about sixteen inches long, and had it been necessary for him, he says, to have used

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spun glass, which was generally considered to be the finest torsion material known, he would have required, instead of sixteen inches, a piece about 1,000 feet long, and an instrument as high as the Eiffel Tower to put it in.

Turning now to the fibre of asbestos, after repeatedly subjecting some of them, especially those of chrysotile, to tests under high powers, which satisfied me of the nature of their



No. 1.—Thetford Ore.

structural form, I got some micro-photographs of fibres magnified in such a way as would best show their peculiar structure. In those marked Nos. 1 and 2 (Thetford ore) we see a few fibres from a piece of ore, brought by myself from the Johnson Mine.

The first attempts were scarcely satisfactory, considerable difficulty being experienced in drawing out a couple of clean fibres entirely free from fluffiness. This would seem a very simple matter, and, judging by the naked eye, one easily accomplished; but when looked at under the lens, the fluffiness is quickly apparent, and a couple of clean fibres seem as hard

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to get as they are difficult to place in parallel lines when ultimately obtained.

When this difficulty was overcome the clear, rod-like, metallic nature of the fibre as seen under the lens at once explained the stubborn obstinacy with which it had so long resisted all attempts to subject it to the spinning or weaving process. Under the microscope this fibre shows up as clear and distinct as a polished steel rod, and in the photograph the rounded glass-like nature of it is distinctly seen; but, in the coarseness



No. 2.—Thetford Ore.

of wood engraving the beauty of the fibre is entirely lost, though the practical idea is conveyed. No. 1 shows the formation distinctly. In Nos. 2 and 3, although the objective is somewhat crowded and the fibre not so clearly drawn out, its composite character, and the constant rounding off, or "silking out," of still more minute filaments from what appears to the naked eye to be but a single line, is very plainly shown. Some of the fibres, on examination, seem to show long cylindrical cavities, but on closer inspection these seeming cavities are found to be merely the interstices between the minute longi-

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tudinal filaments, as will be better seen in the fibre of the Italian varieties which follow.

These fibres are of great beauty; when drawn out as finely as it is possible to do with the fingers, their extreme tenuity can be best realised by comparing them with some of the coarser kinds. Under the lens they look like glass or steel rods of the most precise and regular form, and in these also their compound nature can be seen from the exquisitely fine lines slightly separated from the thicker fibre. The flossy are more



No. 3.—Thetford Ore.

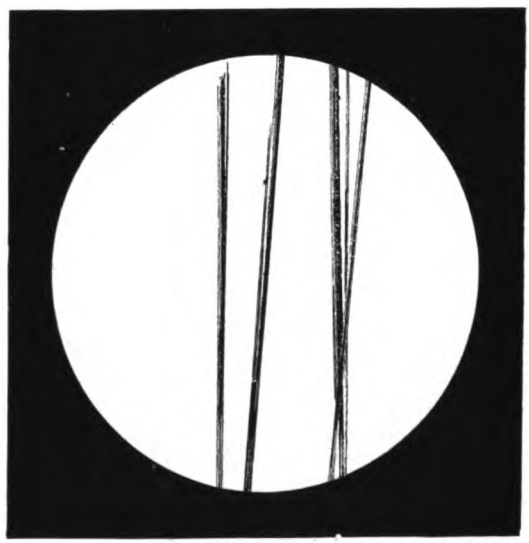
unctuous to the touch than the silky, and although not so brilliantly beautiful as the latter, are exceedingly soft and ductile. The nature of the asbestos fibre is thus so far identical in structure with the organic fibres already considered, that each apparently single fibre is actually composed of other still finer lines, ranged side by side, and these more minute fibres can be distinctly seen to be composed of other yet finer lines, when higher powers are used. So beautifully clear and fine are these lines when carefully drawn out that, at the suggestion of Professor Wallace, Mr. Troughton successfully employed

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them for micrometrical purposes, fibres of $\frac{1}{3000}$ of an inch in diameter giving an even line, and being considerably opaque.

The single fibre would not appear to possess any great degree of strength; but, in its natural form of a combination of fibres, its comparative tensile strength is in reality, like that of silk, very great indeed, the cause of which is easily understood. But in whatever manner the fibre is examined,



Italian "Silky" Fibre.

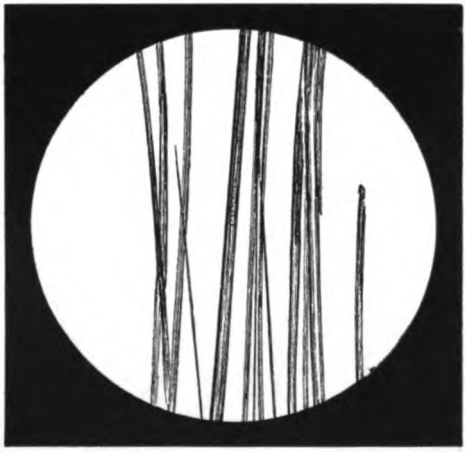
its rod-like smoothness of surface, and total absence of imbrications, irregularities, or twisting, at once explains the difficulty first experienced in spinning it, without the accompaniment of some foreign substance, such as a fine thread of flax, to give it the necessary clinging power. Under polarised light there would seem to be some slight approach to knots or irregularities, but it is quite clear that, even if these in any way detract from its smoothness, they in reality add little, if anything at all, to its spinning qualifications.

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The Italian "grey" variety, as seen on page 354, is a coarser and altogether different fibre from any of the preceding. This was, no doubt, the kind selected by Madame Perpenti for her experiments in the manufacture of paper, cloth, and lace, as mentioned in page 14 *ante*.

The fibres of the fine quality of Corsican asbestos, magnified like the foregoing, have a far more rod-like structure even than chrysotile, and look considerably more like spun glass, which,



Italian "Flossy."

in fact, they nearly resemble in appearance; consequently they are very little adapted for spinning, though excellently fitted for interlacement so as to lead up the flame in gas stove fires. The colour is of a soft, delicate brown, shading off to a pearly white. The coarser quality is of a greenish-white colour, and consists of bundles of shortish twists of fibres, which have a soft and greasy feel and a fair amount of tenacity.

The South African variety, from Griqualand West, although beautiful to the eye, and not at all unlike the Italian "flossy," exhibits a coarse and irregular appearance under the lens. The ultimate fibres in this also are of extreme tenuity.

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In the neighbourhood of Queenstown, South Africa, there exists a wild plant which grows in profusion, the seed vessels of which are surrounded by a profusion of fibre of extreme delicacy, beautifully soft and silky, and of some tenacity. The name of the plant I am unacquainted with; it was sent to me from the Vaal River, and is quite strange enough and suggestive enough to form another of Africa's "surprises."

Before leaving this interesting subject it may be worth



Italian "Grey."

while to note an extreme illustration of the delicacy to which mineral fibres can be drawn out, which was shown by Mr. C. V. Boys, in the paper referred to. Making mention of some quartz fibres which he had drawn out to the millionth part of an inch in diameter, he says, these were of course invisible to the naked eye, but he had in actual use for some time a fibre of the ten thousandth part of an inch in diameter, and in this he found the torsion to be 10,000 times less than that of spun glass. These fibres, moreover, were wonderfully uniform in diameter, so uniform, indeed, that the spectrum from end

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to end consisted of parallel bands, whilst a spider line is so irregular that these bands are hardly observable.

And in regard to strength, it appears that as the quartz fibres become finer, their relative strength proportionately increases, and actually surpasses that of bar steel, reaching in engineering language as high a figure as eighty tons to the inch, fibres of ordinary size having this strength.

And as the figures of length given can only be realised with



Corsican Fibre.

difficulty, Mr. Boys illustrates his meaning by saying that a piece of quartz an inch long and an inch in diameter, if drawn out to the degree of fineness alluded to above would be sufficient to go all round the world 658 times, while a grain of sand just visible—say the hundredth part of an inch long and an hundredth in diameter—would make a thousand miles of such a thread.*

Having now drawn to a close the description of the very curious and valuable mineral *asbestos*, with which the foregoing pages have been mainly concerned, and shown the nature and

* "Jour. Soc. Arts," June, 1889.

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some of the properties of the newly discovered *asbestic*, the writer has, for the present, concluded his task. It only remains for him to say that; although since the date of the first edition of this book asbestos has wonderfully grown in public estimation, and the discovery of asbestic is as yet too new for its merits to be thoroughly tested, or its practical utility sufficiently appreciated; yet he trusts that his endeavours to promote the object he has had in view in writing the foregoing account of them, that is, to give as clear an explanation as was possible of both minerals, and of their manifold uses, so far as is yet known, will help to make them still better known and even more widely appreciated.

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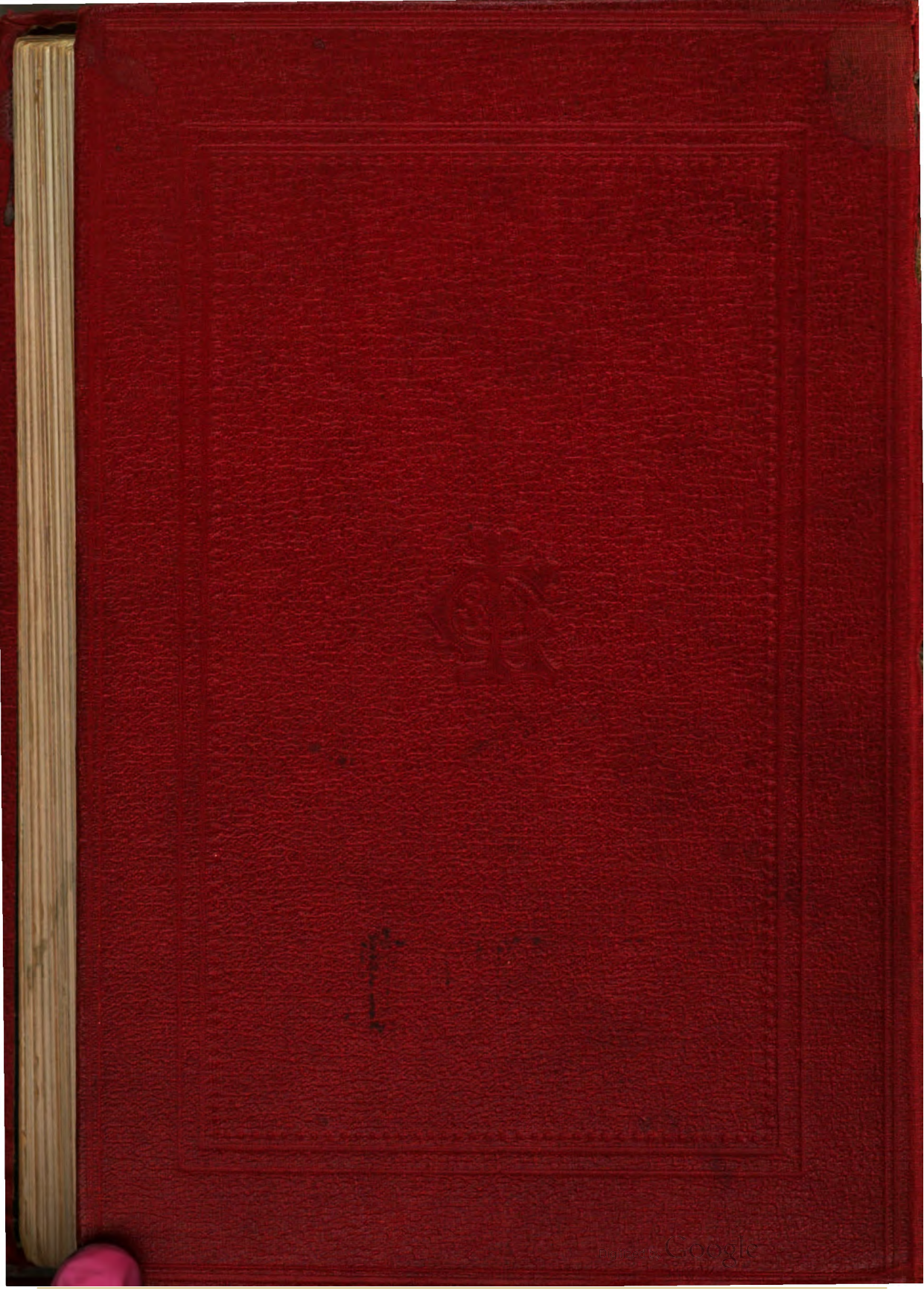
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