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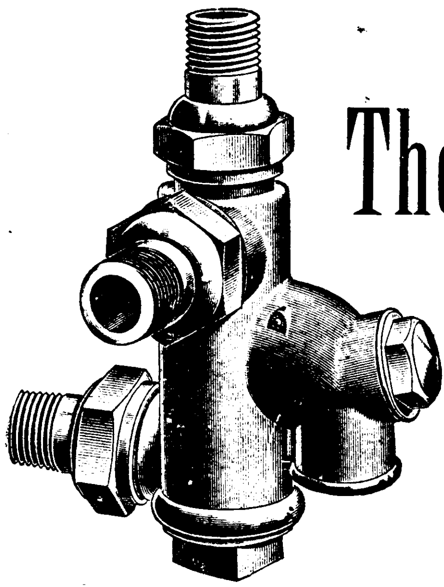
Established 1882

Vol. XI.—No. 8. 1892—OTTAWA, AUGUST—1892. Vol. XI.—No. 8.



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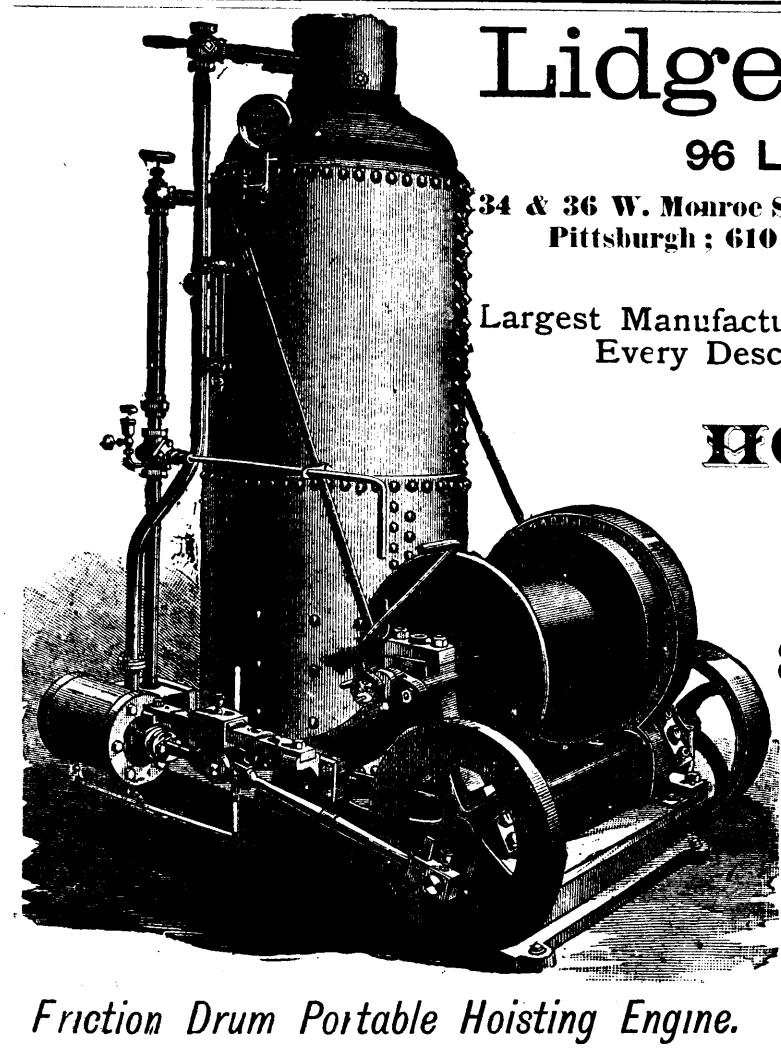

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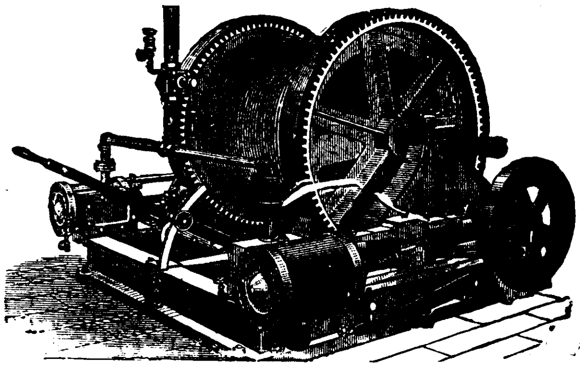

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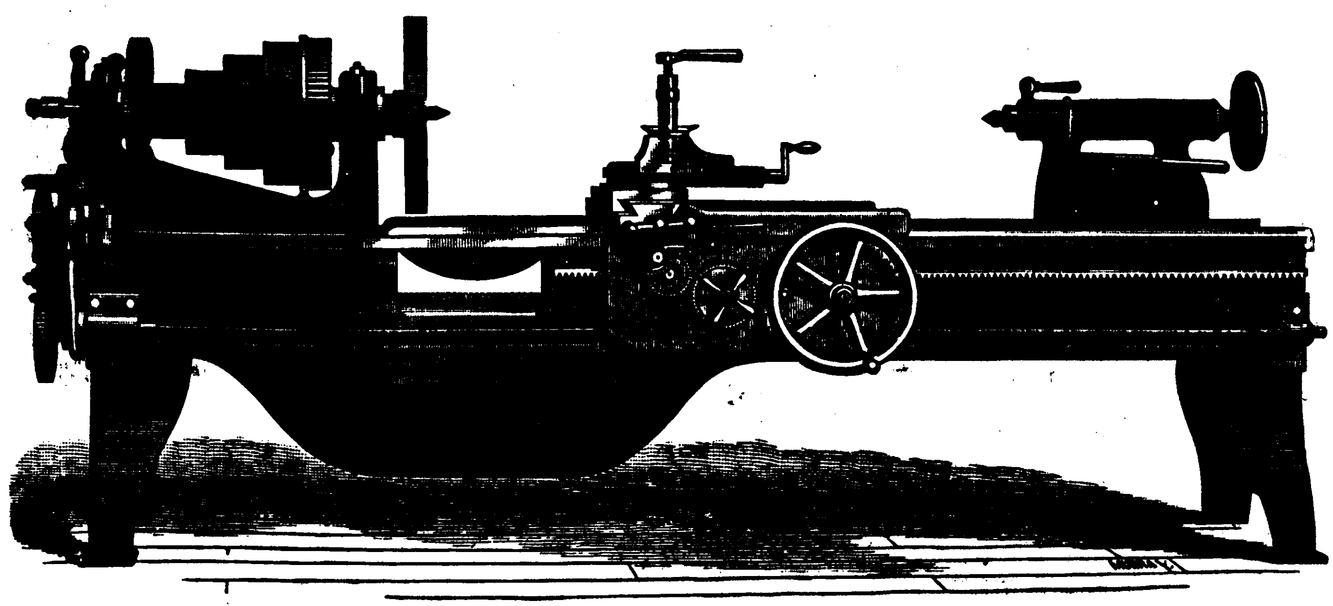

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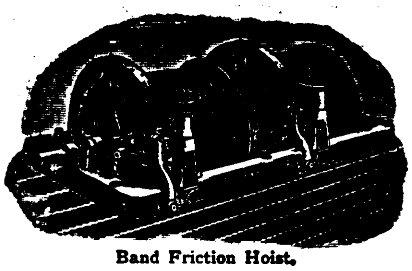

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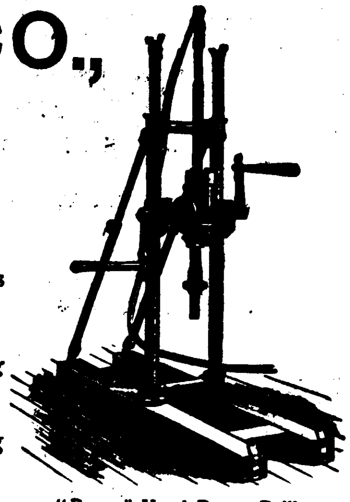

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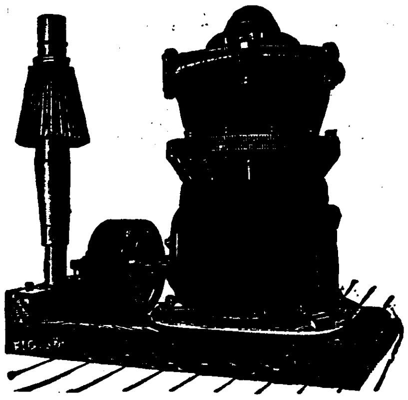

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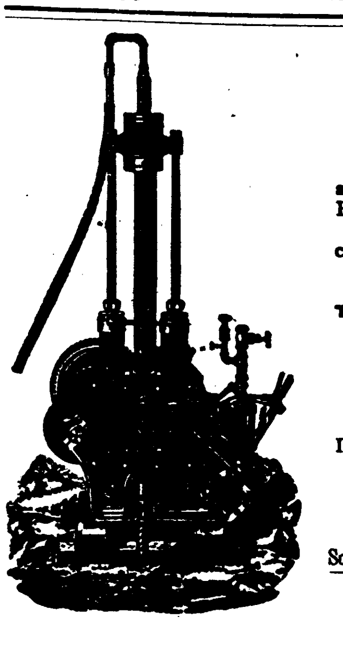

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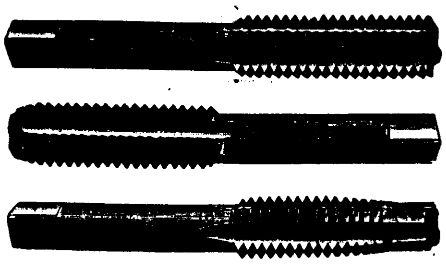

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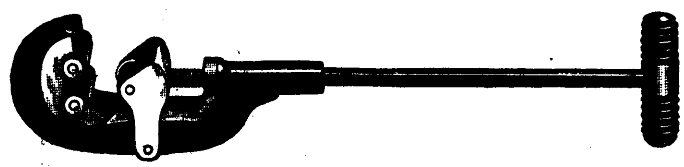

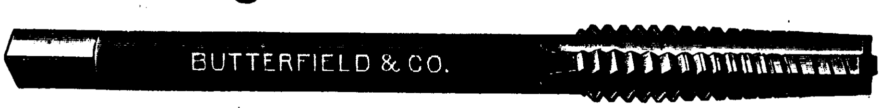

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"At the annual meeting of the Gold Miners' Association of Nova Scotia, held at Halifax on 6th March, 1889, THE CANADIAN MINING REVIEW was adopted the official organ of this Association.
(Signed), B. C. WILSON, *President.*
G. J. PARTINGTON, *Secretary.*

The Mining Society of Nova Scotia.

"Moved by Mr. R. G. Leckie, seconded by Mr. C. A. Dimock, That the thanks of the Society be tendered to Mr. B. T. A. Bell for his kind offer placing the columns of THE REVIEW at the disposal of the Society; and that THE CANADIAN MINING REVIEW is hereby appointed the official organ of the Society."
(Signed), H. S. POOLE, *President,*
H. M. WYLDE, *Secretary.*

The Asbestos Club, (Quebec.)

"Resolved: That THE CANADIAN MINING REVIEW is, by authority of the Members and Council, hereby appointed the official organ of the Asbestos Club."
(Signed), D. A. BROWN, *President*
A. M. EVANS, *Secretary.*

The General Mining Association of the Province of Quebec.

At a meeting of Council held at Montreal on Friday, 6th May, 1891, it was moved by Captain Adams, seconded by Mr. R. T. Hopper, and resolved: That THE CANADIAN MINING REVIEW be the official organ of the Association.
(Signed), GEORGE IRVINE, *President.*
B. T. A. BELL, *Secretary.*"

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Would Reciprocity in Coal be Beneficial?

A pamphlet has recently appeared entitled "Reciprocal Coal with Canada would give the New England States Cheaper Fuel. By D. J Kennelly, Reciprocationist." Mr. Kennelly is a well known gentleman in Cape Breton, who is stated in the report of the Department of Mines, Nova Scotia, for 1890, to be "agent and manager of the Sydney and Louisburg Coal and R. R. Co., Ltd." He is fairly entitled therefore to be acknowledged an authority on the cost of Cape Breton coal, and fully competent to give figures bearing on the charges of delivery to present and prospective markets. His object in writing the pamphlet seems to be to prove that Cape Breton coal can be delivered in Boston—in view of the adoption of recent improvements in the means of transporting and handling of coal—at less cost to the consumer than he is at present supplied by the home producer of coal, and this cost is *inclusive* of the present duty, 75 cents per ton, on Nova Scotia coal. This is undoubtedly a very important assertion, and one which cannot but be highly gratifying to the coal operators generally of Cape Breton; for it may be fairly assumed that the circumstances of mining, position, quality of coal, etc., are not so diverse as to exclude any of the mines from participating in the advantages of a largely consuming and doubtless profitable market; this last, but most important item, *profit*, being, we may rest assured, a not forgotten factor in Mr. Kennelly's statement of price of Cape Breton coal F.O.B.

With some adroitness, Mr. Kennelly places in comparison, the cost of Cumberland coal, shipped at Baltimore and Philadelphia, and delivered at Boston in 1890; and establishes by his figures an advantage to the consumer of 67 cents per ton in favor of Cape Breton coal. This, too, it must be remembered, is *inclusive* of the duty of 75 cents per ton.

Two most interesting inquiries arise in connection with this statement of Mr. Kennelly's. One is of a practical character, viz: have any of the coal merchants or consumers of coal in Boston and adjoining localities availed themselves of the opportunity of saving 67 cents per ton? The other is in the sphere of politics, and presents itself in this form: if Cape Breton coal can be delivered in Boston at the price stated and with the saving named to the consumer, surely the latter can afford to pay the duty, and why therefore should the United States government remove it? It is an advantage all round—the consumer saves money, and the government earns a revenue that would be of an increasing character as the Nova Scotia imports increased, which they may be surely expected to do under such favorable circumstances as are represented.

With respect to the first of these queries, we have to confess to our having received a chill in making enquiry in the States as well as Cape Breton, and being unable to learn of the existence of any boom in the coal trade in the direction reported. We would be pleased indeed to have the knowledge and the opportunity to disseminate it, that Nova Scotia, nay we will say, that Cape Breton coal only, had forced itself by intrinsic merit, and the accompanying favorable circumstances, on the wants of New England, and become firmly established as the cheap fuel of that part of the States.

In regard to the second query, it has a very important bearing on the protection policy of both Governments—the United State and the Dominion. Assume a mutual abandonment of duty on coal, this would doubtless be, in the circumstances named, a great boon to the American consumer of Nova Scotia coal, for, according to Mr. Kennelly's figures, the total saving to the consumer would in that case be 67c. + 75c. (the duty) = $1.42 in favor of Cape Breton coal.

Is this not too good to be true? Is it a realizable result in the coal trade of Nova Scotia? We do not question the accuracy of Mr. Kennelly's figures; we are pleased to note the details of charges, evidencing care in making the statement of cost of Cape Breton coal, but we cannot fling aside the lasting fear in our mind that there must be something more than cost that affects the question and operates to the disadvantage of the Nova Scotia coal operator, and is a set off against the saving in price adduced by Mr. Kennelly. Is this at present unknown term in the equation of more or less value than the duty of 75c? Would the removal of the duty throw the balance of gain in favour of Nova Scotia coal? We pause for a reply.

Dobson and the "Critic."

The Halifax *Critic* most ungraciously and in very bad humour owns up at last to having boomed a first-class fraud. In its issue of 5th instant it refers to C. M. Dobson thus: "Mr. Dobson did promise to send the *Critic* a full defence of the charges, but when it arrived we found that he admitted having made use of the A.R.S.M. without being entitled to it, and as we consider this an unpardonable offence in a professional man, we concluded to drop the matter . . . but we now, while giving publicity to his defence, desire to recall any complimentary remarks we may have made in regard to him." Then follows a long and characteristically brassy effusion from the pen of the notorious Charles Miles De Tracey himself, from which in the opening sentences we quote:

"He accuses me of having used the A. R. S. M. degree, and I may say and do say, as much *as I regret it and* have regretted it, that while a very young man, scarcely more than a boy in fact, I was indiscreet enough to claim the same and print it *on a card* at the time, certainly not realizing the gravity of the indiscretion and how it might react upon me in after years. It was against all the ethics of a scientific man to do so. I regret it, I have regretted it, but does this one error of a young man's life occasion such articles or justify such articles as were published at Ottawa. I find now, *five years after*, that my stupidity has been stored away against me, and at the brightest time of my life "sprung" in the public press, with all the venom and maliciousness that jealousy and professional hatred could conjure, coupled with outrageous libels full of glittering generalities, no specific charges, but on general principles, for which, please God, I will hold the writer sooner or later legally or physically responsible, and be thankful the laws of the United States are so broad and just in cases of this description."

A youthful indiscretion indeed! Yet in 1886-7-8, only four years ago, when parading the A.R.S.M., he advertises to the world that he has had no less than

"Ten years PRACTICAL experience at the largest Galena mines in Great Britain (Foxdale, Isle of Man), and on the South and West African Gold mines—Lisbon-Berlin (Gold), Kimberley (Diamond), and Gold Coast (Gold) mines—and on Canadian Phosphate and Mica mines."

(*Vide* his card in April issue.)

To this glittering repertory our Annanias now adds (*vide* the *Critic*):

"Experience in Canada, 1886, '87, '88, including the Sudbury and Marmora mines; opened and explored the magnetic deposits of N. E. Georgia successfully, 1889; Experience at the St. Genevieve Copper mines, Missouri, 1889; Cuba copper mines 1889; appointed Superintendent Rico Colorado Metallurgical Reduction works, San Juan, Colorado, 1890 (wet and dry crushing and leaching), condemned them owing to R. R. coming in; experience in the Leavenworth mine, Central City, Colorado, 1890; General Supt. Coal Hill and Spadra coal mines, capacity 400 tons daily; 200 men employed: Choiean air machines, pillar and breast workings, product to the Missouri Pacific R. R. 1890. Resigned after breaking through successfully into old workings with 40 acres of water above us. Reason for resigning couldn't agree with owner's brother. Experience on the San Sebastian mines, Salvador, Central America, 1891; Experience in Manganese; Virginia, 1891; Georgia, Whitefield Co., 1888; Etowah, 1889; New Brunswick, 1892; Nova Scotia, 1892, gold. Nickel silicates, Oregon, 1892; California gold, 1892; Mexico, 1890; lead and zinc mines of S. W. Missouri, 1892."

And it is with such self-evident rubbish the *Critic* fills up space!

One can best appreciate all this brazen-faced parade of vagary when it is remembered that beyond some crude prospecting and miscellaneous reporting, Dobson's mining experience in Canada during the years 1886-7-8 was absolutely nil; neither in the Maritime Provinces nor in Upper Canada has he ever been engaged in any mining operation worthy of the name. He denies having carried falsified credentials from John Taylor & Sons. Again we repeat he deliberately states an untruth. These forged letters *we read* in 1886, and the statements contained therein as to his ability were the means of our introducing him to some professional work. The report on a mineral property which he then prepared for one of our readers is fyled in this office, and is the best evidence of how little he really knew. With unblushing impudence he would fain cast aspersions on the personality of the REVIEW by reciting some ancient history as to its antecedents six years ago, all of which is stale news to our readers; but he carefully avoids any mention of the *deliberate theft* of personal property from the office of Mr. J. A. Gemmill, Barrister, of this city, or the *fraudulent affidavit* sworn to in the Crown Lands Office, Toronto, whereby he fleeced Mr. J. E. Thompson, of that city, out of several hundred dollars, or the *persistent deception* practiced while posing as an analyst and mining expert in Toronto, not to speak of the great multitude of debts to boarding house keepers and tradesmen all over the country. These are not "glittering generalities" but very serious charges, which we are prepared to substantiate whenever Dobson cares to bring us to the proof. But one word more—the last free advertisement Dobson will ever get from us. In his letter to the *Critic* he says: "With this money I went to Toronto, leaving debts of about $50 (?) behind me, some of which have since been paid (?) I got work at my profession and gained *some prominence*. Vide MINING REVIEW, February, 1889." As a matter of curiosity we turned up the fyle containing this issue, and on page 18 read:

"We learn on good authority that C. M. De Tracey Dobson, an individual styling himself a mining expert, and who has recently been posing very prominently in this capacity in the Toronto press, has departed to a more congenial clime. The many and varied peculiarities which have distinguished this party's career since he first made our acquaintance some three years ago would prove most interesting reading, had we space to give it in detail. It is sufficient to add that his departure from Canada is a positive gain to the mining community. Chicago papers please copy."

EN PASSANT.

At the meeting of the Mining Society of Nova Scotia, to be held at Londonderry next month, papers will be read by Mr. R. G. F. Leckie, son of Mr. R. G. Leckie, General Manager of the Londonderry Iron Company, and by Mr. John E. Hardman, Oldham. After an inspection of the works of the Company, the members will take the evening train to Truro, where a programme for their reception and entertainment is being arranged. A full report of this meeting will be given in our next issue.

Reports from Europe do not indicate any change in the price of phosphates. Producers are not sanguine of any material advance before next Spring.

Mr. Walter B. M. Davidson, F.G.S., A.R.S.M., of London, England, has returned to Ottawa from a visit to the mining camps of British Columbia. Mr. Davidson, it is understood, was engaged by Lord Aberdeen to examine and report on his lordship's properties in the Okanagan district. His views on the present condition and future prospects of the mining industries in the West Kootenay mining district, published elsewhere in this issue, will be read with interest.

In view of the suspension of operations at many of the mines, incidental to the stagnation of the phosphate market, the proposed excursion of the members of the General Mining Association of Quebec to the Lièvres river has been reluctantly postponed. A general meeting of the Association will, however, it is expected, be held at an early date, in Montreal, to receive and consider the report of Council anent the proposed united Mining Convention.

On the 25th ultimo a deputation from the General Mining Association of Quebec had the honor of an interview with the Hon. the Minister of Agriculture and Dr. William Saunders, Executive Commissioner to the World's Fair for the Dominion Government, with respect to Quebec's mineral exhibit at Chicago. It was pointed out that the grant of the Quebec Government—a paltry $12,000 to cover the whole exhibit from the Province, was wholly inadequate for a proper representation of the great mineral resources of the Province, and the Dominion Government was urged either to make a special appropriation from its grant or to send the exhibit now in the museum of the Geological Survey at Ottawa. Some assistance from the Dominion Government will be necessary if Quebec is to be represented as it should be at the World's Fair, and it is hoped that the representations of the Association will have a satisfactory outcome.

In another place our readers will find some interesting notes from our correspondent on the Souris coal fields. Last year the Government of Manitoba made an agreement with the Canadian Pacific Railway to run to the Souris coal field. At the same time an understanding was also come to with the Dominion Coal Company to mine and place this coal on the local market on the completion of the railway. As a result, the first car of coal from the district arrived the other day in Winnipeg, and in a short time the Company will be prepared to supply the demand for this coal. The product is situated in a good locality, being accessible to connections with the branch railways in Manitoba south of the Manitoba North-Western Railway. The coal is therefore in direct connection with the most populous portions of the country. The open prairie districts of Southern Manitoba, where wood fuel is scarce, have now a convenient and abundant supply of fuel opened to them. The price of the new coal will be $4.00 on track at Winnipeg, as compared with the old price of $7.00 per ton for a similar coal, while at points nearer the mines the price will be even lower. This reduction in the cost of fuel will be of great value to Manitoba in cheapening the cost of living and reducing the cost of coal for manufacturing purposes.

Rumour hath it that one of our most popular field geologists, whose excellent work as a member of the staff of the Geological Survey is well known, particularly in the gold districts of Nova Scotia, will shortly be married to a charming French-Canadian lady of this city. The REVIEW bespeaks a hearty round of congratulations on the coming event.

The use of cyanogen, in its various compounds, as a solvent for the precious metals in so-called refractory ores, appears to be coming into more general use. That it will prove to be effective and economical on all such ores is not to be expected, but that it has a field for usefulness, which further careful experiment and practice will probably broaden, seems now to have been demonstrated by the continued monthly reports of the "South African Gold Recovery Syndicate," which is working the McArthur-Forrest cyanide of potassium process. The success in South Africa is greatest where the tailings from the oxidised ores near the surface are treated, the percentage of recovery in some cases reaching above 90. That the process will be equally successful upon some of the other classes of ores found there has not yet been demonstrated. Some doubt is entertained by competent authorities as to the validity of the parent company's patents, or any patents, in which cyanide of potassium is used as a solvent; the use of this salt for such purposes being of frequent mention in chemical and technical works long antedating the original Cassel Company's patents. For ourselves, we do not believe that the patents can hold in Canada. In situations where fuel is scarce and roasting would be expensive, this process, or a modification of it, will perhaps be adopted in lieu of chlorination, but if so, solely because of lessened expense, as the percentage of extraction now obtained by chlorination in the best establishments is very high and very regular. Mr. A. J. Colquhoun, representing the Gold and Silver Recovery Syndicate, Limited, of Glasgow, is now at Golden, B.C., and writes to say that he has been commissioned to visit our principal mining camps and report on the suitability of the ores for treatment by the McArthur process.

The Montague Syndicate (limited) is the designation of the new English company which acquired on 1st inst. the Annand group of gold areas, situate at Montague, N.S. The properties include the "Rose," "Montreal," and "Lawson" areas. No particulars of purchase price and capitalization are available up to date of going to press.

Mr. J. Lainson Wills, F.C.S., late General Manager to the General Phosphate Corporation (limited), has gone to the West Kootenay mining district, where it is not unlikely he may practice in the future.

The Legislative Assembly of the North-West Territories has under consideration a Mines Regulation Act. A mine inspector—it is hoped a properly qualified one—is to be appointed.

California papers state that John Hayes Hammond, the young mining engineer of California, has just declined an offer of $15,000 a year to take charge of the South African mines of a wealthy London corporation.

Notwithstanding that most of the Australian copper mines, and a large number of those in America, are either closed or being only partially worked, as the result of discouraging market conditions, the Japanese contemplate reopening a copper mine at Musashi, which was first worked 1,183 years ago. This ancient property is said to be spoken of in Japanese manuscripts of undoubted age and authority, and the galleries and levels are stated to be in some cases just as they were 700 years ago.

The latest of the many uses to which asbestos is being applied is in the formation of a non-conducting rest for flat or box irons. It often happens during ironing operations that the iron resting upon the ordinary stand is so hot as to scorch the sheet beneath, and not unfrequently it makes the stand too hot to touch. By employing a layer of prepared asbestos placed on top of a wooden stand these disadvantages are overcome. The stand does not get heated, the ironing-sheet is not scorched, nor is the face of the flat-iron liable to become scratched or soiled, as when a metal rest is used. The asbestos also, owing to its non-conducting properties, enables the flat-iron to retain its heat much longer than has hitherto been possible.

The report of the mine inspector for East Scotland for the past year states that there were 51,749 persons employed, raising a total tonnage of mineral amounting to 17,489,756 tons, with 80 fatal accidents, and 81 deaths. Under the metalliferous Mines Act there were 733 persons employed, raising 198,713 tons of mineral, with three accidents and equal number of deaths. Of the total tonnage 14,763,193 tons were coal, and 143,639 tods ironstone.

At a recent meeting of the North of England Institute of Mining and Mechanical Engineers, Mr. J. B. Simpson, in an address on improvements in mining methods, said that a great item in the cost of working coal was that of its conveyance from the face to the shaft. In the majority of collieries this consisted of three distinct operations: (1) Conveyance from the face to the point where the main horse roads or self acting inclined planes end; (2) from the station to which the hand or pony putters had conveyed it, and the haulage thence by horses or self acting inclined planes to the engine plane landing; and (3) from the termination of the last haulage to the shaft by means of engine planes. Summarizing the cost of these three different haulages he gave it as 5d. per ton per mile. He feared he could not suggest in what way this could be cheapened; how far the application of electricity might affect any portion of the cost they had not had sufficient experience to judge, but no doubt ere long electricians would assist them in the conveyance of mineral underground both in economy and efficiency. The question of the transmission of power underground for the various purposes of pumping, hauling, coal cutting, etc., had of late occupied a foremost place, and recent papers had enabled them to see the great strides which the application of electricity was making. Compressed air for deep and fiery mines possessed great advantages, but its co-efficient of useful effect, being only about 30 to 40 per cent., and its heavy cost, militated against its general use. Steam conveyed down shafts was common, but was seldom applied for long distances. The question was of such importance that he would venture to suggest the appointment of a committee to investigate the chief systems (1) by steam, (2) by ropes, (3) by compressed air, (4) by electricity, (5) by petroleum and gas engines, and by other means. The substitution of machinery for the labor in hewing coal, although introduced many years ago, did not seem to have made much progress, but no doubt they might look forward to the lessening and cheapening of labor in drilling holes in coal and stone being possible when a general system of electrical transmission of power is adopted. The great quantity of coal consumed in the production of steam for the working of mines was a serious question; he estimated that about five per cent. of the total output was used in this way. In the defence it must be said, however, that inferior and small coal was frequently used. In colliery engines they had not made such marked progress as other branches of industry, where coal had to be purchased and other economy practiced. To ensure great economy, however, required in the first place a greater expenditure in the machinery put up. In mechanical screening great improvements had been made.

The Surveying of Mines.

At a recent meeting of the Engineer's Club, Cleveland, Ohio, Mr. J. L. Culley read a paper on the above subject, of which the following is an abstract.—In order to insure accurate work in the surveying of a mine the surveying party should consist of the engineer, a pilot or fore-sight, who goes ahead and selects the transit or angle points, two chainmen, a torch-bearer for the instrument and a backsight. The pilot should be familiar with all the mine workings, and the mine boss is therefore generally selected for this position. The hind chainman should be specially selected by the engineer, for the accuracy of the measurement depends upon his ability. The duty of the torch-bearer is to first light the plumb-bob, then the upper plate until it is level, then the vernier, then flash the cross hairs, and finally the vernier reading. In setting or reading the vernier the engineer should stand square to the vernier with the left hand on the upper plate, and should cause the torch-bearer to pass his light over the engineer's left hand to a point slightly above and to the right of the centre of the vernier. The engineer will then be able to read it without trouble.

The setting of the plates will be greatly facilitated if a small rosette be put on the outside of the lower plate directly under the o·o of the horizontal limb. Then to set the plate at o·o the engineer should pass his hand around the plate until the rosette is met and then bring it and the vernier at once together. Otherwise frequently several revolutions are made before the desired position is obtained. The flashing of the cross hairs is a very simple operation when properly done. Put the instrument in position, find the light and nail in front of it, then direct the torch-bearer to "flash" and he will pass the flame of his light directly across the telescope axis 2 in. in front of the object glass untill the cross hairs are in position. The position of the sight nail is more clearly defined if an ordinary surveyor's marking pin is held plumb over or in front of it. The sight lamp, nail and telescope should always be in a straight line. The angle having been obtained, the engineer notifies the chainmen to measure up to his position, then proceeds to the fore-sight, the back-sight takes his position and the fore-sight seeks a new point.

Ten years ago it was the universal custom to read and note all the angles as right or left. This is a very bad practice, as it is easy to put the entry in the wrong column and to forget to place the R or L opposite the figures. It is now the usual plan to make all the entries "right" from zero and to record them just as they are observed, even though they are as large as 359 degs. 59 min.

It is not allowable to abridge the underground work, but on the surface the operators only wish to know the location and direction of the most advanced works. This is often done by producing the first and last course of a survey to intersection and then calculating the necessary angles and distances.

As this is a very laborious process, the author has been to much trouble to devise a simpler one. After a most careful study, the following method has been adopted. An accurate map on a large scale, generally 40 ft. to 1 in., is made of the inside survey. All angles are laid off by ordinates, those less than 20 degs. by tangents, the balance by sine and consine and radius, with the radius not less than 10 in. There is no known protractor by which angles, for this purpose, can be successfully plotted. An engine divided paper protractor may and should be used to test every angle, and each course and set of courses that run in one general direction should be repeatedly tested by scale. When the plot thus constructed has been thoroughly tested certain convenient courses are selected and produced to intersection. The lines thus produced are then measured by scale, and the angles of intersection computed from the deflections of the intervening courses, and tested by protractor. This process will give absolute results as to angles and lengths for an entire survey within the fraction of a foot. This method also affords an opportnnity for a careful review, by plot, of the inside survey.

Whenever it is unavoidably necessary to use a short base in connecting the inside and outside lines in a shaft mine the following method is recommended for extending the base at both top and bottom of shaft:—Place, in the direction of the first course, a timber over the top of the shaft, 5 or 6 ft. above the ground if possible, and let down the two plumb-bobs from one edge af the timber at as great a distance apart as possible. When the plumb wires are at rest bring a tightly-drawn fish line 15 ft. long into the vertical plane of the wires and drive a stake at a convenient distance from either wire. Repeat the operation until the two points on the stakes are exactly in the vertical plane of the plumb wires. This is both quicker and more satisfactory than the usual operation of setting the instrument approximately in the plane of the wires by sighting the nearest wire, then removing it to see if the other wire is in line. However, it is a bad practice to use the short shaft base at all, nor should it be used except as a last resort, or where the shaft does not exceed 40 ft. and the extreme workings do not exceed 2,000 ft. distance from the shaft.

Band chains have given the greatest satisfaction in mine surveying. The one drawback to their use is that the feet number-plates are often carried away in passing the chain through the mines *debris*. This could be overcome by etching the numbers into the body of the chain as is done in the printed steel ribbons.

Safety Appliance for Derrick Cranes.—Many accidents arise from the breaking and inadvertent releasing of jib chains. A new arrangement, according to the *Engineering and Mining Journal* (New York), has lately been devised for preventing the falling of jibs from this cause. The extremity of the chain, by which the jib is raised and lowered, is made fast to the bolt at the jib head. This bolt is connected to a pair of pawls which take into two ratchet wheels, cast one on each side of the sheave over which the lifting chain runs into the jib head. The bolt is continuously urged forward to place the pawls into engagement by a powerful coiled spring, while it is drawn back by the tension on the jib crane. The sheave itself is cast with pockets into which the links of the lifting chain drop, and it runs in a casing which prevents the chain getting out of the pockets. If the jib chain breaks the jib begins to fall, and the pawls dart forward into the teeth on the sheave. The latter can now no longer rotate, and as the lifting chain cannot ride over it on account of the pockets, the weight of the jib is thrown on to the lifting chain, and its fall is arrested before it has dropped many inches. When a wire rope is used in place of the chain a modified arrangement is used which grips the rope.

Steel Cars for Mines.—A pressed steel coal car has been made by the Leeds Forge Company, Ltd., Leeds, England, under the Fox patents, for use in underground workings. These cars are designed more particularly for carrying coal and are adapted to be used either in the pits or for taking coal from the pit mouth to boats or cars for shipment. The underframe is made of pressed steel parts, ¼ of an inch thick and is not unlike the Fox freight car truck used in this country, except that the framing has end sills. The track is 7 feet long and 4 feet wide. The sides of the body are 3-16 of an inch thick and are corrugated to give rigidity and obviate the need of stays or stakes. The total weight, including wheels, axles and springs, ready for use, is 720 pounds. These cars have proved very satisfactory in English colliery work on account of their light weight and small cost for repairs.

Recent Gold Milling Practice in Nova Scotia.*

By John E. Hardman, S.B., Oldham, N.S.

In the practice of every art it is always desirable to have a body of reliable data accessible, to which to refer for comparisons, and by which to check one's own methods and results.

So far, in gold milling, the data on record refer almost entirely to large mills, *i.e.*, those having forty or more stamps; and to the (comparatively) softer ores of the United States and Australia. I have thought, therefore, that it might be acceptable to record some data for Nova Scotia, and for small mills of ten or twenty stamps. The time, perhaps, is opportune for the reason that within the last three years there has been a decided step forward in the business of gold milling in the province. Three years ago I had the honor to read a paper on the Empress mill at Renfrew,† which had then recently been built by Mr. D. S. Turnbull for the Empress Gold Mining Co., and which may be regarded as the pioneer mill of the new practice in Nova Scotia. This mill, in its design, construction, and detail, was a reproduction of the type adopted by the Homestake Mining Co. in their large mills at Lead City, South Dakota, and in its operation it fully sustained the reputation of the type for fast crushing, with close saving of the free gold. Like its prototype at the time, it had no concentrating plant to save the sulphurets, which were reported worth $20 or less to the ton. No figures of costs or results from this mill are available for publication.

Since the construction of the Empress mill in 1889, eight other mills, aggregating 150 head of stamps, have been built in the province in which the Homestake type of mortar (modified in three mills as to minor details), has been adopted.

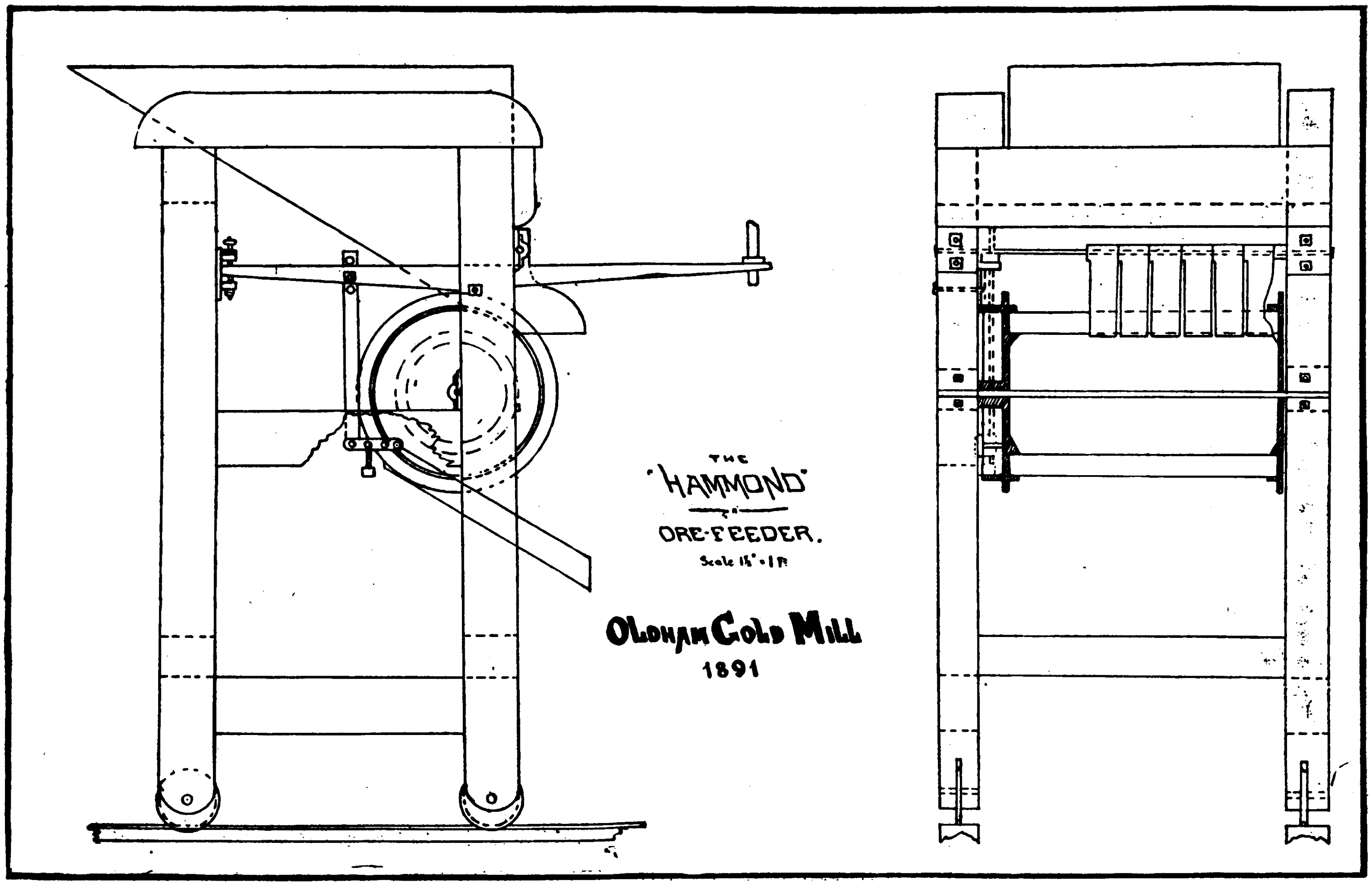
In these mills, the design and construction of the buildings, ore bins and accessories have been subject to local conditions, and hence have been of diverse character.

It is not my purpose to give descriptions of all these different mills, but rather to induce members in charge of the same to put on record their experiments and experience.

As to two of these mills, however, (those of the Oldham Gold Co., and the West Waverley Gold Co., Ltd.), which have been designed and constructed under my supervision, I am enabled to give you descriptions, and figures as to costs, capacity and saving effected. The two mills have been built on practically the same lines, and the plates of the Oldham mill given herewith show essentially the characteristic features of the Waverley mill. The Waverley mill is driven by steam power, the Oldham mill by water power. As the Waverley mill has been dropping its stamps for about two months only, the figures relating to it are given subject to correction, but the figures relating to the Oldham mill represent twelve months' continuous work. In designing the structure, care was given to make each component of the mill independent, *i.e.*, the building, the battery frames, and the ore bins are each entirely separated from the others, so that the building is simply a cover with no strains upon it other than those due to wind and weather; the battery frames are not connected either with the building or the ore bins, and hence no vibrations are communicated to them or from them to other parts of the structure; also the ore bins, upon the top of which is placed the rock breaker, are free and disconnected. The mill contains but ten stamps, and its character and design will be readily understood from the accompanying plan and sectional elevations. I may say here that no originality is claimed for either of these mills. In their design and construction the whole object was to select the best features from practice in other places, and such as had been proved and tested, and to combine them into such an aggregate as should be efficient, economical, and best adapted to the work required.

As to the machinery details, the first one to which I will draw your attention is the use of the "Forster" rock breaker, in the place of the old "Blake" and the newer "Gates." The machine in the Oldham mill is a number three, the size of the receiving opening being 7 inches by 18 inches, which easily takes in a slab of rock 6 inches by 17 inches. The Waverley mill has one of the largest size, jaw opening being 12 inches by 21 inches, and capacity being 125 tons in ten hours. The preference was given to the Forster in both of these mills for the following reasons: (1) for machines of equal capacity the Forster requires very much less power than either of the others, taking less than one-half the power required by a Gates; (2) the total weight of the Forster machine, of equal capacity, is only about one-half that of the Gates and considerably less than that of the Blake; (3) the vibratory motion induced by the machine is very much less than that produced by the Blake, and no more, if as much, as that produced by the Gates; (4) the cost of the Forster is less than either of the two others.

In small mills, to which I wish it clearly understood my remarks are meant to apply, the



* Transactions Mining Society of Nova Scotia.
† Canadian Mining Review, vol. viii., p. 73.

points referring to the amount of power required and the first cost of the machine, are important factors, and where the breaker is mounted on the top of the ore bins, total deadweight and the vibration are almost equally important. For larger mills I am inclined to consider that the Gates might be preferable, but I can see no situation where I believe a Blake would be the equal of the Forster.

The small breaker in the Oldham mill is driven 300 revolutions per minute by a 5 inch belt, and at that speed crushes 5 tons an hour to pass an in h and a half ring.

From the rock breaker the ore drops into the ore bins, which present no points of novelty and which will be easily understood from the sectional view. Chutes lead from these bins to the hopper of the "Hammond" automatic feeder. The feeder is the one which has been in use at the Alaska-Treadwell mill on Douglas Island for some years. It has given us every satisfaction. It is positive with wet and dry ores, is superior in its freedom from attendance, can be regulated with great exactness, and is much cheaper both in first cost and repairs, than either the "Tulloch" or the "Challenge." Its construction will be readily understood from the drawing. A small auxiliary split tappet fastened on one of the stems between the guides, serves to operate the lever.

The style of battery frame is new to Nova Scotia, being adopted from the Grass Valley practice, where it is known as the "knee frame." Its essential point is the removal of the line shaft from its usual position behind the mortar, and beneath the feeder floor, to the front of the batteries and on a level with the cam shaft.

The merits of the arrangement are many: (1) the shaft is always in sight, it has the best light in the mill, and is easy to align when necessary; (2) it is removed from beneath the feeder floor, where it is in darkness, and subject to the dampness, drip and fine dirt which will inevitably work down upon it and its bearings; (3) any repairs to the shaft when below the feeder floor have to be made by artificial light, and in confined spaces which are usually abounding in grit and fine dirt; (4) it enables the cam shaft belt to be run horizontally, or nearly so, without a tightener, and thereby saves a great deal of wear on the belt. As against these advantages, one possible point of disadvantage is made, viz: that the main shaft is more liable to get out of alignment when erected on this knee frame than when placed on the solid cross sills behind the mortar blocks. To this it may be answered that if the knee frame is properly made and braced, of heavy timbers, the chances of malalignment are very slight and are easily remedied.

On this line shaft a Hunter friction clutch pulley serves to disconnect the cam shaft without disturbing the running of the rest of the mill.

The mortar blocks are built of selected two inch spruce plank, twelve inches and six inches wide, planed on both sides and jointed on both edges. The blocks are built thirty inches wide, and are therefore made up of two twelve inch planks and one six inch in each layer; joints in one layer are broken in the next, and each layer is spiked to the previous one with 40dy. nails (five inches long), so that each nail holds in three layers. Each plank is fitted on the bottom to the surface of the solid bedrock, as it was found impracticable to dress off the whin rock to a smooth and level surface, and concrete is valueless unless put down in large masses.

The two blocks for ten stamps are built together, so that the Oldham foundation is one solid piece of timber thirty inches wide, fourteen feet deep, and twelve feet two inches long. In the Waverley mill the blocks were built in the same manner, but are for twenty stamps. As bedrock was four feet deeper, and a clear space of four feet was left between the two cam shafts, the final block in Waverley measured thirty inches by eighteen feet by twenty-eight feet four inches.

The holding down bolts were put in as usual, with the exception that the standard threads for one and one half inch bolts were not used; instead of six threads to the inch, twelve threads to the inch were used, with standard size hexagonal nuts. This substitution of a finer thread not only gives greater strength,* but also serves to prevent the jarring loose of the nut by the vibration of the mortar.

The mortars are modified from the Homestake pattern only in the fronts, which are cut down to within two inches of the bottom, the height of the front being regulated by wooden chuck blocks faced with thin steel plate. Also the lip has been extended three and a half inches. The accompanying detail drawings will show the character and extent of these changes.

The essential character of the mortar is not at all affected by these modifications which have been made only for minor points of convenience. The cutting down of the front was done for two reasons: first, because the Oldham mill is also a custom mill and it was desirable that the whole inside of the mortar should be readily accessible for a thorough clean up; and secondly, because of the very diverse character of the quartz coming to a custom mill, necessitating perhaps a high discharge for one lot and a very low discharge for another lot. It has been found also, in the experience of twelve months, that the slight spring, or give, which the wooden chuck block has (although very slight) is sufficient to cause the amalgam to settle a little lower round the dies than it does in the solid front type. The extension of the lip was made in order that the apron plates might be entirely free from the mortars, and receive no motion or vibration therefrom.

The cams, tappets, bosses, shoes and dies are of the usual Homestake pattern, the full stamp with new shoe, weighing 858 lbs. Sectional guides such as were described in the paper on the Empress mill, have been used, with the addition of a long diagonal washer to prevent checking or warping. The guides are 14 inches long, made of sound yellow birch wood. They have been in use in the Oldham mill for twelve months, and are good for several months yet before being trimmed down. The lubricant used is a mixture of tallow and graphite, applied warm. The front elevation of battery frame shows the sectional guides in position, but does not show the diagonal washer.

The plates for catching the amalgam are four in number.

The first plate lies inside the mortar, just at the lower edge of the screen, and about ten inches above the foot of the dies. It is made from a strip of copper one-eighth of an inch thick and one and three quarter inches wide; the length being the full length of the screen, about forty-eight inches. This copper strip is placed on a bar of square iron, and from one-quarter to three-eighths of an inch in width is bent over at right angles for the whole of its length. It is then fastened to the rounded or bevelled edge of the wooden chuck-block by screws, the longer side sloping upwards towards the screen at an angle of about 45 degrees with the horizon, while the shorter side inclines towards the stamps at an equal angle, forming a narrow V shaped trough, as shown in fig. 1 sectional view of the mortar.

This plate has proved most effectual, as will be shown further on, and the wear upon it, after twelve months, is not noticeable. It does not choke nor fill with sands, the splash from the screen being sufficient to dislodge the sands but not the amalgam. Outside the mortar there is a splash plate eight inches wide, set at a run of three-quarters of an inch to the foot, which catches 80 per cent. of all the gold caught outside of the mortar. This plate discharges the pulp upon what is called the "quadrant plate," which is a sheet of copper running the full width of the apron plate, but curved round the quarter circumference of a circle whose radius is 9 inches in the Oldham mill and 6 inches in the Waverley mill. The prime function of this plate is to spread the pulp perfectly smooth and even upon the long apron plate below, but it has also been found to be a most efficient amalgam and mercury saver. From this quadrant plate the pulp has a drop of one inch upon the upper end of the apron plates, which are fifty-four inches wide by ten feet long and have a pitch in the Oldham mill of one and three-quarter inches to the foot. From the apron plate the pulp drops into a box on the end of the wooden table, whence it is led by an iron pipe two inches in diameter to a mercury box of the Grass Valley type, thence through a short wooden sluice to a box of the same pattern as is used in the Black Hills, thence, in the Oldham mill, to a Golden Gate concentrator, which handles all the sands from ten stamps with ease, being from 24 to 30 tons in 24 hours.

The tables upon which the apron plates are laid are arranged so that the pitch can be varied from one and three-eighth inches to the foot as a minimum to two inches to the foot as a maximum. Reference to the sectional elevation of

* See paper of Major W. R. King. Trans. A. I. M. E., vol. xiv., p. 90 *et seq.*

the mill will show that the tables (F) rest upon two stringers (A) of 3"x 5" scantling and are kept from sliding downwards by a block or cleat (G) nailed to the stringer. These stringers lie loose in notches or gains cut in the standards (B), and a hard wood pin (C) keeps each stringer from sliding downwards, but admits of sufficient freedom to raise the lower end as required. The standards are nailed to the floor and have no connection with the mortar blocks, nor has the floor, a coarse saw-cut separating the boards of the floor from the blocks. At the lower standard a hard-wood wedge (D) is inserted, which has a slot cut in the middle, through which a bolt (E) and thumb nut is run. By means of this wedge the inclination can be changed to suit the character of the pulp passing over the plate, the wedge being locked in position by the thumb nut. The upper edge of the copper apron plate is turned up one inch, behind the lip of the mortar, but not touching the mortar, so that there is no point of contact between the outside plates and the mortars.

The floor of the battery room is laid in hard pine with a pitch of half an inch to the foot, and a sluice is arranged to carry all washings from this floor to a mercury trap below. The floor is washed down by a hose every shift.

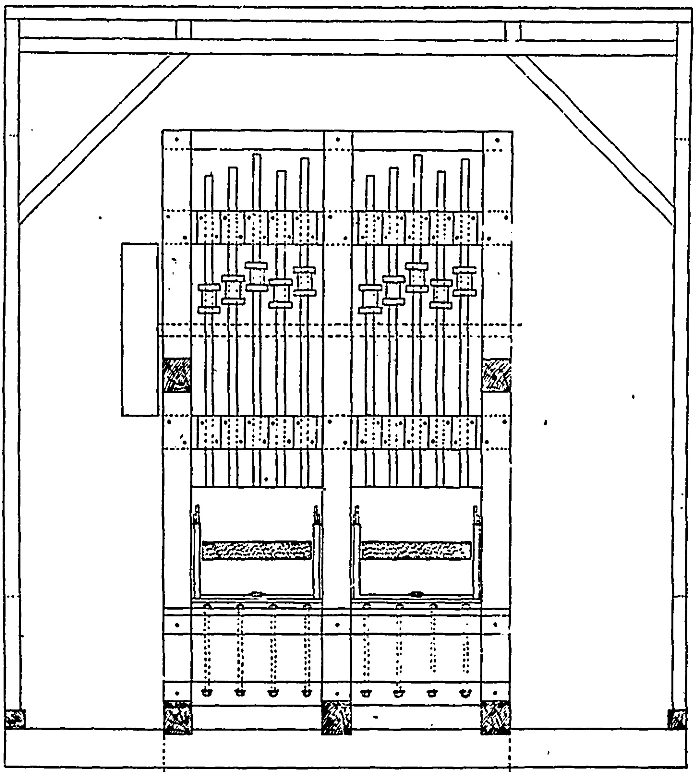
The lowest floor of the mill measures 38 feet by 30 feet. Upon it, besides the Golden Gate concentrator, are the boiler for heating the mill in winter, the coal bin, the retorting and smelting furnace, and the casing or housing of the Pelton wheel which furnishes the power for the mill. The shaft of this wheel is on a level with the floor, the wheel-pit and tail-race being excavated below it. From this shaft a sixteen inch, six ply rubber belt conveys the power to the line shaft, whence it is distributed to the cam shaft, the rock breaker, the exhaust fan and concentrator.

The Pelton wheel referred to is a six foot standard single nozzle wheel, operated by water under a head of seventy-six feet eight inches, or a pressure of about 33 lbs. per square inch. This water is brought in by a ditch 1,026 feet in length, to the forebay, whence 540 feet of pipe, made of No. 14 gauge iron and sixteen inches in diameter, conveys the water to the interior of the mill. Inside the building the diameter of the pipe is gradually reduced to eight inches, where it is joined to the wheel gate by flanges. This pipe line is provided with three valves, located in appropriate places, one for blowing out air when filling the pipe, one for automatically admitting air in the event of a vacuum being formed in the pipe, and the third valve is an Ashton pop safety to relieve any abnormal pressure arising from suddenly shutting the water off the wheel. Four nozzles of different diameters (2¾", 3", 3 1/16" and 4") are supplied, to be used as the demands of power vary; the three inch nozzle is the one usually used at Oldham. With this size of nozzle, venting about 250 cubic feet of water per minute, the wheel develops more than 25 horse power, which is sufficient to run the entire milling plant.

I am informed by the Pelton Water Wheel Co. that this is the first wheel of the kind sent to Canada, outside of British Columbia. It has been continuously in use since it was installed, and has given every satisfaction, both in cold weather and in summer.

As Nova Scotia abounds in water powers, in which in many cases the flow of water per minute is too small to be utilized to advantage in a turbine, it may not be out of place to say that this wheel will render many of these powers valuable wherever the conditions are such as to permit of obtaining readily a head of 40 feet or more at reasonable distances.

The motive power of the Waverley mill is a tandem compound condensing engine, cylinders 8" and 12" by 12", with a Meyer's adjustable cut-off. Boiler pressure is carried at 100 lbs., and steam is cut off at ¼ when condensing, and at ⅓ when run compound but not condensing. The economy of this type of engine is too well known to need further demonstration.



FRONT ELEVATION OF BATTERY FRAME. Scale ½ inch = 1 Foot.

In the Oldham mill the pulp, after leaving the last mercury trap, flows into the hopper of a Golden Gate concentrator, whence the tails run into the brook, the headings being saved in a box. The average mineral contents of the quartz crushed is about 2 per cent., the sulphurets saved are very clean, averaging over 90 per cent. mineral, and assay $70 per ton in round numbers.

No concentrator has yet been added to the Waverley mill, the merits of several machines being under consideration. The percentage of sulphurets will run about the same, from 2 per cent. to 3 per cent.

This brief description of the equipment and character of the mills under consideration will serve to bring out the main points wherein the recent practice differs from the older practice. The adoption of the narrow mortar with inclined screen, the rapid, but short, drop of the stamps and the narrow V shaped inside plate, are features which have been developed by reason of the necessity for getting increased capacity without impairing the efficiency of the battery as an amalgam saver.

I am enabled to give some of the actual working results of these mills, and hope to supplement them in a future paper.

As to increased capacity: The Oldham mill drops its stamps 85 drops per minute, six and a-half inches, and the screen used is an indented Russia iron slot, having a No. 7 needle, the equivalent of 30 meshes to the inch. Under these conditions the capacity of the mill is from 28 to 30 tons per 24 hours, or 1⅙ to 1¼ tons per hour; or 2⁹⁄₁₀ to 3 tons per stamp per diem.

I may say here that the Oldham mill has to be used as a custom mill, being the only operating mill in the district. Hence the variety in the character of the quartz in the lots presented for crushing causes a considerable variation in the capacity under the conditions given. From clean, hard, compact quartz, the mill often goes upon soft, much weathered and decomposed slate belts, carrying very little hard quartz. But with the speed, drop and screen given, the capacity of the ten stamps is a minimum of 1 ton per hour, and a maximum of 1¼ tons per hour.

As to the efficiency of the amalgamation, I have summarized the results of the last twelve months' work from records which have been kept of each and every lot or parcel crushed. As stated before, the lots come from three different companies as well as from tribute workers, and the gold contents varied during the year from $1.50 per ton to $800 per ton of stuff crushed, the average being about $18. The size of the lots also varied from 5 tons to over 200 tons.

Of each separate lot a record is kept, showing among other things:—

(1) The weight of material crushed.
(2) The time occupied in actual milling.
(3) The weight of amalgam obtained from the outside plates (*i.e.*, splash, quadrant and long apron plates).
(4) The weight of amalgam in inside V plate.
(5) The weight of amalgam in mortar sands.
(6) The weight of retorted gold.

There is, therefore, a body of data upon which to base satisfactorily a general average, and also an opinion as to the efficiency of the mortar.

Calculated into percentages the results are:—

	Per cent.
Percentage of gold on outside plates....	8.55
" " inside plates......	23.40
" " in mortar sands	68.05
Total gold......................	100.00

It will be seen that the percentage of gold retained in the mortar behind the screen is 91.45 or 91½ in even numbers.

The *highest* percentage ever obtained on outside plates was 15⁶⁄₁₀, leaving 84⁴⁄₁₀ per cent. as the lowest percentage of gold saved in mortar.

The *lowest* percentage ever obtained on outside plates was 2⁸⁄₁₀, or 97²⁄₁₀ per cent. saved in mortar.

These figures are, to my mind, the most satisfactory answer to the statement which has been made, that this style of mortar would not save the gold inside the screen, but would grind it. In only one case have I seen the gold show signs of having been ground, and that was in one small lot which was crushed while the cam shaft belt was slipping, and the speed was consequently reduced to 70-75 drops per minute.

The mill-man seeing these figures will next ask: "What is the value of your tailings?" The average assay value of the tailings as they go upon the concentrator is $2 per ton, but this value is almost entirely in the sulphurets, the tailings from the concentrator varying from 20 cents to 50 cents per ton. Samples of tailings from which the sulphurets were eliminated by careful panning showed only traces of gold.

The mill-man from Australia or South Africa will be inclined to doubt these figures until he is told that the gold in Nova Scotia quartz is coarse (comparatively speaking). It is very doubtful if there is any quartz vein worked in Nova Scotia which carries gold of such a degree of fineness as to be invisible to the eye, or so fine as not to be saved by stamp-mill work if the mill is a proper one and the amalgamation skilfully performed. I am fully aware that this statement will provoke discussion, but I make it after nearly eight years diversified experience in this country, and after two years very careful study of the question. In some veins the sulphurets carry fine gold mechanically combined, of which a certain proportion is set free by fine grinding in a pan, but all such sulphurets with their contained gold are much more satisfactorily handled by concentration than by fine grinding with the consequent sliming.

The essential and important factor of this large percentage of gold saved in the mortar is the rapid short drop of the stamp. With the narrow mortar of western pattern, slow speed is the enemy of successful saving of gold behind the screen. The relative height of the screen above the die, and the coarseness of the mesh, are important factors it is true, but they are entirely secondary to the speed. I have dilated somewhat upon this point because some of the mills having mortars of this type in Nova Scotia have been blamed for not saving gold, and upon them has been laid the blame of unsuccessful ventures.

Whatever the true cause of these failures may be, it certainly cannot be the form of the mill mortar, if this same form does the good work it has done for years in the Western United States, and has done lately in the mills under consideration in this paper.

The results, as to capacity and efficiency, in the Waverley mill, although covering only a limited period (some 800 tons crushed) fully bear out the figures given above. The speed in the Waverley mill is 100, the height of drop six inches and the screen 30 mesh. The duty is 30 tons per diem. The average saving behind the screen has been 90⁶⁄₁₀ per cent., on the plates 9⁴⁄₁₀.

Coming finally to the costs of milling, we naturally cannot expect small mills to work as cheaply per ton of material handled as the large ones do, but yet in Nova Scotia, where both fuel and labor are cheaper than in the west, we may expect to approximate the costs of the best mills elsewhere.

In Prof. Hofman's paper on "Gold Milling in the Black Hills," the cost at two different establishments is given as: $0.8349 per ton, and $0.87 per ton. If we deduct from these figures the item for fuel, a very expensive item there, the costs stand about .56c. per ton milled. Taking the costs at some of the best of the California mills,* the results in 188β were:—

Plymouth mill, 160 stamps, water power.	$0.3900
Bunker Hill mill, 40 stamps, water power....................	0.6000
Plumas Eureka mill, 60 stamps, water power........................	0.4875
Sierra Buttes mill, 80 stamps, water power........................	0.3450

The costs at the Oldham mill are given in detail as follows:—

	Per ton.
Labor	$0.2730
Supplies..............................	0.0293
Iron..................................	0.0264
Quicksilver...........................	0.0205
	$0.3492

This figure, it must be borne in mind, is for a mill doing custom work, which necessitates much loss of time and consequent loss of tonnage, and higher costs per ton. The same mill, when running on large lots, has reduced the cost per ton for labor $0.063, making the total cost per ton for large lots $0.2862. During the winter months an extra charge of $0.0351 is made to cover the cost of fuel required to warm the mill. The highest cost per ton, therefore, in the Oldham mill during the past year has been 38⁴⁄₁₀ cents, and the lowest 28⁶⁄₁₀ cents.

Figures of costs for the steam mill at Waverley are not yet available, for the reason of the short time the mill has been at work, but the cost sheets for May showed the figure of 48⁴⁄₁₀ cents. I have reason to believe that this figure is not far astray; and that the result of the first year's work will show a cost figure not to exceed 50 cents per ton.

The Use of Asbestos in Mines.

Asbestos is a highly refractory fibrous mineral, having about 90% of silica and magnesia in its composition. It is insoluble in water, and will not change its mechanical (that is, fibrous) structure when wet.

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

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

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

Assuming, further, a steam pressure of 70 lbs. we have a body of heat at 316° Fahr., 1,250 square feet in extent constantly radiating into an atmosphere about 250 degrees cooler than itself, with results which anyone familiar with the condensation of vapors can easily predict. Theoretically, it would take over 8 tons of coal per annum to remedy the waste in each 100 lineal feet of pipe, or, at $3 per ton, $24 per 100 feet, making a total waste on the line of pipe in question of $240 per annum, but *practically the pump could not be run, as the water of* condensation would clog the cylinder and valves so as to stop the motion and injure the machinery.

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

The loss from radiation under such favorable circumstances is infinitesimal, and compared with the loss of waste through friction and other causes, is not worthy of note. It is hard to obtain reliable statistics owing to the difficulty of making accurate observations from apparatus covering so much ground. In a recent test, however, of a system of piping carrying hot water under pressure at 400 degrees Fahr., the total loss, in a travel of 10,000

*California State Mining Bureau. Eighth Annual Report of State Mineralogist.

feet, chargeable to radiation, was placed at 3%. These tests were made by competent engineers, and with the use of every means known to science. All of the pipes in question were insulated with 1½" in thickness of asbestos.

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

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

1. It must be a non-conductor of heat.
2. It must be unaffected by heat.
3. It must be unaffected by water.
4. It must stand rough usage.

A countless list of articles have been offered by enterprising vendors, with various devices for fire-proofing, water-proofing, etc., and in turn have been discarded for some fatal defect.

The fire-proofing lining has been found no protection or the water-proof cover has been broken away and the water has destroyed the coverings.

It may be interesting to review a few of these to see in what way they fall short of the standard we have just set up, *i.e.*, durability under heat, water, and rough usage.

First comes hair felt, the oldest form of pipe covering in use, one of the best non conductors of heat known, because so full of air cells, but hair felt is short lived under heat, and disintegrates rapidly when wet. The various fire-proof linings used under hair felt do indeed prolong its life but do not give it real durability, and for mine work it cannot be recommended. Then there is an extended list of paper pulp and wool felt materials, usually made up in sectional or cylindrical form. Some have a thin sheet of asbestos as a lining, placed there more for appearance than use, as a close examination will show the asbestos to be too thin to afford much protection.

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

We would refer right here to the well known effect of heat and moisture on organic substances, which is to disintegrate them rapidly. Hence these, and similar coverings, containing a large percentage of hair, wool and other organic matter will be quickly destroyed in mines, and we therefore lay down the general proposition that no covering should be adopted for use in mines that contains organic matter in its composition.

The various forms of non conducting cements are more durable under the heat but are too easily injured by rough usage to last long in a mine. We can divide them into two classes, those containing heavy clays or earths with animal or vegetable fibres as binders, and those made from asbestos and infusorial, or fossil earths. The former are only nominal pipe coverings, as they do not retain the heat and have no real value. The latter have merit, but are not of service in the line of work we are now contemplating.

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

We have just referred to various forms of non-conducting coverings and point to the fact that in each case the materials used in their make-up other than asbestos cannot be recommended for use when exposed to great heat, continued moisture, and rough usage.

We now point to another most important fact to be observed, which is that all the durability these goods possess is found in asbestos fibres, which they contain. The hair, wool, paper, pulp, etc., chars under heat, while the clay, magnesia, plaster, and other similar fillings wash away under exposure to moisture or crack and break when subjected to abrasion.

It was the discovery of these facts that led to the construction of the style of pipe covering manufactured by the H. W. Johns Manufacturing Company. This meets all the demands of mine work, and we will now fully describe it.

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

In conformity to these well proven facts the covering we are about to describe is made solely from fibrous asbestos.

The asbestos is taken in its crude or natural state, and by special processes it is cleaned from all foreign substances and the long silken fibres are selected and separated and divided until they are as loose and fine as a bat of cotton.

This material has been found to answer the first stipulation as laid down earlier in this article, *i.e.*, it is a good non-conductor of heat.

It also meets the second requirement and will stand the most intense radiated heat that can be brought to bear on it, for it is entirely free from all organic substances, and hence will meet the third requirement, which is to be unaffected by water.

This material is then taken and by machines invented by the H. W. Johns Company, it is shaped into cylindrical form, of sizes to fit pipes of any diameter and of any required thickness.

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

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

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

We have thus far treated asbestos only in its function as a non conducting covering, and we can justly claim to have demonstrated its unequalled merit for this purpose.

There is certainly no material known that in any way approaches to it for such a purpose.

But it is not only in this way that it is useful to the miner. There are many other ways in which it is useful and doubtless many more will be devised in the near future.

It is largely used as a piston packing in cylinders of engines and pumps, and also as a flat packing to make cylinder heads, steam chests, and all kinds of flange joints.

As a fire proofing it admits of great possibilities. Its long silken fibres can be spun and woven into a fine fabric that would make an excellent brattice-cloth, and the many light flexible and durable forms into which it can be made could, when intelligently used, greatly decrease the fire risk in mines.

We venture to predict that the present known uses of asbestos are to its soon to be discovered possibilities, as the feeble steam of the pioneer Cornish pumps are to the present million gallon Worthingtons of to-day.

We therefore commend it to the notice of every thoughtful and progressive mining engineer.

Notes on Sampling.

By Herbert R. Wood, M.A.*

Vein and Mine Sampling.—On the methods of sampling, vein outcrops, prospects and mines, depend the actual value of the property, and its value as known to the public. Vein contents, their assay value at the surface, and at moderate or great depth, vary greatly. The character of the ore vein will largely determine the value of the assay-return method of sampling. The changed chemical condition which sulphides of iron, copper and lead, undergo at the surface, and frequently to considerable depth, with an increase or decrease of silver, renders sampling uncertain and not indicative of the actual value of the mine, but only in that region of the vein in which the sampling is done.

Vein outcrops rarely assay the average value of the vein; in some instances, however, they do, and, indeed, exceed the average value of the vein at greater depth.

A Prospect, or the first sampling done on a vein, should be made from a series of pits, dug at intervals along the vein, as a single excavation cannot represent the average value of the ore. Such pits should be ten or twelve feet in depth, and, if the vein is much decomposed on the surface, such samples cannot be taken as any criterion of the value of the vein throughout. Surface samples cannot be regarded of any value as to the real character of the vein. It has been said that the depth of the test pits should be at least ten feet, but they may be regulated according to the nature of the ore. If the surface cappings consist of iron oxides and the carbonates of low assay-yield, a short distance may reach the ore body in the form of sulphides, but this must be determined by the judgment of the prospector. Gold bearing veins are frequently richer at the surface, and the gold more apt to be in the form of large agglutinations, though at the immediate outcrop the gold may be entirely removed. When the gold accompanies iron pyrites, and oxidation goes on, the ferrous sulphate formed, acting as a slight solvent of gold, removes it, or washes it out, or deposits it in nugget-like masses.

In sampling ore in which there is native silver and silver sulphides, the same care is taken to get a quantity of ore representative of the quality of the vein, holding rock and silver in constant ratio.

In sampling a mine throughout, for buying or selling purposes, it should be sampled in all the levels, and the shaft as well.

1. When the ledge is exposed in end of tunnel, sampled thus, ×.
2. When the ledge is exposed in bottom of the shaft, sampled thus, ×.
3. When the tunnel follows ledge, the vein should be sampled from wall to wall, across both roof and floor, every ten or twenty feet.

In the shaft, the vein should be sampled from wall to wall on both sides, every fifty feet.

These samples should be kept separate, and separately assayed, and the average of all taken; or, the samples may be combined, quartered, crushed, and assayed—the result being the value of the ore output from the whole mine.

Pay streaks, when distinctly marked from the rest of the vein, may be separately sampled—such streaks usually constituting first-class ore, and the balance, second-class. When the ledge is decomposed on the surface, careful sampling should be made from wall to wall as usual. Marked variations in ledge matter should be kept separate.

Dump Sampling.—In sampling a dump, or an ore pile, it may be done quickly by grab-sampling. The sampler may be blindfolded while he picks up from the pile the fragments of vein and ore with which his hand comes in contact. Or, the pile may be sampled by a careful selection from its surface.

Car samples may be taken in the same way. None of these methods are as accurate as the regular methods of sampling for buying and selling purposes.

The most satisfactory method of sampling a mine is to take from five to ten tons of the ore and ship it to a mill or smelter, where the actual commercial value of the ore can be obtained. Such a car load should be taken from all portions of the vein.

Smelter Sampling—Slags.—In sampling slags it is better to do so while they are hot and fluid. A slender iron rod may be used, a portion of which bent at one end serves as a handle. It is thrust into the red hot slag and quickly withdrawn, and instantly placed in a bucket of water. The thin shale of slag coating the end of the rod falls into the water. Where the slag is run in pigs on the ground as from matte reverbatory furnaces, the slag must be broken before too cool, and the red hot thrust into its centre. In this case the rod is far the best, but when the slag is run into pots a small iron cap with a long handle may be used, the surface of the slag in the pot being broken and the cup thrust into the molten fluid, care being taken that all the particles of matte suspended in the slag be first allowed to settle. The slag in the cup should be cooled slowly, and, on breaking, present a glassy appearance. Slag may be sampled when cool, several pieces being broken off from it, but this method is more inconvenient, and is not so representative of the quality of the slag. Surface samples should not be taken as bits of coke or flux are apt to adhere.

Matte.—In sampling matte the cup should be used, the slight crust which has formed on the pot broken and the cup thrust well in, as slag is frequently on the surface. If, however, the pot is full of matte, it is not advisable to thrust the cup to the bottom as speiss is very apt to be present. The sample is cooled by dropping it into a bucket of water. Where the matte is run into a mould as in copper reverberatories the matte is sampled by breaking small chips from the centre and one end of the pig.

Zinc Pots.—The following is the method of sampling the zinc pots in the desilverization process: After the final zincing and the last alloy of zinc, a rich silver-lead is skimmed from the surface of the pot; and a long-handled pair of tongs having a cavity in each tong, which when closed resembles a bullet mould, is thrust into the pot by the workman, worked back and forward until heated then suddenly closed, drawn up and opened on a clean board or flag-stone. This is the method of sampling the bottom of the pot, two bullets usually being taken. The upper portion of the pot is sampled by quickly thrusting in and quickly withdrawing a thin short bar of steel, rounded at one end; a thin coating of lead will adhere, which can be readily removed by slitting one side. These samples will vary slightly .10, .08. The lower portion of the pot usually runs a trifle higher than the surface sample, though the workman can usually tell by the nature of the last alloy removed, its crystalline structure, etc., whether the silver is all taken out.

Bullion.—The bullion direct from the blast furnaces is sampled with a punch hammer, which removes a core from each bar. These cores may be duplicated by one from the middle of the bar and one from the end.

When pure refined or test lead is manufactured, the desilverizing process is continued till the lead assays .005 or less silver to the assay ton. This requires a repetition of the zincing process, and a re-sampling after each removal of the zinc alloys. The sampling is performed in the same way, however, but the assayer uses two assay tons from the top and bottom of the pot, which he first scorifies and then cupels.

These should be taken, melted down in a pot by a moderate heat in a wind furnace and the contents poured into a mould. This may be done at the close of a month's run. The bar has a piece chiselled from the end and across the middle. This is rolled out with a hand roller to a ribbon the thickness of sheet lead, and with shears, cut across into the strips, then again cut across into small squares which are mixed up. Two assay tons weighed out which are scorified and cupelled. Usually it will be found that the middle of the bar runs a trifle higher in silver than the end.

Blast-Furnaces.—The furnaces are sampled at the lead wells, the antimonial and copper oxides brushed off the surface and a little lead poured on to a flat cold sheet of iron near.

Softening Furnaces. — The softening furnace is sampled in much the same way, the surface cleaned and sample poured on the flagstone pavement near the furnace.

Cupels and Silver Furnaces.—In sampling cupels the surface oxide is brushed away and a cup thrust in and the contents poured on a clean portion of the hearth.

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In silver furnaces the bar or poker end, first cleaned, is quickly thrust into the molten silver, coated and knocked off on to the hearth. The sample should be taken from a portion of the bath on which no trace of lead oxide floats. In sampling the silver while pouring into the moulds a bucket of clean water should be at hand, into which a portion of liquid silver from the ladle is dropped at intervals. If the ladle is held high and carefully shaken the silver will be granulated. After each sample the bucket should be cleaned and refilled.

In smelter sampling—such products as the *zinc oxide* formed by driving steam into the molten lead—after the zincing process, the *flue dust* from blast, cupel and silver furnaces, the *litharge, cupel bottoms, furnace linings*, the most of these being sampled and assayed at the close of a month's run.

The *sampling of flue dust and zinc oxide* is done by selecting portions from the heaps and cutting these down by a riffle to a small bulk.

The Dangers of Dynamite

In an article contributed to the *Genie Civil* of the 11th June, M. P. F. Charon, Ingénieur des Arts et Manufactures, discourses on the influence of dynamite on the health of miners, observing that its use—and in fact, the use of all so-called nitro-explosives in mines and public works—exercises an injurious influence, which it is desirable to point out. Dynamite is obtained by mixing nitro-glycerine with an absorbent substance, the office of which is to furnish a solid or, at any rate, a pasty mixture more convenient than a liquid one for use in mines. Notwithstanding the great variety of names given to modern explosives, for the most part they differ very little from dynamite, being mixtures of nitro-glycerine with one or more absorbents. Although some of them have as bases nitro-cellulose, nitro-benzine, nitro-naphthaline, &c., they are all nitrogen explosives, exercising an injurious influence through the poisonous or, at any rate, deleterious gases which they generate.

Theoretically, nitro-glycerine becomes decomposed into oxygen, nitrogen, steam and carbonic acid; but in point of fact, explosives of this nature, which are very difficult and dangerous to manufacture, give out a large volume of gas of highly complex nature, including carbonic oxide and vapours of nitro-glycerine, which, with the carbonic acid, are very dangerous to inhale, some of them, indeed, causing suffocation or poisoning. In addition to this, the explosion of dynamite often projects a *tourbillon*, or whirlwind, of dust, which penetrates the lungs, the injurious effects being in direct proportion to the quantity of the charge. According to M. Berthelot, M. Vieille, and M. Sarrau, 1 kilog. (2·2 lb.) of nitro-glycerine gives out, on explosion, a volume of 713 litres (2,520 cubic feet) of gas and steam, when reduced to a temperature of zero Cent. 32 degs. Fahr.), and a pressure of 76 mm. (3 in.) of mercury, the elevation of temperature due to the explosion being 6,980 degs. Cent. Admitting a free and instantaneous expansion of these gases would be, according to Mariotte's formula, nearly 20 cubic metres (706 cubic feet). In a mine heading of 3 square metres (106 square feet) sectional area it may be admitted that the products of explosion, driven along by the enormous pressure developed, would displace double the volume of air,—that is to say 40 c.m., which is equivalent to 13 m. (42½ft.) longitudinally. Of course the gases very soon contract on cooling, and are dispersed more or less quickly by the ventilation; but it is no less true that these gases remain mingled with the atmosphere of the mine sufficiently long to incommode the men. Approximately these gases are composed of—steam 19 per cent., carbonic oxide and carbonic acid 58 per. cent., nitrous products 15 per cent., and nitro-glycerine vapour in varying quantity; therefore about 11,000 litres (388½ cubic feet) of carbonic oxide and carbonic acid, and 3,000 litres (106 cubic feet) of nitrous products are instantaneously liberated on the explosion taking place, and must exercise an injurious influence on respiration if the explosions are often repeated.

Dr. Darlington who studied the deterioration of the workmen's health owing to dynamite explosions while driving the tunnel for the new Croton Aqueduct, at New York, noticed the following symptoms:—Headache, cough, indigestion and nervous trouble, severe cases being characterised by nausea, vomiting, violent and irregular beating of the heart, and sometimes feeble and intermittent pulse, with all the effects of asphyxia and poisoning; and these symptoms led him to suppose that the smoke produced by dynamite explosions contains a certain quantity of volatilised nitro-glycerine in addition to the poisonous or deleterious gases already mentioned.

To counteract these injurious effects it is recommended to take a strong decoction of pure coffee, and to inhale the vapour of ammonia, sulphurous acid or a concentrated acetic acid; while a small quantity of carbonate of ammonia, a few drops of ammonia in coffee, a glass of water, or antipyrine may be taken. Prevention, however, is better than cure; and M. Charon recommends, as preventative measures, energetic ventilation at the working face to promptly carry off the products of combustion; while to prevent any partial vaporisation of nitro-glycerine, and even to considerably reduce the formation of nitrous vapours, a much more powerful detonator is recommended than that generally employed—for instance, 1 or 1½ gramme instead of only a ½ gramme of fulminate—a sufficiently powerful detonator having the advantage of causing more complete decomposition, thus approximately realising the theoretical formula of transformation into the simple gases of the explosive.

Mining Development in the Slocan and West Kootenay, B.C., Mining Camps.

By Walter B. M. Davidson, F.G.S., A.R.S.M., Etc., Ottawa, Ont.

In 1888 Dr. G. M. Dawson, C.M.G., published an excellent monograph on the "Mineral Wealth of British Columbia," and his general notes end as follows:—"In the southern district, for which information is most complete, praiseworthy efforts are now in progress at a number of widely separated localities, toward the exploitation of ores, which, in many cases, have already been proved to be of an exceptionally valuable character. Here, at least, we have every reason to believe that we are on the point of witnessing the inauguration of an era of mining activity of the most important kind."

This prediction has not been fulfilled before this year, and there is no doubt that the "era of mining activity" has only just begun.

There is probably no other country where there is such a magnificent opening for successful mining, which has been so much talked about, and where all legitimate mining—except coal mining—has produced so little in actual results. Without doubt all this will soon be altered, and British Columbia will take rank as one of the largest producers of gold, silver, lead, and copper, in the world.

It is easy to trace the reasons for the failures which have marked the history of mining in this Province. Since the dying away of the excitement which started in 1858, when over thirty thousand miners swarmed over the country—penetrating to the head waters of the wildest rivers, and leaving good pay washings for the possibly richer beyond—some gold has been washed by white men and Chinamen, though in constantly decreasing amounts; but this gold, up till now, with the exception of a few small sample shipments of silver ores, has been the only practical outcome of mining achievement. Next year I trust we shall be able to say, *Nous avons change tout cela.*

Not less than three smelters have been erected during the past five years, and another (of which more anon) is in course of erection; one built at Vancouver is now demolished; the one at Revelstoke has had only a disastrous trial run of a week or ten days; and that at Golden, although finished, has not yet been blown in. These three are on the Canadian Pacific Railway, and have all been built by town site companies, and not by practical smelting men. They all attribute their failure to smelt anything to the impossibility of purchasing ore, and to the high percentage of zinc and antimony in the small quantities of ore offered. It was presumed, without doubt, that the erection of these smelters would encourage the miners to mine and produce ore, but it has failed to do so; and I regret to have to record as the result of my observations during an extended trip through all the most important mining districts of British Columbia, that the production of ore is the last thing that these so-called "miners" aim at. Their only wish is to try and develop their mine until a "fine showing" is apparent, and then it is carefully left, and never disturbed, in the hopes that it may be sold to some sanguine capitalist. This system has been carried out even in the Silver King mine on Toad Mountain and the Lanark mine at Illicilliwaet, and in the claims of the prospector who never pretends to do more than prospect. There is no pretense of legitimate mining, and while many mines are in the hands of wealthy individuals, none of them have any idea beyond bonding their properties in the hope of selling out. The only notable exception to this is the Blue Bell mine on Kootenay Lake, owned by Messrs. Franklin Farrell and Tomlinson (of the Parrot mine, Montana), and A. B. Hendryx (of New Haven, Conn.), where the intention is to work the property.

Naturally, under this system, development has been painfully slow; work has been entrusted to cheap, and, therefore, usually incompetent men; there has been no systematic plan of mining, no mining machinery, and often, where there has been a "good showing," the owners will not touch it for fear that the next blast may injure its appearance. I cannot do better than quote Dr. G. M. Dawson's words, which are as true to-day as when written:—

"While speaking of causes which have hitherto stood in the way of vein-mining, it must also be mentioned that not the least important of these has been, and still is, the fictitious or exaggerated value too frequently placed upon entirely undeveloped discoveries. While it is manifestly right that the discoverer should be properly remunerated, it should be remembered that a mere surface showing, however promising, generally requires the expenditure of a large sum before its true value can even be ascertained, and that till thus developed it is unreasonable to expect a large payment for mining claims."

Under these circumstances it is scarcely to be wondered at that there are virtually no results, for foreign capital is shy of investing in any place where there is no output; and as a good tree is known by its fruits, so is a mining camp known by its results. One mine producing ore in paying quantities will attract more capital into the country than thousands of prospects, or specimens, or newspaper puffs; for what attracts capital is a successful mine, and the best advertisement is the figure of output in the mineral statistics. I trust that before next year there will be several mines which will have substantial returns to make.

The district which this year has received the most attention is the West Kootenay, particularly the Slocan district. I have just returned from a professional trip, when I visited all the important prospects. At the time of my visit there were six or seven hundred prospectors—mostly from the United States—camped in "the Slocan," and though most of them have located a claim or two, few discoveries of any importance have been made this year, and attention was centred almost entirely on the most important of the discoveries of last fall. These were, "The Noble Five" group of five claims, (including the Noble Five and the Bonanza King), the Slocan Star, the Freddy Lee, the Lucky Jim (the last two were located by "float" last fall, and found in place this year). There are others, such as the Payne, Chambers, and other groups, which, while being promising prospects, present no extraordinary features.

The different mineral deposits are found in a black argillite or phyllite of the Nisconlith Series (Dawson) of the Cambrian age, which lies unconformably upon micaceous and hornblendic schists, quartzites and gneisses of Cambrian age. The mining field is a basin some twenty miles long by ten miles wide, and it is underlaid by micro and macro-crystalline granites to the south, and by an altered volcanic rock (mostly trachyte and diabase) to the north. The argillites are much contorted and folded, the cleavage planes are indistinguishable from the bedding planes, and they are traversed by frequent dykes of intrusive granite or felspathic trap. The argillites are frequently fissile, and are often calcareous.

The different mineral claims have generally a similar formation, and vary only in width, assay, and continuity. They have probably been formed in the following manner: When the upheaval which caused the mountain range took place, these slaty beds were crushed and folded as a quire of paper might be crushed between the hands; in this way certain crevices and spaces would be formed lying parallel with the bedding planes, or at right angles to the direction of the pressure. This pressure was energy and was accompanied by heat, and the two caused a molecular redistribution of the minerals contained in the calcareous clay slate, and the crevices were filled up by different minerals, quartz, calcite and argentiferous galena predominating. I noticed as associated minerals marcasite, copper pyrite, zinc blende, bornite, and tetrahedrite (Fahlerz), but only in small quantities. The galena is locally distinguished as "coarse cube," "steel" and "wavy" galena, the latter usually being antimonial. The pyrite is sometimes arsenical, forming mispickel. Crystallization is rarely complete and there are very few vuggy cavities.

The mineralized zones seem to be fairly regular and continuous for some little distance. At the Bonanza King, the zone is plainly traced on the course of a snow slide for two or three hundred feet, varying in width from six to fourteen feet, carrying a very varied percentage of galena in places; the galena appeared to form about ten per cent. of the zone, and there were occasional lenses of a foot to eighteen inches in width of pure ore. As no work had been done except clearing away the snow, and in places a little picking on the surface, it is impossible to estimate the percentage of lead ore to the total contents of the mineralized zone.

The assays of the galena vary extremely, but without doubt they carry an exceptionally high percentage of silver, varying from 80 oz. to many hundred ounces per ton. This group of mines, in my opinion, will prove to be a very fine property, judging by the surface indications, and of the claims, I think best of the Bonanza King. From its altitude, over 6,000 feet, and the great steepness, of the mountain, the want of water, and the ever present danger of a snow slide, the development work will have to be very carefully laid out, and in working the mines successfully there are many difficulties to be overcome. Judging from the surface indications it will be possible to cob and hand pick a good deal of the ore, but when operations are undertaken on a large scale the proper way to treat the ores will be to send the majority of it through a crusher and some form of separators; to do this it will have to be sent down 2,000 or more feet to Carpenter Creek, which can be best done by ærial tramway.

For this group of mines Mr. H. G. Bond, a well known capitalist and mining broker of Seattle, Wash., offered this spring $25,000 cash and $275,000 in September, but both parties seemed glad that the negotiations failed, though the owners are now very anxious to sell and would probably be glad to accept other terms.

The Slocan Star is in a more accessible position on the southern and opposite side of Carpenter Creek, but presents the same general features. Where the owners have commenced work they had made a cross cut of seven feet into the lode, exhibiting a fine body of galena measuring in all about 4 feet 6 in. in width, and several tons of ore were in the dump. According to the owners, average assays of this ore gave about 60 oz. of silver to the ton of galena. This lode or zone could be traced in the Creek some 700 yards away and 500 feet below; here it showed itself much wider, but apparently carrying only a very small percentage of lead and silver. No work had been done in this place, but the owners were taking energetic steps to drive a cross cut 100 ft. below their present outcrop, I hope and believe with every chance of their finding a fine deposit of ore.

The Freddy Lee is in the next canyon and on the same side of Carpenter Creek as the Slocan Star. It is at an altitude of 1,000 to 1,500 ft. above the stream, and on the course of a snow slide. Very little work had been done at the time of my visit, not enough to determine exactly if there was a lode or zone, or if it was only a "blow out" or pocket. On the dump formed by breaking up the croppings at this place, there were some 20 tons of galena, mostly of coarse cubes with occasional nodules of tetrahedrite (Fahlerz) which it is reported run very high in silver. Some 20 feet above where this work was done there is a narrow seam of ore some four inches in width, and the same is found about 30 feet below, but the lode is not traced or its dip or strike determined. James Wardner, the Lucky Jim of the Cour d'Aléne miners, and a local celebrity, who was once connected with the Bunker Hill and Sullivan mine, has bonded this property for $15,000, and had made a payment of $1,500 and was expected to do some development work and to ship the ore on the dump to some American smelting works, but there was no trail when I was there within about five miles of the mine.

The Lucky Jim is about 1,000 ft. above Bear Lake and presents the same general appearance as the other mines, it has been uncovered for about 30 ft. on the strike of the lode, the mineralized zone having a width with possibly 3½ ft. of galenite, where there is the best showing. No development has been done on this claim.

There are other groups of claims such as the Brennan camp and Jardine camp, but they do not claim to be of much importance.

The country is extremely rough, the mountains being from 6,000 to 9,000 ft. high, mostly with rocky summits, covered with snow till midsummer, but generally wooded high up the slope; the valleys are V-shaped. Snow slides are very frequent and the creeks have many falls and rapid declivities, and some may be used for water power, notably, Carpenter and Kaslo creeks.

Three rival trails have been cut, one by the Government, one by the C. P. R., and one by the Kaslo Town Site Company, all of which are now finished and passable for mules. It is reported that the C. P. R. will make a waggon road from Nakusp to the head of Slocan Lake, but this can scarcely be finished and will probably not be begun this year.

The Slocan River Trail is 32 miles, from the crossing on the C. P. R. to the Slocan Lake; it is then probably 14 miles to New Denver by boat. The trail is fairly good and the grade easy.

The Kaslo Trail is 21 or 22 miles from Kaslo Lake to the Bear Lake at the summit, with a rise from 1,750 (Kootenay Lake) to 3,780 ft. at summit. There is an uncut trail from Bear Lake to the forks of Carpenter Creek, about 6 miles, which would connect with trail to New Denver. The trail is made about 6 miles beyond Bear Lake, round the mountain hog-back, and zig-zag up the mountain to the Payne mine, at a height of about 5,000 ft. The trail stopped there, about 2½ miles from the Noble Five group, because of the snow.

The Nakusp Trail I did not go over.

The season here when transport is feasible, is short, and the winters are long, but now that there are three trails into the mines, it is to be hoped that at least one will be kept open all the winter.

The smelter and concentrating works which are being erected at Pilot Bay will be, when completed, the finest in Canada, and equal to any in the United States. The concentrators will have a capacity of 100 tons a day, and the roasting furnaces will be able to treat 50 tons to 75 tons. In addition they are building a refinery which will separate the lead and silver.

There will be no difficulty in procuring the limestone and iron ore needed as flux, as there are beds of limestone in close proximity to the Blue Bell mine, and the ore from this mine in itself contains a good deal of iron; in addition a fine deposit of iron ore has been discovered opposite to the smelter, on the other side of the lake.

The Blue Bell mine, owned by the parties erecting the smelter, has been sufficiently developed to prove the existence of enough ore to supply the smelter, almost to its full capacity, for some years to come, and the ore is easily and cheaply mined, the tunnel coming out on the edge of the lake near the wharf, about eight miles north of the smelter. The ore is a galena, mixed with considerable quantities of iron pyrites and zinc blende, and will need concentration. It is argentiferous, carrying from 15 to 25 ounces of silver to the ton.

There is a large quantity of decomposed ore matter forming a talus at the foot of the hill in which the mine is situated; the limestone underlying the ore having been leached away, the overlying ore has fallen in, and has formed by double reaction oxides and carbonates.

Although the Pilot Bay smelter expects to depend mainly on the Blue Bell mine for its supply of ore, it will also be a custom smelter, and proposes to buy any lead or silver ores offered, and to give prices which, while leaving a fair profit, will encourage the extraction of ore. Next year there will be no excuse for any miners in the Hot Springs camp or round Kootenay Lake to remain inactive.

This smelter will depend at present on Montana coke or charcoal made in the vicinity, but they eventually look to the Crow's Nest Pass as their source of fuel.

The plans for the smelter were laid out before the discoveries at the Slocan last year, or doubtless another location would have been chosen, but it can smelt all the ores coming out by the way of Kaslo. Unfortunately the proposed railroad on the route is not of easy grade, and will be expensive to build, and the natural outlet is by Carpenter Creek to New Denver.

Canada has to thank the McKinley tariff for this American enterprise on her side of the line, and the same cause has led to the erection of many furnaces in Mexico, and the rich dry ores of Arizona and New Mexico are now taken to the poorer galenas of Mexico, and the silver is smelted there to the great benefit of the southern republic, and the injury of the American mining industry. The great smelters of Helena, Montana, and Butte City, have great difficulty in securing sufficient lead to flux the "dry" ores of Nevada, Idaho and Montana, and there is no reason, with proper enterprise, that Canada should not become a purchaser of these rich ores and a smelter of them in conjunction with her own silver and lead.

Up till now the smelters have only offered the miners London prices for the metals in their ores, less freight, insurance, etc., to an English port, and have had to charge high smelting rates from the heavy cost of labor and fuel. It is self-evident that lead or other metals can be brought to Montreal cheaper by ship from England than they can be brought by the C.P.R. from British Columbia, and they have claimed that there was no local market to speak of in British Columbia. Owing to the enterprise of the C.P.R. this state of affairs is now altered, as by their Pacific line of steamers to Japan and China the market of the east can be more cheaply reached by the product of British Columbia mines than any other route. The consumption in China of lead for lining tea chests alone amounts to nearly 10,000 tons per annum, and there is no reason why large manufactories of white and red lead should not be erected on the coast, and even India and Australia supplied by the manufactured article. It will be found too that the Californian market will prove a profitable one, notwithstanding the duty which is paid by the consumers, and not by the producers.

It must be borne in mind that the China market is a peculiar one, and great care should be taken to have the lead pigs of the same size and quality as those to which they are accustomed.

In this article I have dwelt particularly on the Slocan camp, as it is the newest and least known; but the whole country is teeming with mineral wealth, and development is not confined to this district. The Slocan camp promises, even now, in its infancy, to become a very large ore producer, judging from the prospects already found, and doubtless many more and equally good locations will be discovered, and from the high silver content of the lead, it should take rank as one of the largest silver producing camps in the world. Many disappointments will undoubtedly occur, but I have every confidence that there will be in time several silver mines of world-wide repute, if they are properly developed and judiciously worked, and I trust that Canadians will reap the profits.

There are several other very promising new mines in the Kootenay district, of which I may particularly mention the Tam O'Shanter, owned by Montreal parties, and since the date of my visit I have received word of several most promising prospects having been found.

I do not refer to the well-known Toad Mountain group, which includes the Silver King, for at the time of my visit Mr. Charles Roepel, a well known mining expert, was making a professional examination of the Silver King mine, and it is to be sincerely hoped that his report was favorable enough to induce the parties by whom he was employed to complete the negotiations and transfer this extremely valuable property to a syndicate or company which will have the means to exploit it. Should this be done, and the working of the mine prove a financial success, it will be the finest possible thing for mining in Canada generally, and British Columbia in particular. The ore of this mine is mostly bornite, a sulphide of copper carrying a large percentage of silver, and should it be treated on the spot, the erection of concentrating and electrolytic refining works will be necessary. These in the United States have had the greatest financial success, and should prove equally remunerative in Canada, while the products in the rough or manufactured would find their natural market in China or Japan.

In other districts there seems to be real mining activity. Mr. John B. Hobson, of the State Mining Bureau, San Francisco, and perhaps the best authority on hydraulic mining in the world, has been retained to report on the gravels of the Fraser and Thompson rivers, and has reported favourably on them; and I understand that hydraulic mining will be commenced at once. The platinum and gold deposits on the Tullameen and Similkameen rivers are attracting great attention and some are likely to pass into the hands of powerful companies. The same is true of the Okanagan and East Kootenay districts, and great developments are promised in the Boundary Creek district, where there are very rich deposits of copper and silver lead, and the late discoveries on Fish Creek are, I was informed, looking well, and some claims are being intelligently proved under the management of Mr. Fishburn.

In conclusion, I will state that never before since the early days of Nevada and Colorado excitement, was there such a chance of successful mining enterprise and investment as there is to-day in British Columbia, for enough has been proved and discovered to show the presence of the ore bodies of great extent and richness. The C.P.R., the Dominion and the Provincial Governments, are most anxious to assist the country's development and aid private enterprise in every way by the granting of land and the building of roads. A splendid market in China and Japan is within easy reach, and I believe that British Columbia in a few years will take its place as one of the largest mineral producing countries in the world.

Unveiling of a Monument at Westville, N.S.—On Saturday, 20th inst., a monument to the memory of the colliers who lost their lives in the deplorable explosion at the Drummond colliery in 1873, was unveiled in Drummond Park, Westville, Nova Scotia, with becoming ceremony. Speeches were made by Mr. John McDougald, Mr. Rod. McDougald, Mr. Hall, (the chairman), and by Mr. Charles Fergie, the highly esteemed manager of the Drummond colliery.

Mr. Robert Simpson, M.E., formerly manager for the Intercolonial Coal Company at Westville, has gone to British Columbia, where it is thought he will practice in the future.

Process of Manufacturing Alloys of Iron or Steel and Nickel.

We give below a brief description of the process of manufacturing nickel steel recently patented by E. F. Wood, of the Homestead Steel Works, who has assigned the patent rights to the Carnegie Steel Company.

The invention concerns, chiefly, the method of introducing the nickel into the presence of the melted iron or steel and securing its admixture therewith, and it consists in effecting the reduction of oxide of nickel in the presence of the fused iron or steel, either before or after the decarburization of the pig metal, by mixing the oxide of nickel with carbon and exhibiting the mixture to the metal fused or in the process of fusion, so that the nickel ore may be reduced.

The nickel oxide used may be any of the natural ores, or what is known as "artificial" nickel ore, which is preferable on account of the leanness of the natural ores, and generally analyzes about as follows:—

	Per cent.
Iron	23.870
Nickel	48.230
Phosphorus	0.007
Silica	1.900
Sulphur	0.264
Copper	trace.
Oxygen and earthy matter	25.729
Total	100.

The process of manufacture of this nickel steel differs only from the ordinary open-hearth or Bessemer process in the manner of introducing the nickel, which is thus accomplished:

The nickel addition is prepared by grinding or otherwise pulverizing the nickel oxide and then mixing it with powdered charcoal or coke in the proportions of about 1 part, by weight, of carbon with 3 parts, by weight, of pulverized nickel ore. If a lean natural ore is used, a smaller percentage of carbonaceous matter will be required, and if the proportion of nickel in the material used is greater or less than before mentioned the amount of carbonaceous matter should be correspondingly increased or diminished. The object of the carbon being to effect the reduction of the oxide of nickel, the exact proportions of carbon added being easily determined in practice. The nickel and carbon being intimately mixed, are formed into a plastic mass, with a sufficient quantity of some binding material, such as tar or silicate of soda, and this plastic material is formed into small masses, preferably bricks, which are compressed into a solid condition. The purpose of this pressure is to compact the materials, so that they can the more readily be kept immersed in the melted metal. It is preferable to previously dry the ore, so as to render the bricks more compact and to prevent the presence of water. The amount of oxide of nickel contained in these bricks can be readily determined by a previous analysis of the ore (natural or artificial) of which they are composed, and on the quantity of such bricks used with a given charge of metal will depend, of course, the percentage of nickel contained in the resulting product, which may vary in any desired degree, according to the character of the nickel-iron or nickel-steel to be manufactured, it being understood that an allowance should be made for the loss of about 10 per cent. of metallic nickel which passes into the slag and is lost. The amount of this loss varies, however, somewhat with the different processes of iron or steel manufacture.

The application of the process to the open-hearth furnace is thus described: The open-hearth furnace being suitably heated, a proper proportion of nickel-addition bricks are placed on the hearth, mixed with the charge of pig metal, which is so placed as to prevent the bricks rising to the surface of the metal as it melts, after which the open-hearth process is carried on in the usual way, the decarburization of the pig metal and its subsequent recarburization, together with the addition of spiegeleisen or ferro-manganese, being conducted in the usual manner. The effect of introducing the nickel addition in the manner described is that the oxide of nickel is reduced in the presence of the melting or melted pig metal, and the metallic nickel thus produced becomes intimately mixed with the iron, while the earthy and foreign matter of the nickel ore is melted and unites with the slag.

The process applies also to the use of the nickel addition in the basic process of decarburizing pig metal without any other change than the addition of the nickel bricks; and it is found preferable in the basic process to add the bricks after the addition of the limestone and before charging the pig iron, so as to bring the nickel bricks into more intimate contact with the melting iron or steel.

When used in connection with the Bessemer process it is perferable to introduce the nickel additions into the iron ladle as the molten pig metal is being charged into the converter, if the iron were hot enough at that stage of the process; but as this is usually not the case it is better to introduce the nickel brick into the Bessemer converter before the molten iron is charged, no other change in the conduct of the Bessemer process being required; or the nickel bricks may be added to the Bessemer metal in the steel ladle at the end of the process, the steel being blown hot enough to cause the complete fusion of the bricks, in which case the nickel ore will be at once converted into metallic nickel and mingled with the liquid steel.

Coal Mining at Lethbridge, N.W.T.

By Frank B. Smith, B. Sc., M.E., Anthracite, N.W.T.

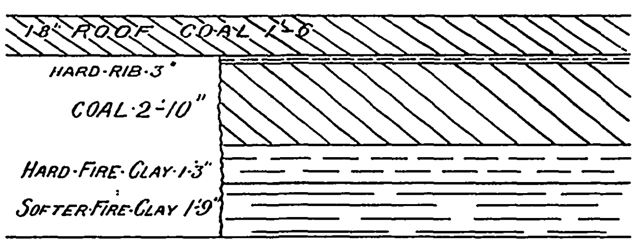
The railway to the Galt Coal Mines, operated by the Alberta Railway and Coal Company, leaves the Canadian Pacific Railway main line at Dunmore Station, and is constructed as a narrow gauge, running in a south-westerly direction for 110 miles to the town of Lethbridge, in Southern Alberta. A few miles east of this town another narrow gauge branches off to the south and crosses the line to the city of Great Falls, both lines being owned by the Alberta Railway and Coal Company. The town of Lethbridge is beautifully situated on the prairie close to the valley of the Belly River, where the trail crosses the valley to Fort McLeod. The town possesses some very substantial buildings, and has every indication of being one of the most flourishing in the North-West.

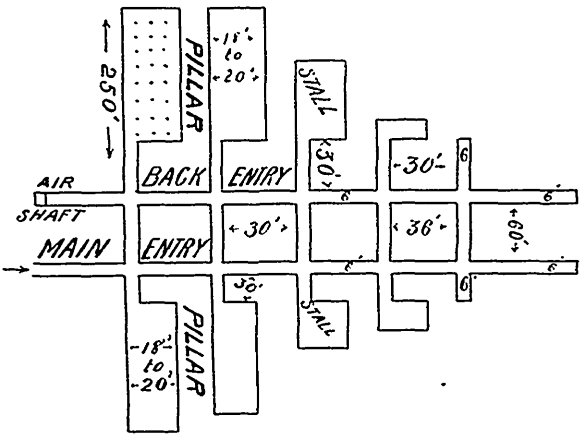
The mines are situated near to the town, and consist of entries made from the level of the valley, and four shafts sunk from the level of the prairie to the coal, a distance of about three hundred feet, and half a mile apart. From the river valley the coal can be seen cropping out along the banks and dipping generally in a north-west direction. From the valley there have been eight double entries working out the coal; all but two have, however, been worked out to the required distance for the economical working of the coal. The principal entry now at work is a stone drift for about one hundred and fifty yards, and driven at an easy gradient to strike the coal at a lower level. The system of working the coal in this district is by driving double entries, a main and a back entry. These again are connected by ends or rooms about thirty-six feet apart, to allow the air to circulate freely, and continue the working of the coal on the pillar and stall system. The main and back entries are driven six feet wide, and every thirty-six feet a room is branched off right and left, driven in the solid coal for thirty feet, and then opened out into a stall about twenty feet wide. The work is now carried on in a breast keeping the road close to the fast side of the place, the waste part of the working being partially timbered and filled in with dirt. The stalls are now worked forward at right angles to the main entry for a distance of about 250 feet; when this required distance of the stall has been reached by the miner, he opens out the full width of the place, about 36 feet, and takes out the pillar of coal to the waste of the stall, which has been previously worked to the required distance. The general section of the coal as wrought here is:

Shale.
Coal, 1' 6".
Hard Rib, 3".
Coal, 2' 10".
Hard Fire Clay, 1' 3".
Softer Fire Clay.

The main entries are driven straight, and the roadway formed by leaving on the top coal for the roof and lifting about three feet of the fire-clay, making a roadway six feet high by six feet wide, suitable for pony haulage, which is the system adopted for drawing the coal from the mine. When the rooms have been formed and the miner has opened out the stall to the required width, the coal is broken up to the full height and carried forward in a breast, as previously mentioned.

SHALE SECTION MAIN ENTRY





SYSTEM OF WORKING

MAIN ENTRIES PILLAR & STALL

The mode of ventilation used in the entries is by a furnace built on the back entry, a shaft to the surface, surmounted by a chimney about 50 feet high, giving an adequate amount of air to all the miners. The coal is drawn from the river level to the bank head up a double track incline by a geared engine lifting eight hutches at a time, and weighing in all about 12 tons, not including the rope. When the coal has been landed at the bank head, it is tipped over screens into a waggon which stands on the platform of a weighing machine, and so the amount of each hutch is registered. The bars of the screens are respectively 1" and ¾" apart, and the slack which passes through the screens is landed in a pit, and again elevated by buckets and passed through a revolving screen with half-inch meshes. This revolving screen divides the coal into two classes, nuts and dross. Near to the bank head No. 1 shaft has been sunk to the coal, a depth of 275 feet, and in connection with it an air shaft has also been sunk, and to this shaft is fitted a Murphy fan 6 feet diameter. This fan will either exhaust the air from the shaft or force it down, as sometimes required by the state of the weather. The reversing of the current of air is made by opening or closing certain openings. The speed of the fan is usually about 200 revolutions per minute. The winding engines for No. 1 shaft are two 20 inch cylinders, direct acting, on a spirally grooved drum and excellent brake connection. The pithead frame, screening, and general arrangements at this shaft are of the most modern type, including a safety clutch on the cage, so that if the wire rope was breaking, the cage would only descend a few yards until the clutch acted on the guides of the shaft, stopping any further descent.

Nos. 2, 3 and 4 shafts sunk to the coal are all equally well equipped, so that should a greater demand take place for coal this company could on the shortest notice increase their output of coal to 1500 to 2000 tons of coal per day. The coal is of an excellent quality, and is used largely for steam raising purposes, being equally good for heating and cooking stoves.

Souris Coal Fields.

What a pleasing sound the mention of the above name must be to the ears of all, and especially commercial men, in Manitoba and the eastern portion of Assiniboia. The opening up of the coal fields in this part of the Dominion, so destitute of wood, will be one of the greatest boons that this part of the country has yet experienced. In the great city of Winnipeg, and all towns along the track to the coal fields, the general topic of conversation is the probable development of the new city of "Estevan," and these remarks usually interspersed with the never ending subject, the crops. The journey to the coal fields at present is a tedious one, but in a few months the Canadian Pacific Railway is sure to be running trains direct through to this promising town. Along the route from Brandon to Oxbow, the present railway terminus, are many flourishing towns, and the land for miles on either side of the track is well settled and cultivated. The distance from Oxbow to the coal field is about 42 miles, and this part of the railway has now been completed, although not yet open for passenger traffic; this distance is covered by stage, the trail following the construction line the greater part of the way. When within five miles of the coal fields there rises to the view a number of "Buttes," relieving to the eye the monotony of the level prairie. It is about one mile on the south side of these Buttes stands the present tent city of Estevan on Sec. 23, R. 5, Tp. 2. Here we find a mining, railway contractors' and surveyors' camps, also a wooden boarding house, livery stable, and a Jew's dry goods store. On the side of the Long Creek, which joins the Souris River a mile further south, are to be seen entries going into the side of the valley where the miners have been prospecting. Some of these entries are driven in the coal about 200 feet, and the coal as seen in them is of very fair quality, and an average thickness of eight feet. The bottom of the coal seam lies about forty to fifty feet below the level of the prairie, and from all appearance seems to lie very flat, or in some places may lie in troughs like the prairie. The pavement and roof of the coal seam is not what a practical miner would desire if he had the making of them, as they are both a trifle soft, but there is no doubt a system will be devised after experiment for the safe and economical working of the coal. The seam is of a woody structure and friable, which will render it a little difficult of transportation, but the system of dumping the coal direct from the mine into box cars, and from them to coal sheds or cellars, will obviate to a great extent the slacking that takes place when the coal is exposed to the atmosphere for any length of time. The coal burns extremely well, and leaves a light ash; there is no doubt that it will be largely used for heating and cooking purposes, and supersede the burning of wood, and to some extent the hard coal in this part of the country. About one mile to the south of the new town site, in the Souris Valley, are vast flats about 50 to 60 feet below the level of the prairie, and nearly one mile wide. These flats have been formed by the burning out of the coal at no very distant date, and the exposures of strata in the cliff shew that in conjunction with the coal are fine seams of clay suitable for brick making purposes. Here also good building stone is to be found, which will ensure that the great coal field city of the future will not be a wooden one, but good substantial buildings of brick and stone. Twelve miles further down the Souris River are two coal mines which have been in operation for a number of years, supplying all who liked to come to the mine for it at the moderate sum of $1 per load. The coal in these mines is also eight feet thick, and the entries run below the prairie about one hundred and fifty yards, with rooms branching right and left. The mining here has not been carried on in a systematic manner, but the quality of the coal is very fair, and seems to be harder than what has been already mined at the new coal fields, but in all likelihood the quality of the latter will turn out as good when the miners have penetrated a greater distance below the prairie. The company who have now taken up the enterprise of opening up the coal fields in the Souris district should assure the public that the undertaking will be gone on with in a systematic manner, and no money will be spared to try and make it one of the greatest successes ever attempted in this part of the country. The first car load of coal was shipped to Winnipeg on the 2nd ulto., and is to be sold there at the rate of $4 per ton.

Cost and Uses of Aluminium.—Alfred C. Hunt, President of the Pittsburg Reduction Company, does not encourage the idea that aluminium is to be made "dirt cheap;" but as he considers it probable that the price will be ultimately brought down to 15@20c. per pound, a cheapness is indicated which will have important industrial effects. One of the principal respects in which a lowering of the cost is expected is in the electrical energy required for the process of deposition, which now makes up one-third of the cost. Mr. Hunt thinks that the power to be developed at Niagara will prove "one of the best in the world for the manufacture of aluminium. A small percentage of aluminium makes a handsome bronze with a tensile strength of 80,000 pounds per square inch, while a limit of 130,000 pounds is attained and can be supported under contract. It is feasible to make a wire of aluminium, alloyed with silver, titanium or copper, which will have as compared with copper, weight for weight, an electrical conductivity 70 per cent. greater than copper. In view of the magnitude of the problem of transmitting electrical power, this declaration that the aluminium-titanium alloy will be the cheapest and most advantageous electrical conductor has a vast importance. The important qualities which this metal seems to possess are its relative lightness; its non-tarnishing quality; its extreme malleability; the ease with which it can be cast; its influence and value in alloys; its high comparative strength and elasticity; its high specific heat and its conductivity of both electricity and heat.

The Minerals of Ontario.

AN ADDRESS BY MR. A. BLUE, DIRECTOR OF MINES, TORONTO, TO THE STUDENTS OF UPPER CANADA COLLEGE, MAY 6, 1892.

Continued from page 129.

with those primary rocks, or those still older and formless rocks whence the primaries had their origin? To think on those themes, or seek to answer those queries is only to bring up afresh the questioning which came to Job out of the storm.

Who is this that darkeneth counsel
By words without knowledge?
Gird up now thy loins like a man;
For I will demand of thee, and declare thou unto me,
Where wast thou when I laid the foundations of the earth?
Declare, if thou hast understanding,
Who determined the measures thereof, if thou knowest?
Or who stretched the line upon it?
Whereupon were the foundations thereof fastened?
Or who laid the corner stone thereof;
When the morning stars sang together,
And all the sons of God shouted for joy?
Or who shut up the sea with doors,
When it brake forth, as if it had issued out of the womb;
When I made the cloud the garment thereof,
And thick darkness a swaddling band for it,
And prescribed for it my decree,
And set bars and doors,
And said, Hitherto shalt thou come, but no further;
And here shall thy proud waves be stayed.

We are appalled by the story of our earth's creation; yet it is befitting that we study it, and speculate upon it, and strive to understand it. Even in things too large for finite comprehension it is profitable to speculate and enquire if we do so in a spirit of reverence and of loyalty to truth, for the mind expands by the contemplation of the universe about us. But let us get on to the practicable and the knowable.

The primary rocks, embracing the Cambrian, Huronian and Lauentian systems, together with the igneous rocks which sometimes overflow them as trap, but are oftener extruded through them as veins and dykes, are the source of almost all our minerals. Of the primary rocks we know something. They make up the surface of a very large portion of our country, and small regions of them have been explored and studied with more or less care for many years. They are indeed of vast extent and volume, covering an area in Ontario alone of not less than 150,000 square miles. In the Dominion they reach from the straits of Belle Isle on the Atlantic to Demarcation Point on the Arctic ocean, and cover an area of 2,000,000 square miles. Their thickness has never been measured, and owing to foldings and tiltings it may be impossible to measure it, but one section of the Laurentian series north of the Ottawa river was computed by Logan to be 32,750 feet, or a little over six miles. By others the depth of the upper division of this formation is estimated at 100,000 feet or nearly twenty miles. The Laurentian mountains, which extend in a V-shaped line from Labrador to the region west of Hudson Bay, are the oldest in America; and upon both their northern and southern slopes in Ontario, but especially upon the latter, are stratified beds of successive ages which are no doubt the accumulations of sand and mud worn away by the action of ice and rains upon the mountain ranges during countless time.

"The destruction of the elevations in the Laurentian districts," Prof. Shaler says, "is so complete that we cannot make out the original trend of the several ranges; as in an ancient city where the devastation wrought by time leaves nothing but a confused ruin which we only know to have been the dwelling place of men by the nature of the materials, so this old mountain field can only be shown to have been at one period like the newer systems of the Cordilleras and the Appalachians by the waste of its former structures."*

If you examine a fragment of Laurentian rock under a glass, or even with the naked eye, you will observe that as a rule it does not consist of one mineral or element, but of a variety of metallic and non-metallic substances which enter into almost endless combinations. Of the sixty or more minerals found in this Laurentian series and its enclosing veins, there are twenty-three enumerated by Sterry Hunt which are constituents of the country rock as well as of the veins, including such important ores as apatite, serpentine, muscovite, quartz, magnetite, hematite, pyrite and graphite. Great limestone beds are interstratified with gneisses and quartzites in the formation, and disseminated through the limestone or arranged in parallel bands, in it are grains of specular and magnetic oxides of iron, scales of mica and graphite, and crystals of iron pyrites and apatite, all of which are sometimes met with also in large accumulations either in veins or running with the stratification.

In the Huronian and Cambrian systems the minerals are largely the same as in the Laurentian, from which they have been derived; but they also abound in dykes and are covered in places with extensive overflows of greenstone and basaltic trap, and are reticulated with mineral veins. They are pre-eminently the metal-carrying rocks of our province, and are for that reason of first importance from an economic point of view, or are by most persons so regarded. The Cambrian system is confined chiefly to the shores of Lake Superior, embracing the Animikie, Nipigon and Potsdam formations; but there is also an outcropping of the Potsdam in the eastern part of the province, from the River St. Lawrence below Brockville to the town of Perth in Lanark. The Huronian is much more extensive, consisting of a number of belts or areas from the upper waters of the Ottawa river to Lake of the Woods. The system has not yet been accurately mapped, but the largest belt is no doubt that which extends from Georgian Bay northeastward to the province line at Lake Temiscamingue, where it enters Quebec and continues to Lake Mistassini. Other important belts lie between Lake Superior and the western limit of the province, and these like the one north of Georgian Bay have their greatest length in northeast and south-west lines. The most extensive remaining areas are those in the upper basin of the Moose River and its tributaries, and in the region north of Lake Superior and east of Lake Nipigon. The mineral-bearing district of which the northern part of the County of Hastings is the centre was at one time supposed to belong to the Laurentian system; but its rocks are now by some geologists classed with the Huronian, and by others with a later series, the Taconian.

Rocks of the Silurian and Devonian systems, which constitute all the more recent formations in Ontario, have hardly been disturbed at all since their first deposition, except as changes of elevation or subsidence may have occurred slowly and uniformly over wide areas. Veins carrying small quantities of galena, copper and some other metals cut through the lowest Silurian formations in the eastern parts of the province, where thin beds overlie the Laurentian rocks; but no dyke or vein has yet been discovered in the sandstones, shales and limestones which cover to great depths the country between the great lakes. Mineral veins are most frequent in districts where eruptive rocks are abundant and are confined to certain areas of disturbance, and of these conditions the Silurian and Devonian rocks of western Ontario give no sign. Either they were laid down in a quiet period of the earth's history, or the region over which they extend was never seriously subject to the influence of disturbing agencies. It is a vast plain whose level is only broken by long and low anticlinals, and therefore, there have been no great movements to divert pressure from one part of the earth's crust to another, to find out lines of weakness and develop volcanic excitement along lines of fracture.

I would not, however, have you assume that there are no minerals where there are no veins. Iron ore is sometimes found in large deposits in regions where no veins occur; and although it has not yet been discovered in the Silurian or Devonian systems of western Ontario, except as the local coloring matter of certain strata, no one can definitely say it does not exist there. Salt is found in great abundance in beds of the Onondaga formation, and above it in parts of the same formation are extensive beds of gypsum. Of limestones, sandstones and clays, there are illimitable quantities, suitable for economic uses; and of all the minerals of those newer systems, salt, petroleum and natural gas excepted, the source is to be sought in the Archæan rocks of the north.

As far as known there are about 600 mineral substances in the crust of the earth, which are made up of the 64 or more elements found in the earth and its atmosphere. These elements are classed as gases, metals of the alkalies, metals of the earths, metals proper and non-metallic substances; but many of them must be exceedingly rare, since it is estimated that eleven of the number make up 99 per cent. of the earth's crust. One of the gases, oxygen, forms one half of the whole; silicon, a non-metallic substance, one quarter; aluminium, a metal of the earths, one tenth; calcium and magnesium, two other metals of the earths, 8 per cent. of the whole; sodium and potassium, metals of the alkalies, 3.6 per cent.; carbon, iron, sulphur and chlorine together, 2.4 per cent.; and all other bodies one per cent. Of the compound bodies silica constitutes 53 per cent. of the whole; alumina 19 per cent.; and lime, magnesia, soda and potash, 17 per cent.; leaving the combinations of oxygen with carbon, iron, sulphur and chlorine to make up 7.5 per cent., and with other bodies 3.5 per cent. It thus appears that the metals proper constitute only a very small part of what we know as minerals; and in no corner of the globe are they so generally diffused as to form any great bulk of it, although some areas are vastly richer in the metallic ores than others.

No one can undertake to give an exhaustive account of the minerals of our province, for the sufficient reason that only a small portion of it has been explored. Fifty years ago the work of the Geological Survey was begun by Sir William Logan, with a small staff; but the labors of the Survey were spread over the whole of Upper and Lower Canada. Twenty-five years later the area was extended by Confederation to the Maritime Provinces, and in five years more the country was taken in from ocean to ocean, embracing a land area of 3,315,000 square miles. Logan's survey of Ontario did not extend northward beyond the height of land, and indeed a very large part of the Ontario of our day, northward and westward, was not supposed to lie within its boundaries a quarter of a century ago. Since then other portions of the Dominion have demanded the attention of the Survey, and the result is that little has been added to our geological knowledge of Ontario since the publication of Logan's Geology of Canada in 1863. Small sections have been surveyed with more or less care. Hunt made a report on the Huron salt district, Vennor on the Hastings district, Lawson on the Lake of the Woods, Ingall on the silver-bearing rocks of Lake Superior, and Bell on the Sudbury district. Other larger territories have been explored in a general way, but not so as to supply very definite or practical information on the character of their ores or minerals. Bell's report on the Hudson Bay district will answer for illustration; an exhaustive report on so extensive a region could not be made on the observations of two short seasons of field work. His more recent report on the geology of the Sudbury mining district is based on the labors of three seasons, and embraces a tract 72 miles long by 48 broad, or 3,456 square miles. Now at 130 working days in the season a thorough survey would require the covering of nine square miles per day, which is far more than could be accomplished under the most favorable circumstances. But see what the difficulties were as described in the report.

"Rocky ridges and boulder-covered slopes, alternating with swamps and small lakes, are the rule over the greater part of the area. In most parts the boulders are not only thickly scattered over the uneven rocky surface, but are often piled on top of one another without any finer materials between them. The trees which originally grew between and even on top of the boulders have generally been killed by forest fires, and their trunks have fallen over them in every direction. A second growth thicket of small prickly spruces entangled with tough young birches has sprung up among the boulders and resists the explorer's progress like a continuous hedge. This, together with the uncertain footing, due to the boulders and the net-work of prostrate trunks, renders it very difficult to make one's way through these obstructions. Indeed it sometimes became impossible to do so until we had first chopped a passage through them."*

With such hindrances to exploration large portions of the field must have escaped notice, and so the report cannot be assumed to deal fully with the ores and minerals of the district. It is possible that there are many metalliferous veins and ranges in those two and a quarter millions of acres of his sheet which the geologist either passed over unobserved or did not cross at all. The late Alexander Murray spent a year in surveying the district between Lake Wahnapitæ and the mouth of Whitefish river on Lake Huron, yet only the barest mention is made in his report of a sign of the nickel ore which within the last six years has made the name of Sudbury famous in America and Europe. Not one-tenth part of the province has been explored, we are told by the head of the Geological Survey, although the work has been carried on by the government for fifty years. Therefore we are forced to speak in a qualified way on the extent and value of its mineral resources. We know that they are considerable by the number and variety of discoveries which have been made and proven. They may be vastly greater, but that can be determined only when the whole area has been gone over, and 200,000 square miles is a very large territory to be scanned by the geologist's eye or sampled by his hammer. Fortunately his labours are being supplemented by the explorer, and in recent years the explorer has developed not a few of the qualities of an expert. Accordingly I feel sanguine that the ratio of progress in knowledge of the geology of our province will soon be increased, and that we shall not have to wait five hundred years for a completion of the survey.

I propose now to pass in review, as concisely as may be, some of the principal ores and minerals of the province, their places of occurrence, and the extent to which these resources of our natural wealth have been developed; and for convenience I shall group them under the following heads, viz: I. Metals and their Ores; II. Structural and Decorative Materials; III. Mineral Pigments; IV. Mineral Fertilizers; V. Refractory Materials; VI. Salt and Mineral Waters; VII. Materials of Light and Heat.

I. Of the principal metals we have, in alphabetical order, aluminium, arsenic, copper, gold, iron, lead, nickel, silver and zinc, one or two of which are sometimes found in the native or metallic state, but all of them in chemical combination with other elements in the form of ores and earths. Often they occur in veins traversing the crystalline rocks and in the rocks themselves, frequently as deposits and impregnated beds, and sometimes, but very rarely, in alluvial clays, sands or gravels. How the metals came to occupy veins or the country rock, and whether they came as elements or compounds, no one can tell. We can speculate on their source, and there are many theories,—so many, in fact, as to suggest the story of the young candidate at a civil service examination. "How did you succeed my son?" his father asked. "O pretty well, father, I guess. I answered one question I am sure." "And what was that?" "Well, they asked why Charles I. was put to death? and I answered that I didn't know." As to the metalliferous veins there are theories of contemporaneous formation, of igneous injection, of electric currents, of aqueous deposition from above, of sublimation, of lateral secretion and of ascension. Prestwich says that by Werner and his school "They were supposed to have been introduced in a state of solution from above; by others they were supposed to have been injected simultaneously with the opening of the fissures from below; but the more general opinion of geologists now is, that they are the deposits formed during lengthened periods by thermal mineral waters or by sublimation." And again he observes that—

"Ordinary mineral veins were no doubt fissures in which there were cavities or spaces left open for a length of time, and in the interstices or on the sides of which were gradually deposited a variety of minerals and of metallic ores. The banded structure of some veins, and the fact that the minerals are such that could be deposited in water, tend to prove that their formation has been in most cases due to thermal waters, rather than to sublimations of gases and vapors such as are now discharged in the solfataras of volcanic districts. It is possible that in some instances such emanations may have contributed to a particular

*The Story of our Continent, p. 99.

*Report on the Sudbury Mining District by Dr. Robert Bell, p. 7 F.

result, but in the majority of cases the phenomena agree better with the hypothesis of aqueous solution."*

Sir Archibald Geikie in discussing the various theories of *origin* says:

"The structure and characteristic mineral combination of metalliferous veins are precisely such as would be produced by deposition from aqueous solution. There can hardly be now any doubt that the contents of these veins have generally been deposited by water. But the source from which the metals were derived is not so obvious. The fact that the nature and amount of the minerals, and especially of the ores, in a vein so often vary with the nature of the surrounding rocks shows that these rocks have had an influence on the precipitation of mineral matter in the fissures passing through them, if they were not themselves the source from which the metals were obtained; for, as already remarked, the presence of the heavy metals has now been detected in rocks of almost every kind and age. On the other hand, in some volcanic districts at the present time, various minerals, including silica, both crystalline and chalcedonic, metallic sulphides, and even metallic gold, are being deposited in fissures up which hot water rises. Each of these modes of origin may in different cases have occurred. It is almost certain, from what we now know of the diffusion of metallic substances, that there must be a decomposition of the rocks on either side of a fissure, perhaps to a great distance, and that a portion of the mineral matter abstracted will be laid down in another form along the fissure walls. If, on the other hand, the rocks on either side of the fissure are permeated for some distance by hot ascending waters, holding such metalliferous solutions as have been detected in the hot springs of California and Nevada, some of the dissolved mineral substances will doubtless be deposited in the fissure, and may even be introduced into the pores and cavities of the adjacent rocks."†

Sterry Hunt's theory is set forth as follows:

"The metals . . . seem to have been originally brought to the surface in watery solutions, from which we conceive them to have been separated by the reducing agency of organic matters in the form of sulphurets or in the native state, and mingled with the contemporaneous sediments, where they occur in beds, in disseminated grains forming fahlbands, or are the cementing material of conglomerates. During the subsequent metamorphism of the strata these metallic matters being taken into solution by alkaline carbonates or sulphurets, have been redeposited in fissures in the metalliferous strata, forming veins, or, ascending to higher beds, have given rise to metalliferous veins in strata not themselves metalliferous. Such we conceive to be, in a few words, the theory of metallic deposits; they belong to a period when the primal sediments were yet impregnated with metallic compounds which were soluble in the permeating waters. The metals of the sedimentary rocks are now, however, for the greater part in the form of insoluble sulphurets, so that we have only traces of them in a few mineral springs, which serve to show the agencies once at work in the sediments and waters of the earth's crust."‡

And Arthur Phillips, after demonstrating the almost universal presence of heavy metals in rocks belonging to every geological period, states his conclusions briefly in these words:

"There can be no longer any doubt that the filling of veins has often been derived, in a state of chemical solution, from the surrounding country rock, and the theory of lateral secretion appears to explain more satisfactorily than any other certain phenomena not otherwise easily understood. It moreover not only accounts in a satisfactory way for the changes which take place in metalliferous veins when passing from one formation into another, but it also affords a reasonable explanation for the fact that shoots of ore usually follow the dip of the enclosing rocks."

This relation of ore bodies to surrounding rock was illustrated in the Silver Islet mine, to which I shall again refer, and has long been familiar to m..ers. The famous Dolcoath mine in Cornwall changed from copper to tin some forty years ago, and in both Cornwall and Devon it has been observed that some lodes yield tin where they cross granite, and copper where they traverse slate, changing from one metal to the other as they cross from the one rock into the other. In the north of England, again, the galena is most abundant in the limestones and scarcest in the shales, and Geikie mentions the fact that the veins in the Great Limestone, as it is called, which is 150 feet thick or less, have yielded as much lead as all the rest of a mass of 2,000 feet of strata put together.

The question of the origin of metals as found in veins and in the country rock has not been solved, but I thought it might interest you to be told what theories are held respecting it, as well as some peculiarities concerning the occurrence of metals and their ores.

ALUMINIUM IN ONTARIO—ITS HISTORY AND USES.

As to aluminium, the first of my list, the theory of its origin is not a matter of so much doubt as that of most other metals. Yet it is never found in a free state in nature, and although by great odds the most abundant of all the metals—being estimated to make up a tenth of the earth's crust—it is one of the most modern in respect of discovery. A great French chemist, Lavoisier, suspected its existence about a century ago as the metallic base of alumina, but not until 1827 was it isolated for the first time. Then, however, it was obtained only as a metallic powder; the first ingot was cast in 1854. Alumina itself was not named until 1760, when it was obtained by calcining alum. We find it in many forms and combinations. It is the basis of all clays, and when crystallized in six-sided prisms it is called corundum, the clear and blue varieties of which constitute sapphire and the red varieties oriental ruby. Alumina is one of the chief components of felspar, which is a mineral generally of igneous origin, erupted from below the sedimentary strata. Felspar itself is one of the components of granite and syenite; but occasionally it is found separate and in large masses, as in parts of the counties of Frontenac, Leeds and Lanark. It is very generally diffused in rocks of the Laurentian system. Exposed to atmospheric influences the soda and potash felspars are altered to kaolin or china clay, but generally the admixture of lime, iron and other impurities on this side of the Laurentians has produced the common clays of our farmland. In localities on the other side of the Laurentians, especially on the Missinaibi and Abittibi rivers on the Hudson Bay slope, there are extensive deposits of a very pure kaolin which, when reached by railway communication, will prove to possess great economic value. Doubtless you sometimes wonder at the lightness and strength of porcelain or chinaware, but wonder will cease when you know that it is made up largely of the metal aluminium. The sample of this metal before me, which is 8 inches long, 4⅔ inches wide, one inch in thickness and weighs only 3 pounds 8½ ounces, was smelted from a charge of kaolin in a crucible. As made by the first process thirty-eight years ago, aluminium cost its weight in gold. Six years later it was produced at a cost of $8 per pound and the selling price was $12, at which price it remained for twenty-five years. In 1885, by the application of electricity, the cost of production was reduced to $1 per pound; and by an improvement of the electrolytic preparation the cost in the following year was further reduced to fifty cents per pound, the selling price now being seventy-five to ninety cents per pound. By this last process it is claimed by Prof. Richards, instructor in metallurgy at Lehigh University, that "the electrolytic preparation of aluminium has reached its climax of simplicity." In an article in the January number of the *Cosmopolitan Magazine* Prof. Richards says:

"The electrolytic processes for pure aluminium will be developed, but not radically changed. Details will be improved, but in principle they have reached their maximum development. It is unlikely that by them aluminium will ever be made and sold at a fair profit much below its present selling price. It will be several years before this maximum development is reached, and then the aluminium industry, metallurgically speaking, will again be at a standstill. The next upheaval after this will be the discovery of a process using neither sodium nor electricity, a purely metallurgical one, simple, rapid and cheap, by which aluminium can be produced at a cost of five to ten cents a pound. The writer hardly looks for this within the next fifty years, but before the next century has run its length such a process will be in *operation*."*

Well, the truth of an old adage finds here another illustration: It is never safe to prophesy unless you know. A purely metallurgical process has already been discovered, a sample of what it can accomplish is the block of aluminium before me, and I am assured that at a selling price of twenty-five cents per pound there is a fortune in it for the inventor and the producers. As to its uses in the arts, these will depend on its qualities. It is light, being only 2.6 times heavier than water, while iron and steel are 7.8 and gold 19.3 times heavier than water respectively. A cubic foot of aluminum weighs 163 lbs., while a cubic foot of iron or steel weighs 487 lbs., and of gold 1,206 lb. It is strong, the tensile strength per square inch being 26,800 lb., while that of cast iron is 16,500 lb., of wrought iron 50,000 lb., and of steel 78,000 lb. It is feebly magnetic, it has no sensible taste or odor, it may be forged or rolled like gold or silver, it is ductile, it is fusible, and it is almost non-corrodible, neither air nor water nor sulphuretted hydrogen nor sulphuric acid having an appreciable effect upon it; besides which it has most valuable properties as an alloy with other metals. In his excellent work on Aluminium, published two years ago, Prof. Richards says:

"Whatever its price it can only replace gold or platinum because of its lightness; it already replaces silver, especially because of its resistance to sulphur, as well as for its lightness, besides being cheaper: it can only replace the common metals, at its present price, for uses where its lightness is an extraordinary advantage. But when its price is down to that of these baser metals it will begin to replace them by virtue of its other superior qualities, chemical and physical; aside from its lightness it will win a large field simply in comparison with them on its merits as a metal. Thus there are wide applications now almost unthought of, because the high price has been a blank wall to stop its use, but as it cheapens more and more we hear every day of new uses brought to light. Thus its sphere will widen until, since its ores are as cheap as those of iron, it will be approximate in utility to that universal metal. . . . When aluminium becomes cheaper it will without doubt be used for culinary articles of many kinds, replacing copper and tin vessels, for it is attacked to a less degree by the acids and salts ordinarily found in food than either of those metals, and possesses the great superiority that if dissolved its salts are not poisonous like those of copper or tin, being, on the contrary, perfectly harmless. The sulphurous acid of the air or of the products of combustion likewise leave aluminium untouched, while they quickly blacken silver."*

And in the article in the *Cosmopolitan*, from which I have already quoted, the same authority says:

"It has been discovered that many of the alloys of aluminium with other metals have very remarkable properties. For instance, five or ten per cent. of aluminium added to copper forms a beautiful bronze of a golden color and as strong as ordinary steel. A small portion of copper or titanium added to aluminium makes it much stronger without increasing its weight perceptibly. It is *these alloys which may replace steel for many engineering* purposes, for they approach steel in strength and yet are very little heavier than aluminium. Again, a very small amount of aluminium has a decidedly beneficial effect on cast iron, so that many founderies are using it, while for the difficult process of making steel castings aluminium is coming to be regarded as almost a necessity. Hundreds of pounds are being used weekly for this purpose."†

I have said so much on aluminium that I must necessarily be very brief in referring to other metals and their ores; but I have done so (1) because this metal is less known than most of the others, (2) because it is a metal of great promise, and (3) because it appears likely that no other part of America is so rich in the ores or earths from which aluminium may be extracted as our own province.

Arsenic is not a metal of high commercial value, it is *not consumed in large quantities*, and our supply of it in Ontario in the form of the white oxide far exceeds the call of the market. It is one of the components of the mispickel ores in the County of Hastings, and I believe that a sufficient quantity was produced at the Deloro gold reduction works when these were in operation several years ago, to meet all requirements to the present time.

Copper is found in various localities, on the north shore of Lake Huron, on the east shore of Lake Superior and elsewhere, generally as copper pyrites in quartz veins traversing greenstone or diorite, as at the Bruce and Wellington mines; but sometimes native and in sulphurets, in amygdaloidal trap, conglomerate and sandstone, as at Mamainse peninsula and Michipicoten Island in Lake Superior, and at points on the mainland along the north shore of this lake. It may be noticed here, and the fact has an important bearing, that microscopic observations made by the late Prof. Irving of the United States Geological Survey have established a complete identity between the Michipicoten island rocks and those of the typical copper-bearing districts of the south shore of Lake Superior in which are situated some of the largest and richest copper mines in the world.‡ Copper ore is found in many other parts of the province besides those already mentioned, but perhaps in the greatest quantity in association with nickel in the Sudbury district. For thirty years, ending with 1875, copper mining on a large scale was carried on at the Bruce mines; and Mr. William Plummer, who had charge of the works for a number of years, has estimated the value of the product of these mines at between $6,000,000 and $7,000,000. Operations at these mines were discontinued owing to the low price of copper and have not since been resumed.

ARGENTIFEROUS GALENA.

The ore of lead, galena, usually carries a small percentage of silver. It occurs in veins, the greater number if not all of which in this province are found in rocks of the Huronian and Cambrian systems. Mines have been opened in the Counties of Lanark, Frontenac and Peterborough, and smelting works have been erected at Kingston and near *Carleton Place, but owing to wasteful* management in one case, and to a limited supply of ore in the other these enterprises failed. There are rich veins near Garden River, in the district of Algoma, which were worked about ten years ago; and although considerable quantities of ore were raised, stamped and shipped, the lack of capital and markets led to the works being closed at the end of three or four years. On the north shore of *Lake Superior, near Black Bay, a number of veins have* been discovered, as also in the district of Nipissing, near Lake Temagami.

GOLD AREAS.

We have gold-bearing ores in many localities, as in the Hastings region, in the Sudbury country, in the valleys of the Thessalon and Mississaga rivers north of Lake Huron, on the north shore of Lake Superior, near Lac-des-milles-lacs, and on the islands and mainland of Lake of the Woods. Gold occurs almost always in quartz veins, in rocks of Huronian age; but sometimes it is said to be found in lands of slate, as on a location near the Vermilion river, west of Sudbury. Gold mining in Ontario has never been a profitable business, although fine specimens showing free gold are often exhibited by prospectors and real estate miners; but locations now being worked on Lake of the Woods, in the County of Hastings and in the Sudbury district are claimed to be full of promise. Reduction works recently started in the two regions first named are likely to prove the value of the ores, which as a rule are hard to treat. As illustrating the deceptive qualities of veins supposed to be gold-bearing, I may mention that of 96 specimens examined by the chemist of the Geological Survey, particulars of which

*Geology, Chemical, Physical and Stratigraphical, by Prof. Joseph Prestwich, vol. 1, pp. 331-5.

† Text Book of Geology, p. 590.

‡ Chemical and Geological Essays, 3rd ed., p. 220.

§ A Treatise on Ore Deposits, p. 85.

*The *Cosmopolitan Monthly Magazine*, January, 1892, p. 284.

*Aluminium: its History, Occurrence, Properties, etc., by Joseph W. Richards, M.A., 2nd ed. pp. 367-9.

† The *Cosmopolitan Magazine*, January, 1892, p. 286. The statement that these alloys are very little heavier than aluminium can hardly be correct, except in cases where the latter metal constitutes the principal part of the alloy.

‡ The Copper-bearing Rocks of Lake Superior, by Roland Duer Irving, pp. 341-7.

are given in the last report of the Survey, 46 contained neither gold nor silver, 13 showed traces of gold and 4 of silver, while of the remaining 33 there were 21 which contained gold and 18 silver, some specimens showing both metals. Yet of those 96 specimens 73 were collected by officers of the Survey, thus proving the truth of a saying common among miners that "A great many other things are mistaken for gold, but gold is never mistaken for anything else."

IRON DEPOSITS.

Ores of iron are abundant in the Laurentian and Huronian formations, chiefly as magnetite, but sometimes also as hematite and limonite. In the eastern part of the province there are large bodies of magnetic ores in the counties of Peterborough, Hastings, Frontenac and Lanark, some of which are of excellent quality; but sulphur is often present, and occasionally titanium, both of which are very objectionable substances in combination with iron. Yet it seems likely that methods will be found to get rid of both sulphur and titanium, or to greatly reduce their proportions in the ore, in which direction very marked progress has recently been made by a process which consists in crushing the ore and cleansing it at one operation with a flow of water and a magnetic separator. Limonite, the brown ore, is found in Peterborough, and hematite, the red, in Hastings and Lanark. Hematite ore also exists in what is believed to be large quantities on the north shore of Lake Superior. Farther west, on the Mattawan river, a range containing specular and magnetic ores is found which is supposed to be a continuation of one or other of the great ranges of Minnesota —the Mesabi and Vermilion. Other ranges of magnetic ore, which are described as of vast extent, lie along the Atik-Okan river, a tributary of the Seine, which flows into Rainy lake. These ranges have been traced a length of ten or twelve miles, rising in places 200 feet above the plain, and the ore is said to be very rich and clean. There are many other outcroppings of iron ore besides the ones I have mentioned; yet it has to be confessed that there is not a working mine in the province, for which the only consolation is that we have got the ore still, and that it may perhaps be more valuable in some day to come, when other great deposits in America are worked out.

NICKEL RESOURCES.

Nickel is the most important of all our ores, and there are inexhaustible supplies of it in the country north of Georgian Bay. Nearly fifty years ago nickel was found with copper on what is known as the Wallace location, near the mouth of Whitefish river. It was found also on Michipicoten Island; but at neither place is it known to exist in workable quantities. The construction of the Canadian Pacific Railway led to the important discoveries that have been made in the district of which Sudbury is the centre. A railway cutting through one of the rocky ranges exposed the ore, which at first was supposed to be copper pyrites, but which, six years ago, was ascertained to carry nickel as well as copper. Explorations and workings made since have resulted in proving that the Sudbury district is richer in nickel ore than any other known part of the world, and two engineers of the United States navy department have reported 650,000,000 tons of ore in sight. The data from which this estimate was computed may not have been absolutely trustworthy, but we know that other large and rich discoveries have been made since those engineers visited the district, and there can be no doubt of the vast extent of the ore. Eight mines are being worked, three large smelting plants are in operation, and as the demand is said to far exceed the supply the reports we hear of enlarged development of the mining and smelting industries of the Sudbury field will find ready acceptance. The value of nickel when united with steel, producing an alloy which combines hardness with strength and freedom from fracture under the strain of heavy blows, has been so amply demonstrated that the secretary of the United States navy department has decided to construct the armor plate of all his battle ships with it; and the British admiralty has recently decided to use it largely for the same purpose, extensive orders having been placed for nickel-steel armor which forms the secondary defence of the battle ships now in progress. There are various other objects for which this alloy is well suited, such as in the making of cannon, small arms, boilers and machinery, cutlery, etc., where strength, malleability, capacity to take a fine polish and freedom from rusting are valuable properties. Besides, there are many uses in the arts to which the pure metal may be applied when produced cheaply and in large quantity; so that we may look forward with confidence to great activity in the working of the nickel mines of this province, and, possibly as growing out of it in a natural way, to the awakening of our dormant iron mining industry also.

SILVER MINING.

The silver-producing district of our province is confined almost exclusively to rocks of the Animikie series in the Cambrian system, lying to the north and west of Thunder Bay in Lake Superior. The veins which carry silver are found cutting ranges of table-topped hills or mountains whose summit is basaltic trap and whose base is black slate. Underlying the slate are beds of chert and jasper of extreme hardness which contain a percentage of iron, and it is found that the mineral veins in these beds are much leaner in silver than in the slates. The observation of this fact has depreciated to some extent the value of silver mines in the district, but recent accounts give rise to the hope that beneath the cherts the veins become enriched again. Silver Islet mine, which lies in Lake Superior south of the Thunder Cape promontory, was one of the earliest discoveries in that region, and from its opening, in 1870, to the suspension of work in 1884, the value of the silver output was $3,250,000, the total depth reached being 1,230 feet. Although the vein of this mine has been explored on the mainland for about a mile, no silver ore has been found; the only productive part of it is at the intersection of the dyke which constitutes the islet, and out of which the silver is supposed to have been deposited. Other mines in this district, the best known of which are the Beaver and the Badger, have yielded large quantities of ore during the last four or five years, but if they have been worked profitably the fact has been carefully concealed. It may require more capital and skill than have yet been employed to give them a thorough test.

There are other metalliferous ores in the province, but I shall refer only to one other, viz., blende or the sulphide of zinc. A large vein of it exists on the White Sand river about ten miles from the north shore of Lake Superior. This was discovered eleven years ago, and it is claimed that the ore may be mined with great facility, but for want of a road it cannot be brought to market. A specimen analysed by the chemist of the Geological Survey gave 54½ per cent. of zinc. Another vein has been discovered a short distance from the head of Thunder Bay.

STRUCTURAL MATERIAL.

II. In structural and decorative materials Ontario is richer than most countries, both as regards variety and quality. Sandstones, serpentines, marbles and granites abound in the northern districts, while in the south we have sandstones, limestones, clays and the materials for the manufacture of cement. Native cements are obtained from limestones in the Niagara formation at St. David's, Thorold and Limehouse, and in the Trenton at Napanee Mills. Portland cement is now being manufactured out of shell marl, large quantities of which are found deposited in shallow or extinct lakes, the marl being mixed with certain proportions of clay of a suitable quality, after which it is baked in a kiln and ground to a fine dust. Clay for common brick and tile is taken from deposits of the Saugeen and Erie clays; while for the manufacture of pressed brick and terra-cotta, the shales of the Medina and Hudson river formations are used. The brown Medina shale, which crops out along the base of the Niagara escarpment at frequent points between the Niagara river and Owen Sound, has a depth ranging from 400 to 600 feet. The Hudson river shale crops out along the valley of the Don and Humber rivers, and is probably of as great thickness as the Medina, although not so accessible. A few years ago all the pressed brick used in Ontario had to be imported from Ohio and Pennsylvania, but a better quality may now be produced at home. Its introduction is bound to greatly improve the architecture of our towns and cities.

MINERAL PAINTS.

III. Mineral pigments of natural paints are obtained in a number of localities, and some of them are very abundant. Sulphate of barytes is used as an adulterant with white lead. It is found in many of the veins on the north shore of Lake Superior, and sometimes, as on McKellar's and Jarvis islands in Lake Superior, makes up a large part of the vein. In the eastern part of the province, but especially in the county of Lanark, there are numerous veins of this mineral. Ochres are clays of various colors, such as red, yellow and green. At Limehouse on the Grand Trunk Railway, a variety of colors is obtained, and pigments have been manufactured there for many years, as also at a point in the same formation farther south in the township of Nelson. Yellow ochre is a mixture of clay and limonite or the brown ore of iron, while red ochre is a mixture of clay with the specular or hematite ores of iron. Large deposits of the latter of fine quality are found in the counties of Lanark and Frontenac, one of which is 30 feet wide and three-quarters of a mile long; while another, which has a rich bronze hue, has been explored with a diamond drill to a depth of 65 feet.

PHOSPHATE AND GYPSUM.

IV. Mineral fertilizers exist as marls, gypsum, and apatite or phosphate of lime. The last named occurs as veinstone in the upper rocks of the Laurentian formation in various parts of the counties of Frontenac, Renfrew, Leeds and Lanark, but mining has been carried on chiefly in Frontenac and Lanark. The mineral is rich, but it is difficult to mine, and most of the deposits are remote from railway communication. During the past year the industry suffered partial collapse owing to the discovery and working of large deposits in Florida and the shipment of great quantities to the European markets. Gypsum is found over a large area in the Onondaga formation which underlies the counties of Brant and Haldimand, where mines have been worked for half a century. As plaster of Paris it has been largely used as a fertilizer for grass land, and when calcined it is used to furnish and decorate walls. There are very extensive deposits also on the Moose river and its tributary the Missinaibi.

SALT BRINES AND MINERAL WATERS.

V. Mineral waters and rock salt are of limited occurrence in Ontario, but while the latter occupies one field, the former are found in a number of localities and at points far distant from each other. Salt beds in the Onondaga formation extend over an area of 1,200 square miles in the counties of Bruce, Huron, Lambton and Kent. These beds no doubt were originally deposited at the bottom of inland seas as their waters gradually dried up. The total depth of the beds in Huron is about 100 feet, gradually thinning out to the edge of the basin; but a boring near the River Thames in Kent, is reported to have gone through one bed of white salt 171 feet in thickness. The supply is sufficient to last our province for centuries; yet it is small when compared with some other known deposits of rock salt, such, for example, as the massive accumulations at Sperenberg, near Berlin, which have been bored through to a depth of 4,200 feet, or those of Wieliezka in Galicia which are more than 4,600 feet thick. The annual make of our Ontario wells ranges from 350,000 to 400,000 barrels, and owing to the restricted market this limit of production was reached nearly twenty years ago. Mineral waters impregnated with sulphur and salt are found very generally in the western part of the province, when deep borings are made in rocks of the Upper Silurian and Devonian systems; whereas in the eastern section of the province they are alkaline waters and are found to issue from rocks of the Lower Silurian system.

GRAPHITE, MICA, AND ASBESTOS.

VI. Refractory minerals are such as require an extraordinary degree of heat to fuse them, or as are altogether infusible, among which may be named actinolite, asbestos, graphite, mica and talc or steatite. These are found in commercial quantities in the eastern counties of the province, in rocks of the Laurentian formation. They have not yet, however, been worked upon a large scale, with perhaps the exception of mica. This mineral, from its possessing good insulating properties, has recently come into extensive use in connection with electrical machinery, and last year 240 tons of it were mined in Ontario.

PETROLEUM, NATURAL GAS AND PEAT.

VII. Materials of a mineral character used in the production of light and heat are not of first-class importance in Ontario, being limited to petroleum, natural gas, lignite and peat. They are all of organic origin; the two former derived from animal or vegetable fossils, and the two latter from vegetable only. Our petroleum area at one time extended over portions of Lambton and Kent, but the producing field is now wholly confined to a few thousand acres in Lambton. It is obtained from the Corniferous limestone, but the original source may have been in lower formations. Natural gas is a recent discovery, but reservoirs of good producing capacity have been struck by borings in the Counties of Essex, Haldimand and Welland. In Essex the gas rises, it is supposed, from the Clinton formation, whereas in the two eastern counties it rises from the Medina sandstone. Extensive beds of lignite have been discovered interbedded with the drift in the basin of the Moose river and its tributaries, the Abittibi and the Missinaibi. But the peat deposits of the Hudson Bay slope have a vastly greater area, and when the time comes, as doubtless it will come, that peat can be converted into good fuel at an economic price, a material of first-class necessity will be obtainable for the people of Ontario in limitless quantity. Nor, when that time comes, will we be dependent on the peat bogs of the Moose river basin alone. There is hardly a county in the province which does not possess a supply; there are large beds between the Ottawa and St. Lawrence rivers; our lake country is full of it; and along the line of the Canadian Pacific Railway from the Ottawa river to Lake of the Woods there is more of it than would replace the coal fields of Pennsylvania. And it is with some confidence I express the belief that in a process which I had an opportunity of looking into a few days ago the problem of the conversion of peat into fuel has already been solved, in a simple, practical and economic way.

So I come to the end. The subject is very far from being exhausted, but I know that I must have wearied your patience if I have not exhausted your forbearance. Let me, however, express the hope that something has been said which may serve to arouse in your minds a higher opinion of this great Ontario of ours—the first commonwealth of America in the extent and variety of its resources, in the commanding opportunity of its situation, in the excellence of its institutions and the sterling qualities of its men. If I was to give a word of counsel concerning your relations to this commonwealth, the duty you owe to it and the sphere you should aspire to occupy in it when you also become men, it would be only in the words of the Spartan mother when her son was bidding farewell on going out to meet the enemy of his country and might not evermore return:

"SPARTA IS YOUR PORTION," she said; "DO YOUR BEST FOR SPARTA!"

Lubricating Qualities of Graphite—A correspondent to the *American Machinist* says:—"If engineers, machinists, and millwrights in general, and pipe fitters in particular, knew of the good qualities of graphite, I dare say there would be ten times the demand for it. Its primary object is lubrication, and it is to this fact we must credit good pipe joints and cool bearings. In making pipe cement (or as I would term it, pipe smear), it is not necessary to use the best oil or grease, as it is the graphite, and not the body in which it is suspended, that makes the mixture valuable and the joint perfect. I use the drippings from the line shaft bearings caught in the ordinary way, and mix it with the best Ticonderoga flake graphite, so that it can be applied with an ordinary sash tool. During the past three years I have used about 15 lb. or 20 lb. of graphite for pipe joints, cylinder heads, piston and rod packing &c. Bolts smeared with graphite mixed as above, I have unscrewed after having been in the dampest place for upwards of two years or more proving the antirusting qualities of graphite. To cool hot bearings, put it on as thick as it will mix with oil. Almost any oil or grease will answer; but don't use poor graphite."

"Hutton's Theory of the Earth."

[Presidential Address by PROF. SIR ARCHIBALD GEIKIE, at the Edinburgh Meeting of the British Association, 3rd August, 1892.]

Sir Archibald Geikie, who was received with loud applause on rising, said: In its beneficent progress through these islands the British Association for the Advancement of Science now for the fourth time receives a welcome in this ancient capital. Once more, under the shadow of these antique towers, crowded memories of a romantic past fill our thoughts. The stormy annals of Scotland seem to move in procession before our eyes as we walk these streets, whose names and traditions have been made familiar to the civilized world by the genius of literature. At every turn, too, we are reminded, by the monuments which a grateful city has erected, that for many generations the pursuits which we are now assembled to foster have had here their congenial home. Literature, philosophy, science, have each in turn been guided by the influence of the great masters who have lived here, and whose renown is the brightest gem in the chaplet around the brow of this "Queen of the North." Lingering for a moment over these local associations, we shall find a peculiar appropriateness in the time of this renewed visit of the Association to Edinburgh. A hundred years ago a remarkable group of men were discussing here the great problem of the history of the earth. James Hutton, after many years of travel and reflection, had communicated to the Royal Society of this city, in the year 1785, the first outlines of his famous "Theory of the Earth." Among those with whom he took counsel in the elaboration of his doctrines were Black, the illustrious discoverer of "fixed air" and "latent heat;" Clerk, the sagacious inventor of the system of breaking the enemy's line in naval tactics; Hall, whose fertile ingenuity devised the first system of experiments in illustration of the structure and origin of rocks; and Playfair, through whose sympathetic enthusiasm and literary skill Hutton's views came ultimately to be understood and appreciated by the world at large. With these friends, so well able to comprehend and criticise his efforts to pierce the veil that shrouded the history of this globe, he paced the streets amid which we are now gathered together; with them he sought the crags and ravines around us, wherein Nature has laid open so many impressive records of her past; with them he sallied forth on those memorable expeditions to distant parts of Scotland, whence he returned laden with treasures from a field of observation which, though now so familiar, was then almost untrodden. The centenary of Hutton's "Theory of the Earth" is an event in the annals of science which seems most fittingly celebrated by a meeting of the British Association in Edinburgh. In choosing from among the many subjects which might properly engage your attention on the present occasion, I have thought that it would not be inappropriate nor uninteresting to consider the more salient features of that "Theory," and to mark how much in certain departments of inquiry has sprung from the fruitful teaching of its author and his associates. It was a fundamental doctrine of Hutton and his school that this globe has not always worn the aspect which it bears at present; that, on the contrary, proofs may everywhere be culled that the land which we now see has been formed out of the wreck of an older land. Among these proofs, the most obvious are supplied by some of the more familiar kinds of rock, which teach us that, though they are now portions of the dry land, they were originally sheets of gravel, sand and mud, which had been worn from the face of long-vanished continents, and after being spread out over the floor of the sea were consolidated into compact stone, and were finally broken up and raised once more to form part of the dry land. This cycle of change involved two great systems of natural processes. On the one hand, men were taught that by the action of running water the materials of the solid land are in a state of continual decay and transport to the ocean. On the other hand, the ocean floor is liable from time to time to be upheaved by some stupendous internal force akin to that which gives rise to the volcano and the earthquake. Hutton further perceived that not only had the consolidated materials been disrupted and elevated, but that masses of molten rock had been thrust upward among them, and had cooled and crystallized in large bodies of granite and other eruptive rocks which form so prominent a feature on the earth's surface. It was a special characteristic of this philosophical system that it sought in the changes now in progress on the earth's surface an explanation of those which occurred in older times. Its founder refused to invent causes or modes of operation, for those with which he was familiar seemed to him adequate to solve the problems with which he attempted to deal. Nowhere was the profoundness of his insight more astonishing than in the clear definite way in which he proclaimed and reiterated his doctrine, that every part of the surface of the continents, from mountain-top to sea-shore, is continually undergoing decay, and is thus slowly travelling to the sea. He saw that no sooner will the sea floor be elevated into new land than it must necessarily become a prey to this universal and unceasing degradation. He perceived that, as the transport of disintegrated material is carried on chiefly by running water, rivers must slowly dig out for themselves the channels in which they flow, and thus that a system of valleys, radiating from the water-parting of a country, must necessarily result from the descent of the streams from the mountain crests to the sea. He discerned that this ceaseless and widespread decay would eventually lead to the entire demolition of dry land, but he contended that from time to time this catastrophe is prevented by the operation of the underground forces, whereby new continents are upheaved from the bed of the ocean. And thus in his system a due proportion is maintained between land and water, and the condition of the earth as a habitable globe is preserved. A theory of the earth so simple in outline, so bold in conception, so full of suggestion, and resting on so broad a base of observation and reflection, ought, we might think, to have commanded at once the attention of men of science, even if it did not immediately awaken the interest of the outside world; but, as Playfair sorrowfully admitted, it attracted notice only very slowly, and several years elapsed before anyone showed himself publicly concerned about it, either as an enemy or as a friend. Some of its earliest critics assailed it for what they asserted to be its irreligious tendency—an accusation which Hutton repudiated with much warmth. The sneer levelled by Cowper a few years earlier at all inquiries into the history of the universe was perfectly natural and intelligible from that poet's point of view. There was then a widespread belief that this world came into existence some six thousand years ago, and that any attempt greatly to increase that antiquity was meant as a blow to the

AUTHORITY OF HOLY WRIT.

So far, however, from aiming at the overthrow of orthodox beliefs, Hutton evidently regarded his "Theory" as an important contribution in aid of natural religion. He dwelt with unfeigned pleasure on the multitude of proofs which he was able to accumulate of an orderly design in the operations of nature, decay and renovation being so nicely balanced as to maintain the habitable condition of the planet. But as he refused to admit the predominance of violent action in terrestrial changes, and on the contrary contended for the efficacy of the quiet, continuous processes which we can even now see at work around us, he was constrained to require an unlimited duration of past time for the production of those revolutions of which he perceived such clear and abundant proofs in the crust of the earth. The general public, however, failed to comprehend that the doctrine of the high antiquity of the globe was not inconsistent with the comparatively recent appearance of man—a distinction which seems so obvious now. Hutton died in 1797, beloved and regretted by the circle of friends who had learnt to appreciate his estimable character and to admire his genius, but with little recognition from the world at large. Men knew not then that a great master had passed away from their midst, who had laid broad and deep the foundations of a new science; that his name would become a household word in after generations, and that pilgrims would come from distant lands to visit the scenes from which he drew his inspiration. Many years might have elapsed before Hutton's teaching met with wide acceptance, had its recognition depended solely on the writings of the philosopher himself. For, despite his firm grasp of general principles and his mastery of the minutest details, he had acquired a literary style which, it must be admitted, was singularly unattractive. Fortunately for his fame, as well as for the cause of science, his devoted friend and disciple, Playfair, at once set himself to draw up an exposition of Hutton's views. After five years of labour on this task, there appeared the classic "Illustrations of the Huttonian Theory," a work which for luminous treatment and graceful diction stands still without a rival in English geological literature. Though professing merely to set forth his friend's doctrines, Playfair's treatise was in many respects an original contribution to science of the highest value. It placed for the first time in the clearest light the whole philosophy of Hutton regarding the history of the earth, and enforced it with a wealth of reasoning and copiousness of illustration which obtained for it a wide appreciation. From long converse with Hutton, and from profound reflection himself, Playfair gained such a comprehension of the whole subject that, discarding the nonessential parts of his master's teaching, he was able to give so lucid and accurate an exposition of the general scheme of Nature's operations on the surface of the globe, that with only slight corrections and expansions his treatise may serve as a text book to-day. In some respects, indeed, his volume was long in advance of its time. Only, for example, within the present generation has the truth of his teaching in regard to the origin of valleys been generally admitted. Various causes contributed to retard the progress of the Huttonian doctrines. Especially potent was the influence of the teaching of Werner, who, though he perceived that a definite order of sequence could be recognized among the materials of the earth's crust, had formed singularly narrow conceptions of the great processes whereby that crust has been built up. His enthusiasm, however, fired his disciples with the zeal of proselytes, and they spread themselves over Europe to preach everywhere the artificial system which they had learnt in Saxony. By a curious fate Edinburgh became one of the great headquarters of Wernerism. The friends and followers of Hutton found themselves attacked in their own city by zealots who, proud of superior mineralogical acquirements, turned their most cherished ideas upside down and assailed them in

THE UNCOUTH JARGON OF FREIBERG.

Inasmuch as subterranean heat had been invoked by Hutton as a force largely instrumental in consolidating and upheaving the ancient sediments that now form so great a part of the dry land, his followers were nicknamed Plutonists. On the other hand, as the agency of water was almost alone admitted by Werner, who belived the rocks of the earth's crust to have been chiefly chemical precipitates from a primeval universal ocean, those who adopted his views received the equally descriptive name of Neptunists. The battle of these two contending schools raged fiercely here for some years, and though mainly from the youth, zeal, and energy of Jameson, and the influence which his position as Professor in the University gave him, the Wernerian doctrines continued to hold their place, they were eventually abandoned even by Jameson himself, and the debt due to the memory of Hutton and Playfair was tardily acknowledged. The pursuits and the quarrels of philosophers have from early times been a favourite subject of merriment to the outside world. Such a feud as that between the Plutonists and Neptunists would be sure to furnish abundant matter for the gratification of this propensity. Turning over the pages of Kay's "Portraits," where so much that was distinctive of Edinburgh society a hundred years ago is embalmed, we find Hutton's personal peculiarities and pursuits touched off in good-humoured caricature. In one plate he stands with arms folded and hammer in hand, meditating on the face of a cliff, from which rocky prominences, in shape of human faces, perhaps grotesque likenesses of his scientific opponents, grin at him. In another engraving he sits in conclave with his friend Black, possibly arranging for that famous banquet of garden-snails which the two worthies had persuaded themselves to look upon as a strangely neglected form of human food. More than a generation later, when the Huttonists and Wernerists where at the height of their antagonism, the humorous side of the controversy did not escape the notice of the author of "Waverley," who, you will remember when he makes Meg Dods recount the various kinds of wise folk brought by Lady Penelope Pennfeather from Edinburgh to St. Ronan's Well, does not forget to include those who "rin up hill and doon dale, knapping the chucky-stanes to pieces wi hammers, like sae mony road-makers run daft, to see how the warld was made." Among the names of the friends and followers of Hutton there is one which on this occasion deserves to be held in special honour, that of Sir James Hall, of Dunglass. Having accompanied Hutton in some of his excursions, and having discussed with him the problems presented by the rocks of Scotland, Hall was familiar with the views of his master, and was able to supply him with fresh illustrations of them from different parts of the country. Gifted with remarkable originality and ingenuity, he soon perceived that some of the questions involved in the theory of the earth could probably be solved by direct physical experiment. Hutton, however, mistrusted any attempt "to judge of the great operations of Nature by merely kindling a fire and looking into the bottom of a little crucible." Out of deference to this prejudice Hall delayed to carry out his intention during Hutton's lifetime. But afterwards he instituted a remarkable series of researches which are memorable in the history of science as the first methodical endeavour to test the value of geological speculation by an appeal to actual experiment. The Neptunists, in ridiculing the Huttonian doctrine that basalt and similar rocks had once been molten, asserted that, had such been their origin, these masses would now be found in the condition of glass or slag. Hall, however, triumphantly vindicated his friend's view, by proving that basalt could be fused, and thereafter by slow cooling could be made to resume a stony texture. Again, Hutton had asserted that under the vast pressures which must be effective deep within the earth's crust, chemical reactions must be powerfully influenced, and that under such conditions even limestone may conceivably be melted without losing its carbonic acid. Various specious arguments had been adduced against this proposition, but by an ingeniously devised series of experiments Hall succeeded in converting limestones under great pressure into a kind of marble, and even fused it, and found that it then acted vigorously on other rocks. These admirable researches, which laid the foundations of experimental geology, constitute not the least memorable of the services rendered by the Huttonian school to the progress of science. Clear as was the insight and sagacious the inferences of these great masters in regard to the history of the globe, their vision was necessarily limited by the comparatively narrow range of ascertained fact which up to their time had been established. They taught men to recognize that the present world is built of the ruins of an earlier one, and they explained with admirable perspicacity the operation of the processes whereby the degradation and renovation of land are brought about. But they never dreamed that a long and orderly series of such successive destructions and renewals had taken place, and had left their records in the crust of the earth. They never imagined that from these records it would be possible to establish a determinate chronology that could be read everywhere, and applied to the elucidation of the remotest quarter of the globe. It was by the memorable observations and generalizations of William Smith that this vast extension of our knowledge of the past history of the earth became possible. While the Scottish philosophers were building up their theory here, Smith was quietly ascertaining by extended journeys, that the stratified rocks of the West of England occur in a definite sequence, and that each well-marked group of them can be discriminated from the others and identified across the country by means of its enclosed organic remains. It is nearly a hundred years since he made known his views, so that by a curious co-incidence we may fitly celebrate on this occasion the centenary of William Smith as well as that of James Hutton. No single discovery has ever had a more momentous and far-reaching influence on the progress of a science than that law of organic succession which Smith established. At first it served merely to determine the order of the stratified rocks of England. But it soon proved to possess a world-wide value, for it was found to furnish the key to the structure of the

WHOLE STRATIFIED CRUST

of the earth. It showed that within that crust lie the chronicles of a long history of plant and animal life upon this planet, it supplied the means of arranging the materials for this history in true chronological sequence, and it thus opened out a magnificent vista through a vast series of ages, each marked by its own distinctive types of organic life, which, in proportion to their antiquity, departed more and more from the aspect of the living world. Thus a hundred years ago, by the brilliant theory of Hutton and the fruitful generalization of Smith, the study of the earth received in our country the impetus which has given birth to the modern science of geology. To review the marvellous progress which this science has made during the first century of its existence would require not one but many hours for adequate treatment. The march of discovery has advanced along a multitude of different paths, and the domains of Nature which have been included within the growing territories of human knowledge have been many and ample. Nevertheless, there are certain departments of investigation to which we may profitably restrict our attention on the present occasion, and wherein we may see how the leading principles that were proclaimed in this city a hundred years ago have germinated and borne fruit all over the world. From the earliest times the natural features of the earth's surface have arrested the attention of mankind. The rugged mountain, the cleft ravine, the scarped cliff, the solitary boulder, have stimulated curiosity and prompted many a speculation as to their origin. The shells embedded by millions in the solid rocks of hills far removed from the sea have still further pressed home these "obstinate questionings." But for many long centuries the advance of enquiry into such matters was arrested by the paramount influence of orthodox theology. It was not merely that the Church opposed itself to the simple and obvious interpretation of these natural phenomena. So implicit had faith become in the accepted views of the earth's age and of the history of creation, that even laymen of intelligence and learning set themselves unbidden and in perfect good faith to explain away the difficulties which Nature so persistently raised up, and to reconcile her teachings with those of the theologians. In the various theories thus originating, the amount of knowledge of natural law usually stood in inverse ratio to the share played in them by an uncontrolled imagination. The speculations, for example, of Burnet, Whiston, Whitehurst, and others in this country, cannot be read now without a smile. In no sense were they scientific researches; they can only be looked upon as exercitations of learned ignorance. Springing mainly out of a laudable desire to promote what was believed to be the cause of true religion, they helped to retard inquiry, and exercised in that respect a baneful influence on intellectual progress. It is the special glory of the Edinburgh School of Geology to have cast aside all this fanciful trifling. Hutton boldly proclaimed that it was no part of his philosophy to account for the beginning of things. His concern lay only with the evidence furnished by the earth itself as to its origin. With the intuition of true genius he early perceived that the only solid basis from which to explore what has taken place in bygone time is a knowledge of what is taking place to-day. He thus founded his system upon a careful study of the processes whereby geological changes are now brought about. He felt assured that Nature must be consistent and uniform in her working, and that only in proportion as her operations at the present time are watched and understood will the ancient history of the earth become intelligible. Thus, in his hands, the investigation of the present became the key to the interpretation of the past. The establishment of this great truth was the first step towards the inauguration of a true science of the earth. The doctrine of the

UNIFORMITY OF CAUSATION IN NATURE

became the fruitful principle on which the structure of modern geology could be built up. Fresh life was now breathed into the study of the earth. A new spirit seemed to animate the advance along every pathway of inquiry. Facts that had long been familiar came to possess a wider and deeper meaning when their connection with each other was recognized as parts of one great harmonious system of continuous change. In no department of nature, for example, was this broader vision more remarkably displayed than in that wherein the circulation of water between land and sea plays the most conspicuous part. From the earliest times men had watched the coming of clouds, the fall of rain, the flow of rivers, and had recognised that on this nicely adjusted machinery the beauty and fertility of the land depends. But they now learnt that this beauty and fertility involve a continual decay of the terrestrial surface; that the soil is a measure of this decay, and would cease to afford us maintenance were it not continually removed and renewed; that through the ceaseless transport of soil by rivers to the sea the face of the land is slowly lowered in level and carved into mountain and valley, and that the materials thus borne outwards to the floor of the ocean are not lost, but accumulate there to form rocks, which in the end will be upraised into new lands. Decay and renovation, in well-balanced proportions, were thus shown to be the system on which the existence of the earth as a habitable globe had been established. It was impossible to conceive that the economy of the planet could be maintained on any other basis. Without the circulation of water the life of plants and animals would be impossible, and with that circulation the decay of the surface of the land and the renovation of its disintegrated materials are necessarily involved. As it is now so must it have been in past time. Hutton and Playfair pointed to the stratified rocks of the earth's crust as demonstrations that the same processes which are at work to-day have been in operation from a remote antiquity. By thus placing their theory on a basis of actual observation, and providing in the study of existing operations a guide to the interpretation of those in past times, they rescued the investigation of the history of the earth from the speculations of theologians and cosmologists, and established a place for it among the recognised inductive sciences. To the guiding influence or their philosophical system, the prodigious strides made by modern geology are in large measure to be attributed. And here in our own city, after the lapse of a hundred years, let us offer to their memory the grateful homage of all who have profited by their labours. But while we recognise with admiration the far-reaching influence of the doctrine of uniformity of causation in the investigation of the history of the earth, we must upon reflection admit that the doctrine has been pushed to an extreme perhaps not contemplated by its original founders. To take the existing conditions of nature as a platform of actual knowledge from which to start in an inquiry into former conditions was logical and prudent. Obviously, however, human experience, in the few centuries during which attention has been turned to such subjects, has been too brief to warrant any dogmatic assumption that the various natural processes must have been carried on in the past with the same energy and at the same rate as they are carried on now. Variations in energy might have been legitimately conceded as possible, though not to be allowed without reasonable proof in their favour. It was right to refuse to admit the operation of speculative causes of change when the phenomena were capable of natural and adequate explanation by reference to causes that can be watched and investigated. But it was an error to take for granted that no other kind of process or influence, nor any variation in the rate of activity save those of which man has had actual cognisance, has played a part in the terrestrial economy. The uniformitarian writers laid themselves open to the charge of maintaining a kind of perpetual motion in the machinery of nature.

They could find in the records of the earth's history no evidence of a beginning, no prospect of an end. They saw that many successive renovations and destructions had been effected on the earth's surface, and that this long line of vicissitudes formed a series of which the earliest were lost in antiquity, while the latest were still in progress towards an apparently illimitable future. The discoveries of William Smith, had they been adequately understood, would have been seen to offer a corrective to this rigidly uniformitarian conception, for they revealed that the crust of the earth contains the long record of an unmistakable order of progression in organic types. They proved that plants and animals have varied widely in successive periods of the earth's history, the present condition of organic life being only the latest phase of a long preceding series, each stage of which recedes further from the existing aspect of things as we trace it backward into the past. and though no relic had yet been found, or indeed was ever likely to be found, of the first living things that appeared upon the earth's surface, the manifest simplification of types in the older formations pointed irresistibly to some beginning from which the long procession has taken its start. If then it could thus be demonstrated that there had been upon the globe an orderly march of living forms from the lowliest grades in earily times to man himself to-day, and thus that in one department of her domain, extending through the greater portion of the records of the earths's history, Nature had not been uniform but had followed a vast and noble plan of evolution, surely it might have been expected that those who discovered and made known this plan would seek to ascertain whether some analogous physical progression from a definite beginning might not be discernible in the framework of the globe itself. But the early masters of the science laboured under two great disadvantages. In the first place, they found the oldest records of the earth's history so broken up and effaced as to be no longer legible. And in the second place, they lived under the spell of that strong reaction against speculation which followed the bitter controversy between the Neptunists and Plutonists in the earlier decades of the century. They considered themselves bound to search for facts, not to build up theories; and as in the crust of the earth they could find no facts which threw any light upon the primeval constitution and subsequent development of our planet, they shut their ears to any theoretical interpretations that might be offered from other departments of science. It was enough for them to maintain, as Hutton had done, that in the visible structure of the earth itself no trace can be found of the beginning of things, and that the oldest terrestrial records reveal no physical conditions essentially different from those in which we still live. They doubtless listened with interest to the speculations of Kant, Laplace, and Herschel, on the probable evolution of nebulae, suns, and planets, but it was with the languid interest attaching to ideas that lay outside of their own domain of research. They recognised no practical connection between such speculations and the data furnished by the earth itself as to its own history and progress. This curious lethargy with respect to theory on the part of men who were popularly regarded as among the most speculative followers of science would probably not have been speedily dispelled by any discovery made within their own field of observation. Even now, after many years of the most diligent research, the first chapters of our planet's history remain undiscovered or undecipherable. On the great terrestrial palimpsest the earliest inscriptions seem to have been hopelessly effaced by those of later ages. But the question of the primeval condition and subsequent history of the planet might be considered from the side of astronomy and physics. And it was by investigations of this nature that the geological torpor was eventually dissipated. To our illustrious former President, Lord Kelvin, who occupied this chair when the Association last met in Edinburgh, is mainly due the rousing of attention to this subject. By the most convincing arguments he showed how impossible it was to believe in the extreme doctrine of uniformitarianism. And though, owing to uncertainty in regard to some of the data, wide limits of time were postulated by him, he insisted that within these limits the whole evolution of the earth and its inhabitants must have been comprised. While, therefore, the geological doctrine that the present order of nature must be our guide to the interpretation of the past remained as true and fruitful as ever, it had now to be widened by the reception of evidence furnished by a study of the earth as a planetary body. The secular loss of heat, which demonstrably takes place both from the earth and the sun, made it quite certain that the present could not have been the original condition of the system. This diminution of temperature with all its consequences is not a mere matter of speculation, but a physical fact of the present time as much as any of the familiar physical agencies that affect the surface of the globe. It points with unmistakable directness to that beginning of things of which Hutton and his followers could find no sign. Another modification or enlargement of the uniformitarian doctrine was brought about by continued investigation of the terrestrial crust and consequent increase of knowledge respecting the history of the earth. Though Hutton and Playfair believed in periodical catastrophes, and indeed required these to recur in order to renew and preserve the habitable condition of our planet, their successors gradually came to view with repugnance any appeal to abnormal, and especially to violent manifestations of terrestrial vigour, and even persuaded themselves that such slow and comparatively feeble action as had been witnessed by man could alone be recognised in the evidence from which geological history must be compiled. Well do I remember in my own boyhood what a cardinal article of faith this prepossession had become. We were taught by our great and honoured master, Lyell, to believe implicitly in gentle and uniform operations, extending over indefinite periods of time, though possibly some, with the zeal of partisans, carried this belief to an extreme which Lyell himself did not approve. The most stupendous marks of terrestrial disturbance, such as the structure of great mountain chains, were deemed to be more satisfactorily accounted for by slow movements prolonged through indefinite ages than by any sudden convulsion. What the more extreme members of the uniformitarian school failed to perceive was the absence of all evidence that terrestrial catastrophes even on a collossal scale might not be a part of the present economy of this globe. Such occurrences might never seriously affect the whole earth at one time, and might return at such wide intervals that no example of them has yet been chronicled by man. But that they have occurred again and again, and even within comparatively recent geological times, hardly admits of serious doubt How far at different epochs and in various degrees they may have included the operation of cosmical influences lying wholly outside the planet, and how far they have resulted from movements within the body of the planet itself, must remain for further inquiry. Yet the admission that they have played a part in geological history may be freely made without impairing the real value of the Huttonian doctrine, that in the interpretation of this history our main guide must be a knowledge of the existing processes of terrestrial change. As the most recent and best known of these great transformations, the Ice Age stands out conspicuously before us. If any one sixty years ago had ventured to affirm that at no very distant date the snows and glaciers of the Arctic regions stretched southwards into France, he would have been treated as a mere visionary theorist. Many of the facts to which he would have appealed in support of his statement were already well known, but they had received various other interpretations. By some observers, notably by Hutton's friend, Sir James Hall, they were believed to be due to violent debacles of water that swept over the face of the land. By others they were attributed to the strong tides and currents of the sea when the land stood at a lower level. The uniformitarian school of Lyell had no difficulty in elevating or depressing land to any required extent. Indeed, when we consider how averse these philosophers were to admit any degree of natural operation others than those of which there was some human experience, we may well wonder at the boldness with which, on sometimes the slenderest evidence, they made land and sea change places, on the one hand submerging mountain-ranges, and on the other placing great barriers of land where a deep ocean rolls. They took such liberties with geography because only well-established processes of change were invoked in the operations. Knowing that during the passage of an earthquake a territory bordering the sea may be upraised or sunk a few feet, they drew the sweeping inference that any amount of upheaval or depression of any part of the earth's surface might be claimed in explanation of geological problems. The progress of inquiry, while it has somewhat curtailed this geographical license, has now made known in great detail the strange story of the Ice Age. There cannot be any doubt that after man had become a denizen of the earth, a great physical change came over the northern hemisphere. The climate, which had previously been so mild that evergreen trees flourished within ten or twelve degrees of the north pole, now became so severe that vast sheets of snow and ice covered the north of Europe and crept southward beyond the south coast of Ireland, almost as far as the southern shores of England, and across the Baltic into France and Germany. This Arctic transformation was not an episode that lasted merely a few seasons, and left the land to resume thereafter its ancient aspect. With various successive fluctuations it must have endured for many thousands of years. When it began to disappear it probably faded away as slowly and imperceptibly as it had advanced, and when it finally vanished it left Europe and North America profoundly changed in the character alike of their scenery and of their inhabitants. The rugged rocky contours of earlier times were ground smooth and polished by the march of the ice across them, while the lower grounds were buried under wide and thick sheets of clay, gravel and sand, left behind by the melting ice. The varied and abundant flora which had spread so far within the Arctic circle was driven away into more southern and less ungenial climes. But most memorable of all was the extirpation of the prominent large animals which, before the advent of the ice, had roamed over Europe. The lions, hyænas, wild horses, hippopotami and other creatures either became entirely extinct or were driven into the Mediterranean basin and into Africa. In their places came northern forms—the reindeer, glutton, musk ox, woolly rhinoceros, and mammoth. Such a marvellous tranformation in climate, in scenery, in vegetation and in inhabitants, within what was after all but a brief portion of geological time, though it may have involved no sudden or violent convulsion, is surely entitled to rank as a catastrophe in the history of the globe. It was probably brought about mainly if not entirely by the operation of forces external to the earth. No similar calamity having befallen the continents within the time during which man has been recording his experience, the Ice Age might be cited as a contradiction to the doctrine of uniformity. And yet it manifestly arrived as part of the established order of Nature. Whether or not we grant that other Ice Ages preceded the last great one, we must admit that the conditions under which it arose, so far as we know them, might conceivably have occured before and may occur again. The various agencies called into play by the extensive refrigeration of the northern hemisphere were not different from those with which we are familiar. Snow fell and glaciers crept as they do to-day. Ice scored and polished rocks exactly as it still does among the Alps and in Norway. There was nothing abnormal in the phenomena save the scale on which they were manifested. And thus, taking a broad view of the whole subject, we recognise the catastrophe, while at the same time we see in its progress the operation of those same natural processes which we know to be integral parts of the machinery whereby the surface of the earth is continually transformed. Among the debts which science owes to the Huttonian school, not the least memorable is the promulgation of the first well-founded conceptions of the high antiquity of the globe. Some six thousand years had previously been believed to comprise the whole life of the planet, and indeed of the entire universe. When the curtain was then first raised that had veiled the history of the earth, and men, looking beyond the brief space within which they had supposed that history to have been transacted, beheld the records of a long vista of ages stretching far away into a dim illimitable past, the prospect vividly impressed their imagination. Astronomy had made known the immeasurable fields of space; the new science of geology seemed now to reveal boundless distances of time. The more the terrestrial chronicles were studied the farther could the eye range into an antiquity so vast as to defy all attempts to measure or define it. The progress of research continually furnished additional evidence of the enormous duration of the ages that preceded the coming of man, while, as knowledge increased, periods that were thought to have followed each other consecutively were found to have been separated by prolonged intervals of time. Thus the idea arose and gained universal acceptance that, just as no boundary could be set to the astronomer in his free range through space, so the whole of bygone eternity lay open to the requirements of the geologist. Playfair, re-echoing and expanding Hutton's language, had declared that neither among the records of the earth nor in the planetary motions can any trace be discovered of the beginning or of the end of the present order of things; that no symptom of infancy or of old age has been allowed to appear on the face of Nature, nor any sign by which either the past or the future duration of the universe can be estimated; and that although the Creator may put an end as He no doubt gave a beginning, to the present system, such a catastrophe will not be brought about by any of the laws now existing, and is not indicated by anything which we perceive. This doctrine was naturally espoused with warmth by the extreme uniformitarian school, which required an unlimited duration of time for the accomplishment of such slow and quiet cycles of change as they conceived to be alone recognizable in the records of the earth's past history. It was Lord Kelvin who, in the writings to which I have already referred, first called attention to the fundamentally erroneous nature of these conceptions. He pointed out that from the high internal temperature of our globe, increasing inwards as it does, and from the rate of loss of its heat, a limit may be fixed to the planet's antiquity. He showed that so far from there being no sign of a beginning, and no prospect of an end to the present economy, every lineament of the solar system bears witness to a gradual dissipation of energy from some definite starting point. No very precise data were then, or indeed are now, available for computing the interval which has elapsed since that remote commencement, but he estimated that the surface of the globe could not have consolidated less than twenty millions of years ago, for the rate of increase of temperature inwards would in that case have been higher than it actually is; nor more than 400 millions of years ago, for then there would have been no sensible increase at all. He was inclined, when first dealing with the subject, to believe that from a review of all the evidence then available some such period as

100 MILLIONS OF YEARS AGO

would embrace the whole geological history of the globe. It is not a pleasant experience to discover that a fortune which one has unconcernedly believed to be ample has somehow taken to itself wings and disappeared. When the geologist was suddenly awakened by the energetic warning of the physicist, who assured him that he had enormously overdrawn his accounnt with past time, it was but natural under the circumstances that he should think the accountant to be mistaken, who thus returned to him dishonoured the large drafts he had made on eternity. He saw how wide were the limits of time deducible from physical considerations, how vague the data from which they had been calculated. And though he could not help admitting that a limit must be fixed beyond which his chronology could not be extended, he consoled himself with the reflection that after all a hundred millions of years was a tolerably ample period of time, and might possibly have been quite sufficient for the transaction of all the prolonged sequence of events recorded in the crust of the earth. He was therefore disposed to acquiesce in the limitation thus imposed upon geological history. But physical inquiry continued to be pushed forward with regard to the early history and the antiquity of the earth. Further consideration of the influence of tidal friction in retarding the earth's rotation, and of the sun's rate of cooling, led to sweeping reductions of the time allowable for the evolution of the planet. The geologist found himself in the plight of Lear when his bodyguard of one hundred knights was cut down. "What need you five and twenty, ten or five?" demands the inexorable physicist, as he remorselessly strikes slice after slice from his allowance of geological time. Lord Kelvin is willing, I believe to grant us some twenty millions of years, but Professor Tait would have us content with less than ten millions. In scientific as in other mundane questions there may often be two sides, and the truth may ultimately be found not to lie wholly with either. I frankly confess that the demands of the early geologists for an unlimited series of ages were extravagant, and even, for their own purposes, unnecessary, and that the physicist did good service in reducing them. It may also be freely admitted that the latest conclusions from physical considerations of the extent of geological time require that the interpretation given to the record of the rocks should be rigorously revised, with the view of ascertaining how far that interpretation may be capable of modification or amendment. But we must also remember that the geological record constitutes a voluminous body of evidence regarding the earth's history which cannot be ignored, and must be explained in accordance with ascertained natural laws. If the conclusions derived from the most careful study of this record cannot be reconciled with those drawn from physical considerations, it is surely not too much to ask that the latter should be also revised. It has been well said that the mathematical mill is an admirable piece of machinery, but that the value of what it yields depends upon the quality of what is put into it. That there must be some flaw in the physical argument I can, for my own part hardly doubt, though I do not pretend to be able to say where it is to be found. Some assumption, it seems to me, has been made, or some consideration has been left out of sight, which will eventually be seen to vitiate the conclusions, and wh[illegible] when duly taken into account will allow time enough for any reasonable interpretation of the geological record. In problems of this nature, where geological data capable of numerical statements are so needful, it is hardly possible to obtain trustworthy computations of time. We can only measure the rate of changes in progress now, and infer from these changes the length of time required for the completion of results achieved by the same processes in the past. There is fortunately one great cycle of movement which admits of careful investigation, and which has been made to furnish valuable materials for estimates of this kind. The universal degradation of the land, so notable a characteristic of the earth's surface, has been regarded as an extremely slow process. Though it goes on without ceasing, yet from century to century it seems to leave hardly any perceptible trace on the landscapes of a country. Mountains and plains, hills and valleys, appear to wear the same familiar aspect which is indicated in the oldest pages of history. This obvious slowness in one of the most important departments of geological activity, doubtless contributed in large measure to form and foster a vague belief in the vastness of the antiquity required for the evolution of the earth. But, as geologists eventually came to perceive, the rate of degradation of the land is capable of actual measurement. The amount of material worn away from the surface of any drainage-basin and carried in the form of mud, sand, or gravel, by the main river into the sea, represents the extent to which that surface has been lowered by waste in any given period of time. But denudation and deposition must be equivalent to each other. As much material must be laid down in sedimentary accumulations as has been mechanically removed, so that in measuring the annual bulk of sediment borne into the sea by a river, we obtain a clue not only to the rate of denudation of the land, but also to the rate at which the deposition of new sedimentary formations takes place. As might be expected, the activities involved in the lowering of the surface of the land are not everywhere equally energetic. They are naturally more vigorous where the rainfall is heavy, where the daily range of temperature is large and where frosts are severe. Hence they are obviously much more effective in mountainous regions than on plains; and their results must constantly vary, not only in different basins of drainage, but even, and sometimes widely, within the same basin. Actual measurement of the proportions of sediment in river water shows that while in some cases the lowering of the surface of the land may be as much as 1-730 of a foot in a year, in others it falls as low as 1-6800. In other words, the rate of

DEPOSITION OF NEW SEDIMENTARY FORMATIONS,

over an area of sea-floor equivalent to that which has yielded the sediment, may vary from one foot in 730 years to one foot in 6800 years. If now we take these results and apply them as measures of the length of time required for the deposition of the various sedimentary masses that form the outer part of the earth's crust, we obtain some indication of the duration of geological history. On a reasonable computation these stratified masses, where most fully developed, attain a united thickness of not less than 100,000 feet. If they were all laid down at the most rapid recorded rate of denudation, they would require a period of seventy-three millions of years for their completion. If they were laid down at the slowest rate they would demand a period of not less than 680 millions. But it may be argued that all kinds of terrestrial energy are growing feeble, that the most active denudation now in progress is much less vigorous than that of bygone ages, and hence that the stratified part of the earth's crust may have been put together in a much briefer space of time than modern events might lead us to suppose. Such arguments are easily adduced and look sufficiently specious, but no confirmation of them can be gathered from the rocks. On the contrary, no one can thoughtfully study the various systems of stratified formations without being impressed by the fulness of their evidence that, on the whole, the accumulation of sediment has been extremely slow. Again and again we encounter groups of strata composed of thin paper-like laminæ of the finest silt, which evidently settled down quietly and at intervals on the sea bottom. We find successive layers covered with ripple-marks and sun-cracks, and we recognize in them memorials of ancient shores where sand and mud tranquilly gathered as they do in sheltered estuaries at the present day. We can see no proof whatever, nor even any evidence which suggests, that on the whole the rate of waste and sedimentation was more rapid during Mesozoic and Palæozoic time than it is to-day. Had there been any marked difference in this rate from ancient to modern times, it would be incredible that no clear proof of it should have been recorded in the crust of the earth. But in actual fact the testimony in favour of the slow accumulation and high antiquity of the geological record is much stronger than might be inferred from the mere thickness of the stratified formations. These sedimentary deposits have not been laid down in one unbroken sequence, but have had their continuity interrupted again and again by upheaval and depression. So fragmentary are they in some regions, that we can easily demonstrate the length of time represented there by still existing sedimentary strata to be vastly less then the time indicated by the gaps in the series. There is yet a further and impressive body of evidence furnished by the successive races of plants and animals which have lived upon the earth and have left their remains sealed up within its rocky crust. No one now believes in the exploded doctrine that successive creations and universal destructions of organic life are chronicled in the stratified rocks. It is everywhere admitted that, from the remotest times up to the present day, there has been an onward march of development, type succeeding type in one long continuous progression. As to the rate of this evolution precise data are wanting. There is, however, the important negative argument furnished by the absence of evidence of recognisable specific variations of organic forms since man began to observe and record. We know that within experience a few species have become extinct, but there is no conclusive proof that a single new species has come into existence, nor are appreciable variations readily apparent in forms that live in a wild state. The seed and plants found with Egyptian mummies, and the flowers and fruits depicted on Egyptian tombs, are easily indentified with the vegetation of modern Egypt. The embalmed bodies of animals found in that country show no sensible divergence from the structure or proportions of the same animals at the present day. The human races of Northern Africa and Western Asia were already as distinct when portrayed by the ancient Egyptian artists as they are now, and they do not seem to have undergone any perceptible change since then. Thus a lapse of four or five thousand years has not been accompaied by any recognisable variation in such forms of plant and animal life as can be tendered in evidence. Absence of sensible change in these instances is, of course, no proof that considerable alteration may not have been accomplished in other forms more exposed to vicissitudes of climate and other external influences. But it furnishes at least a presumption in favour of the extremely tardy progress of organic variation. If, however, we extend our vision beyond the narrow range of human history, and look at the remains of the plants and animals preserved in those younger formations which, though recent when regarded as parts of the whole geological record, must be many thousands of years older than the very oldest of human monuments, we encounter the most impressive proofs of the persistence of specific forms. Shells which lived in our seas before the coming of the Ice Age present the very same peculiarities of form, structure, and ornament which their descendants still possess. The lapse of so enormous an interval of time has not sufficed seriously to modify them. So too with the plants and the higher animals which still survive. Some forms have become extinct, but few or none which remain display any transitional gradations into new species. We must admit that such transitions have occurred, that indeed they have been in progress ever since organised existence began upon our planet, and are doubtless taking place now. But we cannot detect them on the way, and we feel constrained to believe that their march must be excessively slow. There is no reason to think that the rate of organic evolution has ever seriously varied; at least no proof has been adduced of such variation. Taken in connection with the testimony of the sedimentary rocks, the inferences deducible from fossils entirely bear out the opinion that the building up of the stratified crust of the earth has been extremely gradual. If the many thousands of years which have elapsed since the Ice Age have produced no appreciable modification of surviving plants and animals, how vast a period must have been required for that marvellous scheme of organic development which is chronicled in the rocks! After careful reflection on the subject, I affirm that the geological record furnishes a mass of evidence which no arguments drawn from other departments of Nature can explain away, and which, it seems to me, cannot be satisfactorily interpreted save with an allowance of time much beyond the narrow limits which recent physical speculation would concede. I have reserved for final consideration a branch of the history of the earth which, while it has become, within the lifetime of the present generation, one of the most interesting and fascinating departments of geological inquiry, owed its first impulse to the far-seeing intellects of Hutton and Playfair. With the penetration of genius these illustrious teachers perceived that if the broad masses of land and the great chains of mountains owe their origin to stupendous movements which from time to time have convulsed the earth, their details of contour must be mainly due to the eroding power of running water. They recognized that as the surface of the land is continually worn down, it is essentially by a process of sculpture that the physiognomy of every country has been developed, valleys being hollowed out and hills left standing, and that these inequalities in topographical detail are only varying and local accidents in the progress of the one great process of the degradation of the land. From the broad and guiding outlines of theory thus sketched we have now advanced amid ever-widening multiplicity of detail into a fuller and nobler conception of the origin of scenery.

THE LAW OF EVOLUTION

is written as legibly on the landscapes of the earth as on any other page of the Book of Nature. Not only do we recognize that the existing topography of the continents, instead of being primeval in origin, has gradually been developed after many precedent mutations, but we are enabled to trace these earlier evolutions in the structure of every hill and glen. Each mountain-chain is thus found to be a memorial of many successive stages in geographical evolution. Within certain limits, land and sea have changed places again and again. Volcanoes have broken out and have become extinct in many countries long before the advent of man. Whole tribes of plants and animals have meanwhile come and gone, and in leaving their remains behind them as monuments at once of the slow development of organic types, and of the prolonged vicissitudes of the terrestrial surface, have furnished materials for a chronological arrangement of the earth's topographical features. Nor is it only from the organisms of former epochs that broad generalizations may be drawn regarding revolutions in geography. The living plants and animals of to-day have been discovered to be eloquent of ancient geographical features that have long since vanished. In their distribution they tell us that climates have changed, that islands have been disjoined from continents, that oceans once united have been divided from each other, or once separate have now been joined; that some tracts of land have disappeared, while others for prolonged periods of time have remained in isolation. The present and the past are thus linked together not merely by dead matter, but by the world of living things, into one vast system of continuous progression. In this marvellous increase of knowledge regarding the transformations of the earth's surface, one of the most impressive features, to my mind, is the power now given to us of perceiving the many striking contrasts between the present and former aspects of topography and scenery. We seem to be endowed with a new sense. What is seen by the bodily eye—mountain, valley, or plain—serves but as a veil, beyond which, as we raise it, visions of long-lost lands and seas rise before us in a far-retreating vista. Pictures of the most diverse and opposite character are beheld, as it were, through each other, their lineaments subtly interwoven and even their most vivid contrasts subdued into one blended harmony. Like the poet, "we see, but not by sight alone," and the "ray of fancy" which, as a sunbeam, lightened up his landscape, is for us broadened and brightened by that play of the imagination which science can so vividly excite and prolong. Admirable illustrations of this modern interpretation of scenery are supplied by the district wherein we are now assembled. On every side of us rise the most convincing proofs of the reality and potency of that ceaseless sculpture by which the elements of landscape have been carved into their present shapes. Turn where we may, our eyes rest on hills that project above the lowland, not because they have been upheaved into these positions, but because their stubborn materials have enabled them better to withstand the degradation which has worn down the softer strata into the plains around them. Inch by inch the surface of the land has been lowered, and each hard rock successively laid bare has communicated its own characteristics of form and colour to the scenery. If, standing on the Castle Rock, the central and oldest site in Edinburgh, we allow the bodily eye to wander over the fair landscape, and the mental vision to range through the long vista of earlier landscapes which science here reveals to us, what a strange series of pictures passes before our gaze! The busy streets of to-day seem to fade away into the mingled copsewood and forest of prehistoric time. Lakes that have long since vanished gleam through the woodlands, and a rude canoe pushing from the shore startles the red deer that had come to drink. While we look the picture changes to a polar scene, with bushes of stunted Arctic willow and birch, among which herds of reindeer browse and the huge mammoth makes his home. Thick sheets of snow are draped all over the hills around, and far to the north-west the distant gleam of glaciers and snow-fields marks the line of the Highland mountains. As we muse on this strange contrast to the living world of to-day the scene appears to grow more Arctic in aspect, until every hill is buried under one vast sheet of ice, 2,000 feet or more in thickness, which fills up the whole midland valley of Scotland, and creeps slowly eastward into the basin of the North Sea. Here the curtain drops upon our moving pageant, for in the geological record of this part of the country an enormous gap occurs before the coming of the Ice Age. When once more the spectacle resumes its movement the scene is found to have utterly changed. The familiar hills and valleys of the Lothians have disappeared. Dense jungles of a strange vegetation—tall reeds, club-mosses, and tree ferns—spread over the steaming swamps that stretch for leagues in all directions. Broad lagoons and open seas are dotted with little volcanic cones which throw out their streams of lava and showers of ashes. Beyond these, in dimmer outline and older in date, we descry a wide lake or inland sea, covering the whole midland valley and marked with long lines of active volcanoes, some of them several thousand feet in height. And still further and fainter over the same region, we may catch a glimpse of that still earlier expanse of sea which in Silurian times overspread most of Britain. But beyond this scene our vision fails. We have reached the limit across which no geological evidence exists to lead the imagination into the primeval darkness beyond. Such in briefest outline is the succession of mental pictures which modern science enables us to frame out of the landscapes around Edinburgh. They may be taken as illustrations of what may be drawn, and sometimes with even greater fulness and vividness, from any district in these islands. But I cite them especially because of their local interest in connection with the present meeting of the Association, and because the rocks that yield them gave inspiration to those great masters whose claims on our recollection, not least for their explanation of the origin of scenery, I have tried to recount this evening. But I am further impelled to dwell on these scenes from an overmastering personal feeling to which I trust I may be permitted to give expression. It was these green hills and grey crags that gave me in boyhood the impulse that has furnished the work and joy of my life. To them, amid changes of scene and surroundings, my heart ever fondly turns, and here I desire gratefully to acknowledge that it is to their influence that I am indebted for any claim I may possess to stand in the proud position in which your choice has placed me.

During the delivery of his address, Sir Archibald was frequently applauded, and at the conclusion he was heartily cheered.

CORRESPONDENCE.

Notes from Illecillewaet, B.C.

The Editor:

SIR,—It is quite refreshing to read all the varied incidents that crowd the columns of a weekly newspaper, especially when you yourself are located in one of the bye corners of the world. You feel like one who had drifted into a quiet eddy, whilst the great stream of life went swirling past on its mighty way, and only a dim and distant echo of the many eventful episodes that go to make up the sum of the daily struggle of the teeming, toiling millions of this great continent, floats, as it were, to your ears, or rather eyes. Buried among the mighty mountains of the Selkirks, which tower 5,000 feet on either side into the air, time was, and not many years ago, when as far as reaching the outer world, buried would be the proper description of existence in this locality. Now, thanks to the iron road, we can say with our French neighbours, "Nous avons changé tout cela;" and having access therefore to the outer world, our woes, wants, hopes, fears, prospects, etc., etc., can find a vent through the columns of your valuable paper, and if our small contribution does not interest the readers, at least the effort to rescue ourselves from oblivion has been made.

We are still in existence; that is the main point to bear in mind; and we shall be heard of in a rather surprising manner before long, or the indications are all wrong. Perhaps such a statement needs verification by facts, and such will be forthcoming. The spring of this year opened up with apparently the most cheering prospects, and all looked forward to a great impetus in mining development; perhaps the hopes were too sanguine, or rather unforeseen contingences were not counted on. Progress is the order of the day, but not the feverish, wild, exciting rush that was expected and looked forward to with longing eyes by those who had stood by their prospects for years, and looked forward to a substantial reward for their patience.

No fevered rush has taken place, but a large number of claims have changed hands; in some cases large prices have been given. The best known claims are now held by parties who intend developing them, and as such work is not of the rushing order, and requires time, and intelligent direction of work, there is not apparently much difference in the appearance of things to the outside or superficial observer. Some people seem to run away with an idea that mines can be tested, tramways built, reduction works established, and an army of men put to work in the course of a few weeks, or like the transformation scene of a pantomine, and that paying dividends are become an immediate contingency on the investment of a little capital in a mine—or perhaps a very shadowy prospect. Consequently, so many are ready to decry all kinds of mining investment, because they really know nothing about it. But this is old news, and repeats itself "ad nauseam." This is not our situation. We have the mineral in large quantities, and our mines will bye and bye be one of the features of British Columbia. We have had a fair number of visitors from the outside world wishing to become better acquainted with the value of the mineral deposits. Each and every one has been greatly impressed with what they were shown, and mean returning; at least they say so, and there is some comfort in that for those who are satisfied with the day of small things. Now to speak of tangible progress. The "Maple Leaf" has changed hands for $50,000; the "Dunvagan" for $15,000; the "Blue Bell" for $6,000; the "Goat Cave" for $20,000; and quite a number of other claims from $150 to $1,000. These claims have been bought from the original prospectors by the representatives of real live companies, who mean testing them for all they are worth, so if our progress is not fast, the probabilities point to a sure and steady progression that will be lasting, and by which the resources of the district will be more fully known. A large amount of prospecting is also going quietly on, and a number of new claims are being located. The new Act restricting the number of claims to be held in one district by any individual miner to two by location, has prevented what could have been made quite a monopoly if no limit had been placed on the number of claims held by one miner. The number that can be held by purchase is practically unlimited. Thus the prospector has an excellent opportunity to dispose of his claim or prospect to those wishing to purchase or invest in mining property, if through lack of funds (which is generally the chronic condition of the prospector) he is unable to develop the property himself.

The tramway to the "Lanark" mine has not been commenced yet, though rumour is busy with the statement that it is soon to be an accomplished fact; time will show. At present the mine is shut down for a while. They have a very large amount of ore ready to send down on completion of tramway, and an immense quantity in sight. It is said from pretty good authority that this mine could give an output of $800,000 worth of ore in a short time. The ordinary assessment work has been the order of the day so far, and kept all hands occupied.

At Fish Creek, Messrs. Fishburn and Fowler are steadily working, developing the properties they bought in the spring. They speak hopefully of their prospects. They employ some twelve men constantly and have done so for some months.

Messrs. Ryckman and Scott are busy on the "Elizabeth" at present, sinking a shaft on the lead, and driving a tunnel to tap the lead at about 150 feet below the surface. They are in about 70 feet, and their tunnel, when completed, will be about 160 feet in length. The rock is very kindly to work and they are making most satisfactory progress. They keep three shifts of men going—eight hour shifts—employing about 14 men all told. A tunnel has also been driven some 40 feet on the "Link," but is now shut down for a while. All the claims here have the assessment work done, and they are waiting developments in the other claims now working.

The Elizabeth people expect to strike something very good when they arrive at the lead—and the probabilities are that their expectations will be realized.

Apropos of Fish Creek and the Elizabeth, there is a true story. They had a great quantity of red carbonates, with solid galena while sinking the shaft, and by some means took a notion that the carbonates were worthless and threw them all away down the waste dump. As there was about two feet six in width of carbonates and they had gone down 25 feet, a considerable amount was thrown away; but they saved about two tons of it. No one seemed to think it any good. It was, however, resolved at last to send some to Golden for assay, which was done. Judge of their feelings when the assay return showed the following result: Silver, 701 oz.; gold, traces; lead, 4%; and as they had thrown some five or six tons away, they felt comfortable. *But of such*, etc., etc.

Also *re* Fish Creek: We had a gentleman, accompanied by a friend, who came to explore for soft snaps, recruit health and enjoy sport. They had an excellent outfit; required six horses to carry baggage; they came to Fish Creek and camped. They were not aware that every party in these mountains has, by some unknown and occult understanding, a bear told off to attend them. I expect a sort of courtesy shown by the hierarchy of bears. It is nevertheless true, each party will always have a bear looking after him or them. Our friends had an interview with their attendant sprite, with the result that they sold off everything as it stood and left for the East, vowing anathemas against the country and its inhabitants. No one knows what took place at the interview, but the result was palpable.

The Government have sent Mr. E. D. Ingall to survey the different mineral localities between here and Kootenay Lake, and doubtless the result will be some important and reliable information on this new section. By the way, the last report that came out was for '89 to '90, two years old, and therefore almost valueless to a stranger. Such are the methods of red tape and economy.

The Lardeaux country is coming to the front for placer gold, and also big ledges of silver, lead and galena. It will be heard of prominently soon, but the old drawback (which time and money only can overcome) of no trails, or, at least only tracks, prevents much prospecting being done. Most encouraging accounts are heard of the prospects. For some reason the amount appropriated for the making and repairing of trails was curtailed, for this district, by $3,000, and much dissatisfaction was the result. The district has been divided into two divisions, and they are not evened up yet. Altogether, the outlook is promising and encouraging.

E. A. WATSON.

ILLECILLEWAET, 7th August, '92.

MINING NOTES.

[FROM OUR OWN CORRESPONDENTS.]

Nova Scotia.

Caribou District.

Little is doing in this district apart from the mines of Messrs. Dixon, Putnam *et al*, which continue their steady yield. The product for August is expected to be greater than usual.

The old Lake Lode property, sold at sheriff's sale some months ago, still lacks a speculative purchaser.

East Rawdon.

It is reported that Mr. Brown, the principal owner in the old Rawdon mine, intends to re-open the property. It is known that one or two men have been sent up to make a start, and that a representative will shortly arrive from England. This is the property whose surface plant was destroyed by fire in 1889.

Killag.

Mr. D. S. Turnbull, manager of the Old Provincial Co., reports the mill ready to start at five days' notice. The shaft, however, is not yet down deep enough to start off levels, and the mill, as yet, has no supply of quartz. The lode is reported to be a strong one, showing eight to ten inches of quartz which prospects well in gold. The surface plant has been re-arranged by Mr. Turnbull, and will be of ample power for some time to come. The electric plant for lighting and for drilling has not been received, delay having been encountered in the manufacture of the same. The drill it is proposed to put in is the invention of Mr. McKay, one of the owners of the property, and is said to be the most promising electric drill that has yet been made.

Lake Catcha.

It is understood that Mr. J. M. Reid, the manager of the Oxford mines, has been very successful in his attempts to get pay gravel on the property of the company, and that the results have shown good margins for profit. It is also reported that the underground work looks better than for a long time past.

Montagu.

On the 1st of August, the properties in this district which have been so long under negotiation for sale to London parties, were transferred by Manager McQuarrie to Mr. W. H. Harrington, the financial agent in Halifax of the London syndicate. Mr. Lucius J. Boyd has been temporarily placed in local charge of mines, which embrace the Rose, Annand, Montreal and Lawson. It is understood that the sale has been made to a few gentlemen in London, who purpose promoting a joint stock company so soon as the condition of the London financial market will permit.

Major Johnson, representing the syndicate which purchased the Oland property two months ago, has arrived out from England and has taken over the charge of the Oland property, temporarily in Mr. Boyd's care.

Oldham.

The operations of the Concord Mining and Crushing Company appear to have been brought to a permanent standstill. The liabilities of the company are reported still unsettled.

The Rhode Island Co., after sinking over 100 feet, cut the Dunback lode on its western extension on the 20th inst. The lode showed only two inches of black, barren looking quartz. This is the third place on the property on which this lode has been cut, and each opening failed to show pay quartz.

It is reported that the Oldham Gold Co. will permanently close its Baker mine in September. The extensive prospecting work done underground during the past two years having failed to show any paying proposition.

Stormont.

The work of the MacNaughton Gold Mining Co. at Seal Harbor has been suspended, pending investigation by the company of its own affairs. The same company is operating at Country Harbor, and it is reported have had an expert examining into matters there also.

The recent decision by the Privy Council in the case of the Palgrave Gold Mining Co. vs. McMillan, is of great importance to this district as it will permit the re-opening of the Palgrave mine on Hurricane Island, a mine which, at the time of its closing down, was a steady producer and employed a large number of men.

The North Star Co., on the west side of Isaacs Harbor, have re-opened their workings under the management of Mr. Roderick McLeod, formerly at the Parker-Douglas mine, Queens County.

Tangier.

The property of the Mooseland Co., under the management of Mr. H. G. Stemshorn, is increasing in value daily. The Bismarck lode has narrowed to about two feet, but has increased in value from 4 dwts. to over an ounce to the ton. With continued good management this property should become a marked gold producer.

Quebec.

Lievres River.

Only four phosphate mines are in active operation at the present time. The High Rock mine of the Phosphate of Lime Co., the Ross Mountain mine of the General Phosphate Corporation, the Etna and Squaw Hill mines of the Anglo-Continental Guano Works Co.

Two properties are being worked for mica, being the Lake Terror mine in Portland West, and north of this property and further up the river near High Falls, Mr. McIntosh is mining dark mica.

An asbestos mine has been opened near Farley Lake, in Portland West. The Lomer and Harris crushing mills at the Basin du Lievre, are at present grinding the asbestos from Templeton Township.

Jacob Weart of the Graphite Lubricating Co., Jersey City, is operating his plumbago mine and the mill by the dry concentration process, and this manner of dressing the ore is now a success, as one and a half tons of the dressed product have been shipped to the United States. One hundred tons of low grade disseminated graphite ore are being shipped to England on trial from another property.

Eastern Townships.

The Richmond *Guardian*, under date of 9th inst., contains an interesting description of the mining operations for asbestos, carried on by Mr. W. H. Jeffrey, on lot 9, in 3rd Range of Shipton, widely known as the Jeffrey asbestos mines. The article is too long to be reproduced in full, but the following particulars will be of interest: "We visited the Shipton mines this week, and we found a change there, and in its surroundings, which is simply marvellous since we visited the place five or six years ago. Mr. Webb's farm house, Mr. Morrill's, and the school house near by, were then the only buildings near the mine, while at the mine itself, the office, a small slight wooden structure for the manager, a blacksmith's shop, and a couple of rough sheds for sheltering the men doing the "cobbing," were all that was to be seen; there is now a village crowding round the mines, and substantial houses 80 in number, many of them of a comfortable and neat appearance, and between 600 and 700 people, all dependent upon the mine, inhabit them. There is also a post office as well as a thriving well-stocked general store. At the mines, also, there has been a complete transformation. There are powder magazines—four large well appointed engine houses, store houses, cobbing houses, tooling sheds—and other buildings, all of the most perfect character, and "built to live"—nothing being temporary—there are no less than seven enormous derricks operated by powerful model steam engines; only one—that at a small auxiliary pit is now operated by horse power. The pits are five in number—including the small one referred to; they vary in depth from 75 to 130 feet and the larger ones are, we should judge, 400 feet in width. They are working on the walls towards each other; so that in a few years the whole vast area will be one enormous pit, except in one place, where a vein of bastard granite carrying masses of iron pyrites was struck, and which is about 80 to 100 feet in width; the entire rock is asbestos and a large proportion of the veins are of No. 1 quality—the fibre being about 1½ inches in length. The workings cover altogether about 40 acres and the entire property is 75 acres. The quantity got out averages 8 tons per day—though during the week ending the 6th instant 59 tons were got out and bagged ready for export. Speaking generally, 50 per cent. of the whole ranks No. 2, 10 per cent. is No. 1 and the balance is No. 3, though there is, besides, a No. 4 quality which is made from the "scrappings" and is found to be a readily handled commercial article. There is now ready for shipment about 600 tons, and Mr. Jeffery has 150 tons stored in Montreal One hundred and thirty hands is the regular staff employed, and the wages paid amounts to $4,000 per month."

South and south-west of the great dumps, down on the lower level are the engine houses recently erected by Mr. J. C. Bedard and Mr. N. Noel—the latter for a Philadelphia company—both of whom are about to engage in making these huge dumps tell what they are worth in asbestos. The contents of these dumps are the huge stones from which Mr. Jeffery had taken asbestos. They are going to crush them by a new patented process with the expectation of taking from them the asbestos that is still embedded in them. It is an experiment; but it is believed that sufficient will be found to pay a handsome return on the outlay these two companies propose to invest in the venture.

CANADIAN COMPANIES.

The Hastings Mining and Reduction Co. (Ltd.)—This company gives notice of application for charter of incorporation under the Ontario Joint Stock Companies Act. Authorised capital, $100,000 in 1,000 shares of $100. Directors: F. B. Allan, Toronto; W. H. Wylie, Carleton Place, Ont.; Mrs. Theresa Allan, Toronto. Formed to explore for, mine, treat, reduce, smelt, separate, convert, amalgamate, refine, manufacture, buy, sell and transport gold, silver, copper, iron, iron pyrites, lead and other ores, metals, minerals, and mineral substances, and to utilize the by-products in such minerals and ores. For these purposes to acquire and hold by purchase, lease, or other legal title, lands, mines, leases, etc., etc. Head office: Toronto, Ont. The operations of the company are to be carried on in the counties of Peterborough, Hastings, Addington, Frontenac, Lanark and Renfrew.

The Toronto Chemical Co. (Ltd).—Authorised capital stock, $100,000 in 2,000 shares of $50 each. Directors: Arthur English, Oliver B. Shepherd, Charles Gordon Richardson, all of Toronto; Henry Shepherd, Orillia, and William H. F. Russell, Waubaushene, Simcoe Co. Head office: Toronto. Formed to carry on the business of purchasing and treating all manner of ores and their by-products, and to carry on in all its details and branches the business of smelting and refining of ores, with full power for that purpose to purchase all patents covering all and every process in connection with the carrying on of the said business. Also to hold real estate sufficient for the purposes of a place of business and for the supplying of dwellings to employees; also with power to purchase mining properties to be worked in connection with said business. The operations of the company are to be carried on in the Province of Ontario.

The Crescent Nickel Mining Co. of Algoma, (Ltd.)—Capital stock, $200,000, in 20,000 shares of $10 each. Directors: John W. Cheeseworth, merchant; William A. Dewar, George Peter Sharp, Herbert A. Hilyard, broker; and Henry Morgan, hotel keeper, all of Toronto. Head office, Toronto. Formed to acquire, sell, and dispose of, and generally deal in mining claims in the Province of Ontario, and work and operate mines thereon, and smelt and refine, sell and dispose of minerals found thereon.

The Sarnia Salt Co., (Ltd.) — Incorporated 28th July, 1892. Capital stock, $20,000, in 400 shares of $50 each. Directors: Harrison Corey, of Petrolia, County of Lambton; Martin Jesse Woodward, of Petrolia, County of Lambton, oil operators; Wm. Keenleyside, of Sarnia, Ont., merchant; Henry H. Green, of Tp. of Moore, Ont., grain merchant; Jas. H. Kittemaster, of Tp. of Moore, Ont., oil operator. Formed to acquire the plant, premises, business, stock-in-trade, credits and assets of every kind and description of the Sarnia Salt Co., and to carry on the business of the said company in the production and manufacture of salt and of all other articles that may be made therefrom. To sink and work artesian wells; to procure salt, petroleum oil, natural gas or other minerals; and with the consent of the parties interested to lay down and work pipe lines for carrying and conveying brine, petroleum oils, natural gas and other fluids; and, for the purposes aforesaid, to manufacture barrels and to buy, sell, or deal in any, or all of the articles aforesaid; and to enter into contracts and do all such other matters and things as are necessary, incidental or conducive to the due attainment of the said objects or any of them.

The Eagle Nest Gold Mining Co. of Ontario, (Ltd.)—Incorporated 3rd August, 1892. Capital stock, $200,000, in 2,000 shares of $100 each. Directors: Alex. McArthur, lumber merchant; Reuben Millichamp, merchant; Geo. Alex. Shaw, Lieut.-Col.; William Howard Hunter, barrister-at-law; Nelson Mills, barrister-at-law; all of Toronto. Formed to acquire, hold, lease, exchange and sell mining lands, and to develop the said lands by working mines, smelters, stamping mills and other necessary works.

Eustis Mining Co.—The annual general meeting of this company was held on 10th instant at Capelton, Que.

Ontario Natural Gas Co., (Ltd.)—This company makes application for a grant of supplementary letters patent, increasing its capital stock to $100,000.

Amherst Red Stone Quarry Co., (Ltd.)—This company gives notice of application for charter of incorporation under the Nova Scotia Joint Stock Companies Act. Head office, Amherst, N.S. Capital, $6,000, in sixty shares of a value of $100 each. Directors: John McKeen, James Donalds, and Thomas Dunlap, all of Amherst, N.S. The purposes for which the said letters patent are sought are the opening and working of stone quarries of all kinds within the County of Cumberland or elsewhere in the Province of Nova Scotia, and for manufacturing the products of such quarries, and for the selling and exporting the said stone and products in any form whatever; and further, for the purpose of carrying on business as builders and contractors, and for the purpose of purchasing, leasing or otherwise acquiring any lands or other property necessary for the objects aforesaid, or any of them; and for selling/or otherwise dealing with the same; and for the transacting of all business connected with the purposes aforesaid, or any of them.

The Laprairie Pressed Brick and Terra Cotta Co.—Capital stock, $150,000, in 1,500 shares of $100 each. Directors: Hugh Cameron, Toronto; Archibald Dunbar Taylor, Montreal; Thomas Auguste Brisson, Laprairie; William Johnson, Montreal. Head office, Montreal. Formed to manufacture bricks, tiles and all other articles from clay or shale.

Economical Coking of Coal, with Recovery of the By-Products.

The Bois-du-Luc Company owns and works, in addition to its royalty proper, the colliery of Havre, near Mons, Belgium; but it has so happened that just where working was begun the coal measures have been disturbed by two extensive faults, and the coal is rendered so friable as to greatly diminish its commercial value. Under these circumstances the best course to pursue was manifestly to make coke on the spot. But the coal, without being absolutely poor, only contains generally from 18 to 23 per cent of volatile matter; that is to say, it is only just capable of being coked, while some of it contains as little as 16 per cent of volatile matter. In 1882 M. Semet put up 6 of his coke ovens, which were experimented with for about a year, after which the Solvay Company erected a set of 25 ovens, which the Bois-du-Luc Company subsequently took over, extending them to 4 sets of 25 each, capable of coking from 100 to 110 tons of coal per 24 hours, and working them on its own account. The gas generated from the coal in the combustion chambers of the ovens is led by a collecting flue through the boiler flues (each set of 25 ovens firing 2 Havrez boilers of 75 square metres (810 square feet heating surface), and up the chimneys 25 metres (82 feet) high, and 1.6 metre (5 feet 3 inches) in their smallest diameter. The discharging floor is on a level with the tops of railway coke waggons, and the discharging is effected mechanically from the opposite side, by steam rams moved along their rails by endless chain and fixed capstan, in such a way that, in case of a breakdown, a single ram can discharge all the 100 ovens. The rams are supplied with steam from the boilers by a fixed pipe running the whole length of the ovens, and connected by movable elbow joint pipes. The steam also drives pumps for rising the water required for quenching the coke, the tar and ammoniacal liquor pumps, the disintegrators and the gas exhausters. The gas, drawn by the exhausters, passes first into the hydraulic mains, of which there is 1 to each set of ovens, and successively through the condensers, the exhausters and the scrubbers, into the boiler flues. The hydraulic main is so arranged that the gas is obliged to pass through water, which has the effect of cooling it rapidly, and thus preventing the formation of hard tar. The condensers are water-jacketed, and the scrubbers have 7 superposed chambers, in which the gas, finely subdivided by perforated plates, passes through water. The exhausters are of the Beale type, capable of drawing 35,000 cubic metres (1,225,000 cubic feet) in the 24 hours. There is 1 exhauster, driven by an engine, to each set of ovens, so that its speed may be regulated to suit the working of that set of ovens. The tar and ammoniacal liquor are received in a tank, whence they are pumped into large reservoirs, mounted on towers, sufficiently high to permit of their flowing into the tank waggons. The coal, brought in 10 ton waggons from the pit mouth, is raised in elevators to the Carr disintegrators, driven at 600 revolutions per minute. The ground coal is led by tracks, opening at the bottom, directly over the ovens, which are changed by shafts in the ordinary manner.

The distinguishing feature of the ovens themselves is that the gas flues, instead of being formed as usual in the walls of the ovens, necessitating their being almost completely pulled down to effect repairs, are made of fireclay flues or retorts, in lengths fitting into one another with socket joints, and in 3 superposed heights or stages on either side of the coking or combustion chamber. In this way the heat is evenly distributed and easily transmitted through the thin sides of the gas flues, while the latter may be readily repaired or renewed without interfering with the main structure of the ovens. Experience shows that this arrangement favors rapid calcination, and therefore a high production per oven, while the reduction of joints to a minimum, and therefore the prevention of direct passage of gas into the ovens, increases the yield of sub-products. The inside dimensions of the ovens are: Length 9 metres (30 feet); width at front end, 38 centimetres (1 foot 3 inches); and at back, 36 centimetres (1 foot 2 inches); height, 1.7 (5 feet 8 inches); the walls being 2 bricks or 16 inches thick, and the sides of the gas flues or retorts, 7 centimetres (3 inches) thick. The mass of brickwork above the vaulted roof of the ovens is 1.2 metre (4 feet), so as to reduce loss of heat to a minimum and favor an even distribution of heat. The ordinary luted doors are also protected by outer doors of sheet iron against the cooling influences of the weather; other openings, such as the charging shafts and the cleaning holes in the ascending gas pipes, are closed by tight covers, kept against their rests by springs. That no outer air enters is proved by the batch of coke when drawn, which shows not the slightest signs of combustion; and therefore the yield of coke is very high, viz., 81 per cent. of the coal charged, or very nearly the theoretical yield. To more evenly distribute the heat the gas is introduced at two separate points, part at the back end of the upper row of gas flues or retorts and the other part at the front end of the middle row, while the air necessary for combustion, previously heated to a temperature of 200 or 300° C., is admitted at the first inlet. The gas enters its flues by gauged orifices, so as to be evenly distributed over all the flues of all the ovens. Although the ovens work at a high temperature, that of the escaping gases barely reaches 200° C. at the base of the chimneys. Of the 16 or 17 per cent. of volatile matter contained by the coal, there are 4.5 per cent. water and 1.5 per cent. tar, which are condensed, leaving only 10 or 11 per cent. available for heating. Only about half of this quantity is used for firing the ovens, which have no supplementary fires as in other ovens with recovery of the by-products. The remaining half of the gas is used to fire the boilers, or allowed to escape into the air, when, as is frequently the case, the requisite pressure is exceeded. Moreover, the quantity of steam generated more than suffices for the requirements of the works, the excess being sent to neighboring works for converting the ammoniacal liquor into alkali or sulphate of ammonia. Before the by-products were recovered the excess of gas was used to light the works; but it is now deprived of its illuminating properties, which, however, can, of course, be readily restored by passing it over cheap hydrocarbons.

The ton of coal produces 16 cwt. of hard blast furnace coke, 31 pounds of tar and 13.5 pounds of ammonia calculated as sulphate of ammonia. The by-products obtained with every ton of coke are worth 1s. 6d. Deducting 3d. for the extra expense incurred in their production, the 1s. 3d. left constitutes a handsome return for the extra capital sunk in plant for their production. An ordinary oven producing only 60 tons of coke per month, and without recovery of the by-products, costs £80; for 100 tons per month the figure would be £133 6s. 6d. But the Semet-Solvay oven for 100 tons with recovery, costs £260. The difference, viz., £126 13s. 7d., yields £72 per annum, or 57 per cent., on the additional capital sunk for recovery of the by-products, and this not only without supplementary heat, but also with a considerable excess of available heat, from coal containing so little volatile matter that it can only just be coked.—*Iron and Coal Trades Review.*

The Mining Society of Nova Scotia.

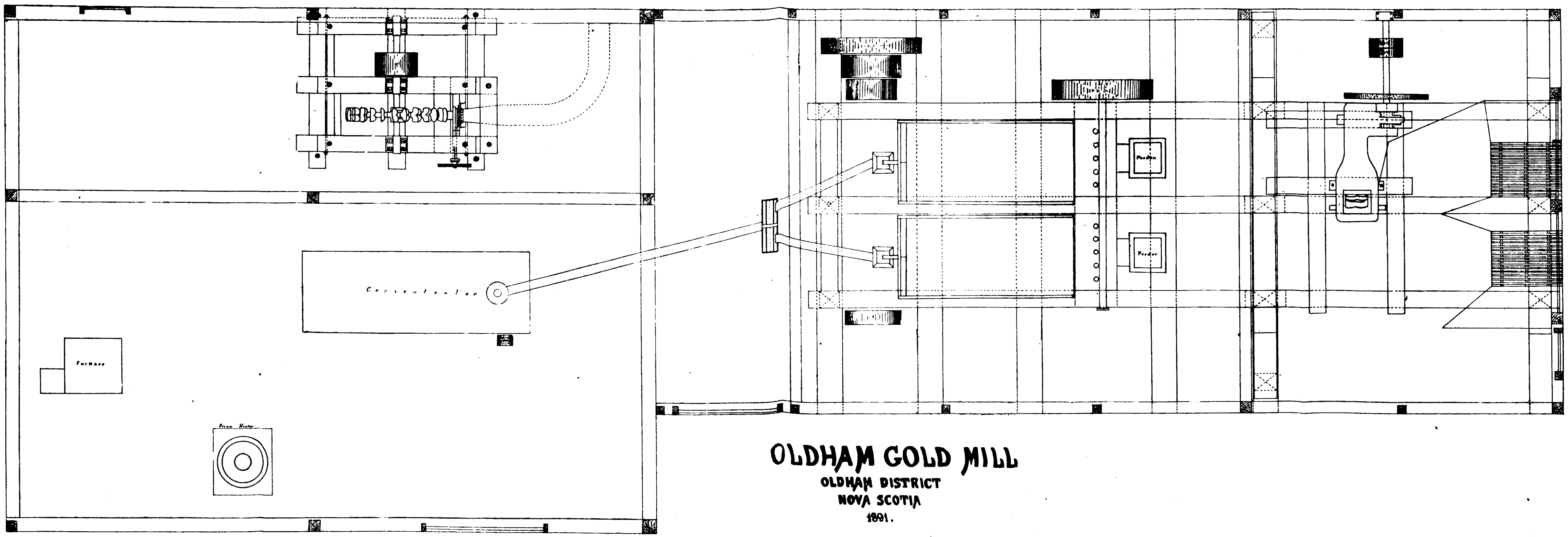
The next quarterly meeting of this Society will be held at Londonderry on 7th September next. Papers will be read by Mr. David McKeen, M.P., on "Coal Cutting in Cape Breton;" Mr. R. G. E. Leckie, on the "Iron Deposits of Torbrook;" and by Mr. John E. Hardman, on the "Crawford Mill." Mr. R. G. Leckie will also, it is understood give a description of the new furnace plant and equipment recently installed at the Londonderry works. An after session will be held in Truro on the same evening.

Electric Drill.—An electric drill is in use at the Brooklyn Navy-yard for drilling holes in ships' plates from ½ to 1½ inch thick, or more, in positions where the use of a power drill is almost impossible. The box containing the drill is 18 inches in length over all; it contains the motor and a flexible shaft, 6 or 8 feet long, for working the drill. The motor runs at 2,800 revolutions per minute, and is geared down. An inch hole can be bored through half-inch iron in less than 30 seconds.

TRANSACTIONS OF THE MINING SOCIETY OF NOVA SCOTIA

To Illustrate Mr. John E. Hardman's Paper,

"RECENT GOLD MILLING PRACTICE IN NOVA SCOTIA."



OLDHAM GOLD MILL
OLDHAM DISTRICT
NOVA SCOTIA
1891.

PLAN

Scale ½ Inch – 1 Foot.

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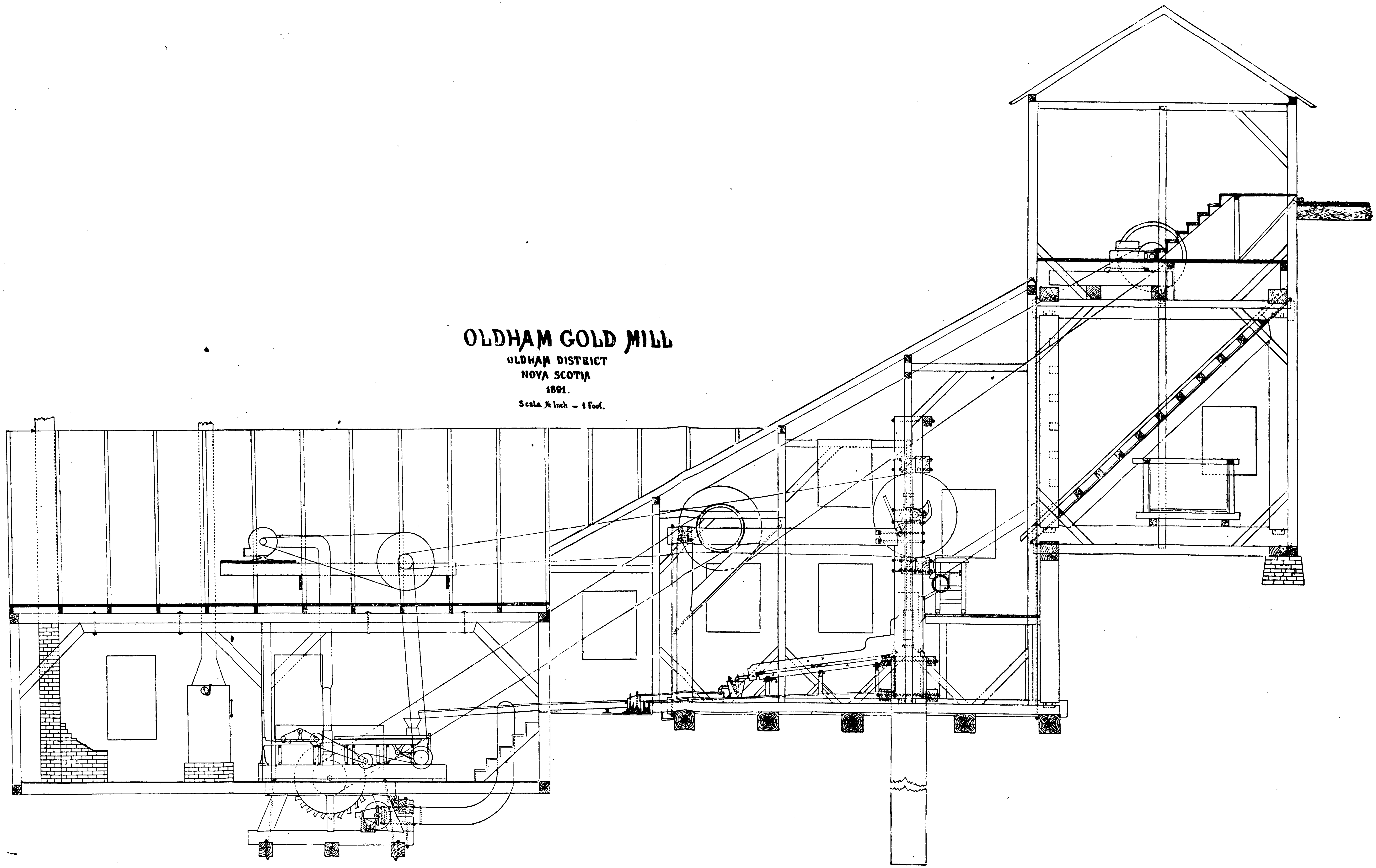

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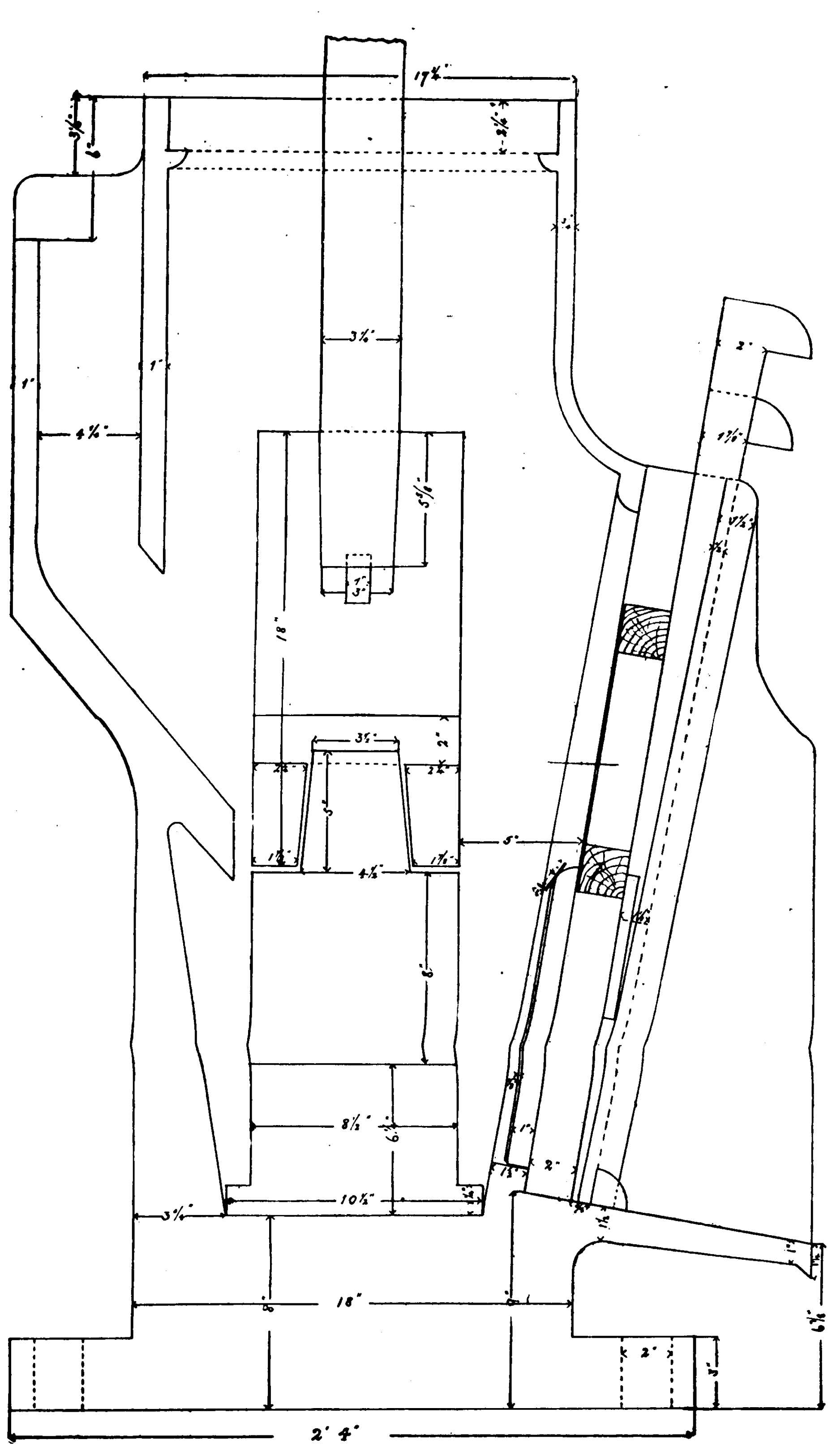

Fig. 1

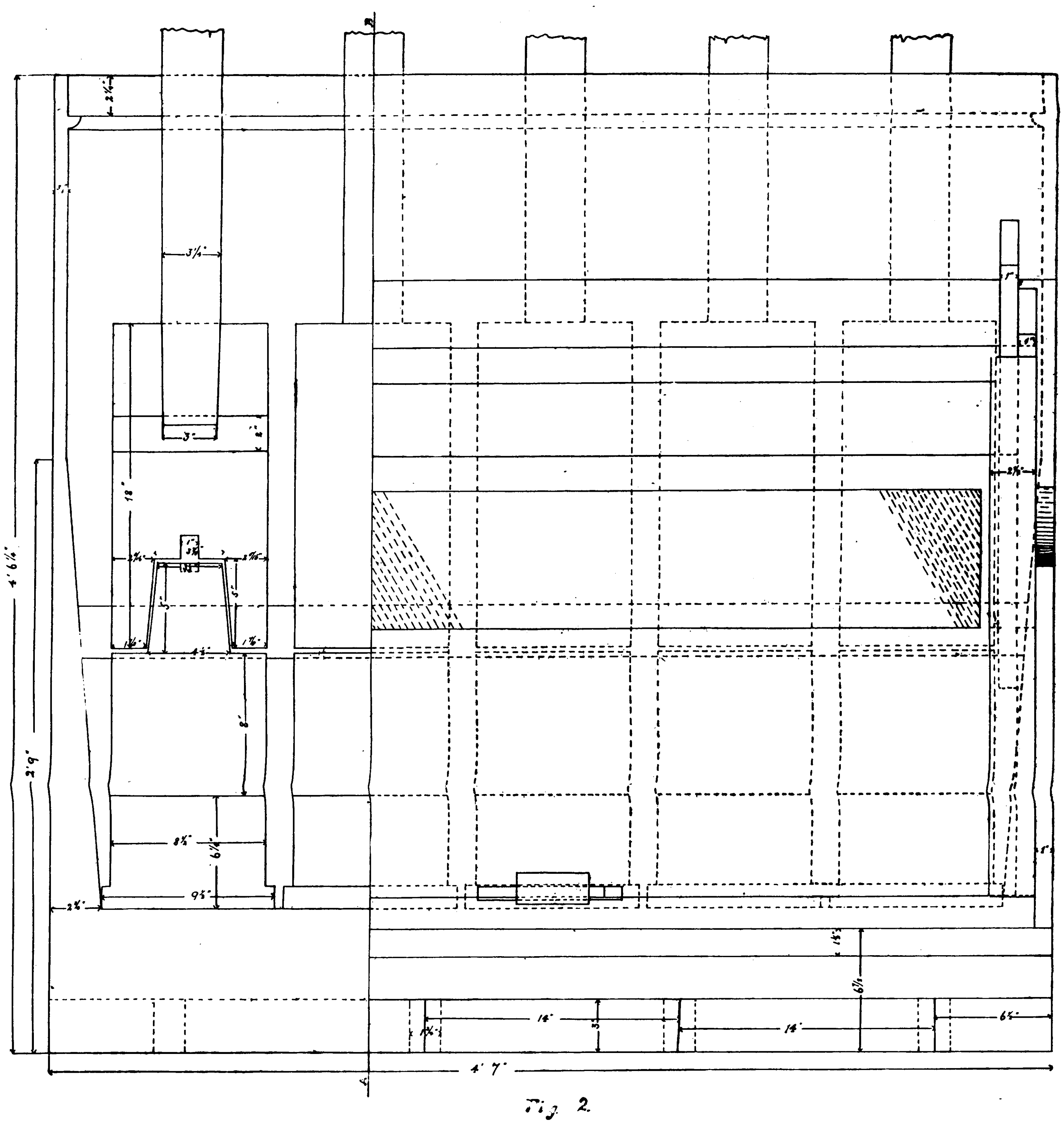

Fig. 2

OLDHAM GOLD MILL

OLDHAM DISTRICT
NOVA SCOTIA
1891.

PLAN AND SECTIONAL ELEVATION
OF
MORTAR.

Scale 3 Inches = 1 Foot.

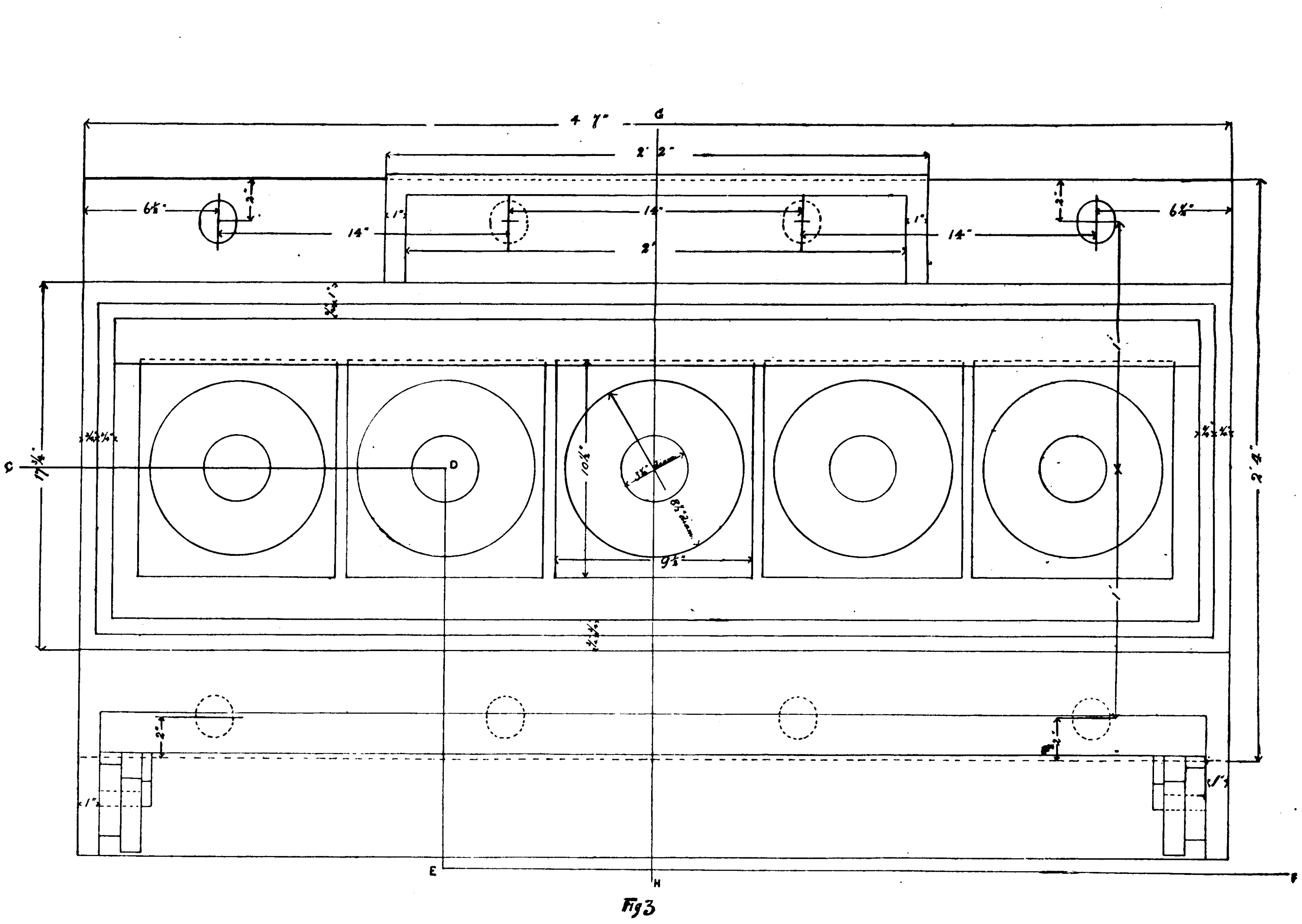

Fig 3

MINING LAWS OF ONTARIO.

ANY person may explore Crown Lands for minerals.
Mining lands may be taken up as surveyed locations or staked claims.
Locations range from 40 to 320 acres.
Claims range from 10 to 20 acres on vein or lode.
Locations may be acquired in fee or under leasehold.
Price of locations north of French River \$2.50 to \$3.50 per acre, and south of it \$2 to \$2.50 according to distance from railway.
Rent of locations first year 60c. to \$1 per acre, and subsequent years 15c. to 25c. per acre.
Rent of claims, \$1 per acre each year.
Claims must be worked continuously.
Royalty on ores specified in the Act, 2 to 3 per cent. of value at pit's mouth less cost of labor and explosives.
Royalty not charged until seven years from date of patent or lease, nor (as provided in s. 4 (3) of the Mines' Act, 1892) until fifteen years in the case of an original discovery of ore or mineral.
Original discoverer of ore or mineral on claim entitled to stake out a second claim.
Crown Lands sold under provisions of mining laws in force prior to 4th May, 1891, exempt from royalty.
Copies of the Mines Act, 1892, may be had on application to

ARCHIBALD BLUE,
Director Bureau of Mines.

TORONTO, April 24, 1892.