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Established 1882

Vol. XII.—No. 9. 1893—OTTAWA, SEPTEMBER—1893. Vol. XII.—No. 9.

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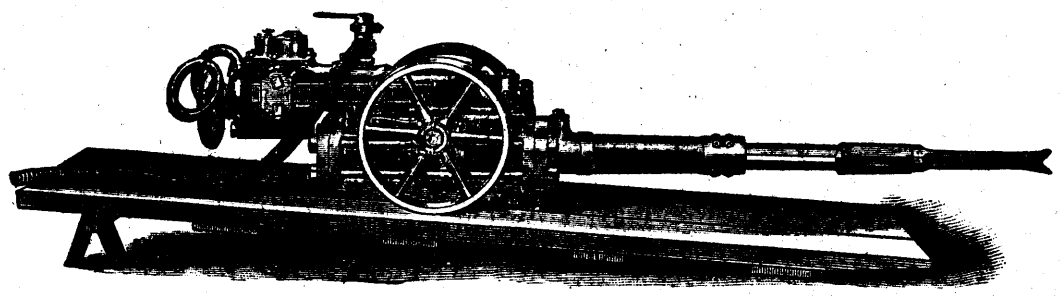

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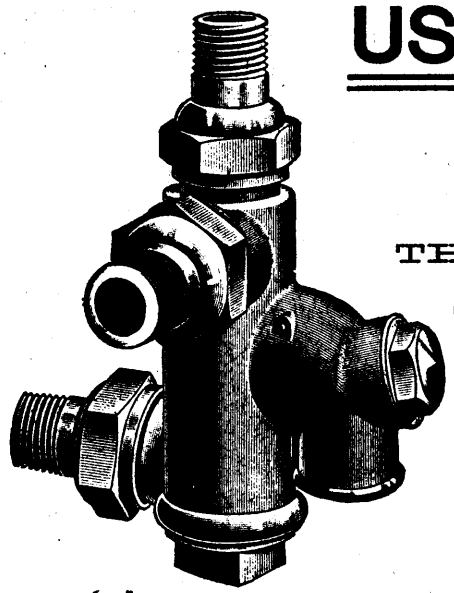

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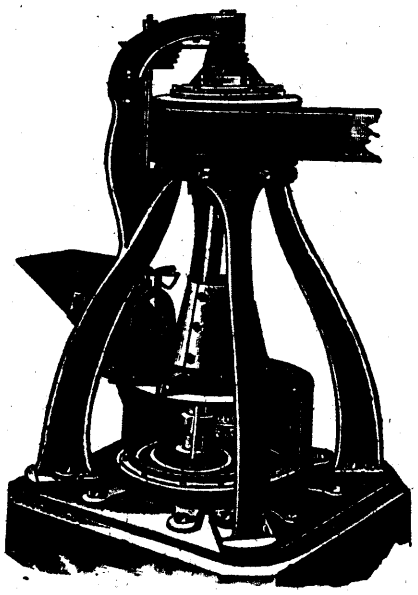

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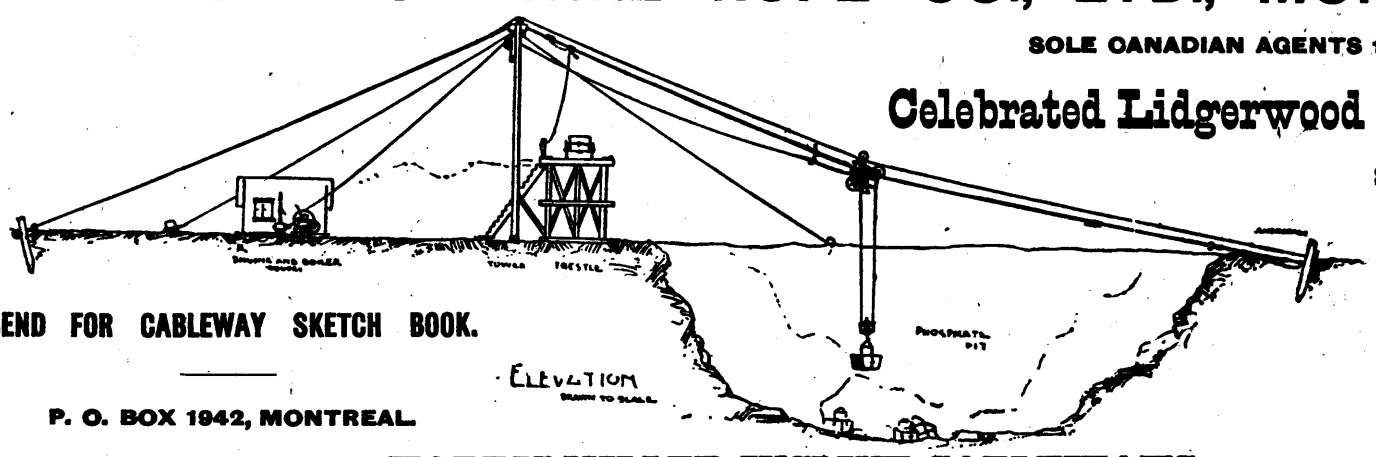

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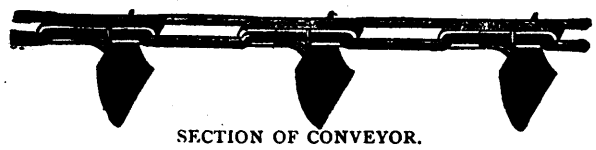

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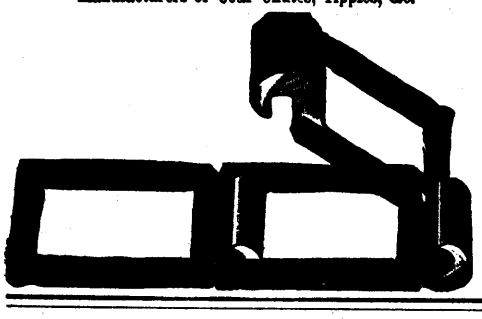

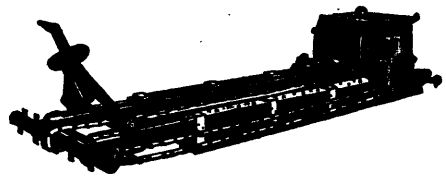

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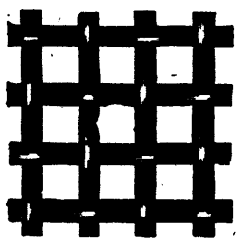

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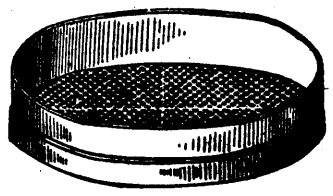

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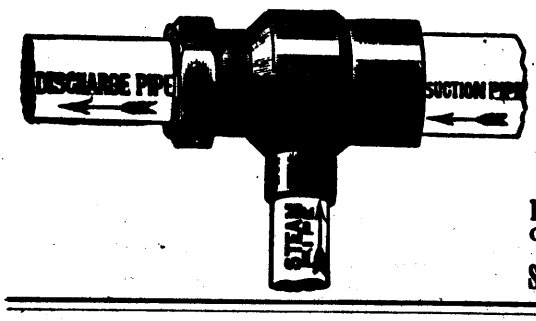

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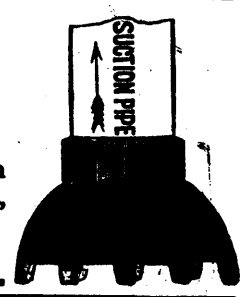

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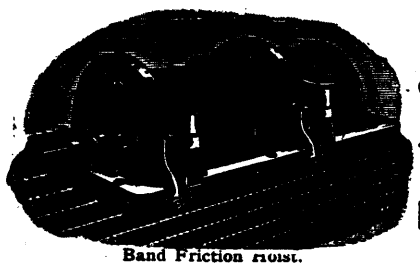

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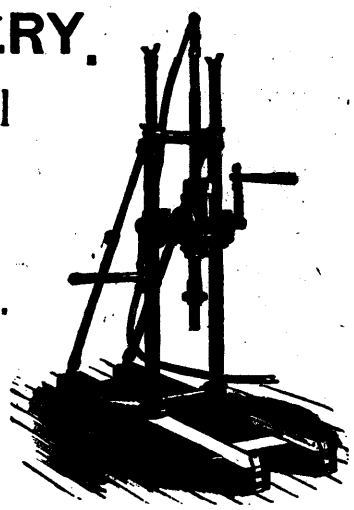

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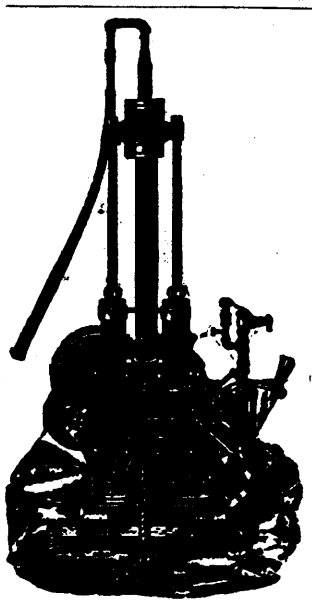

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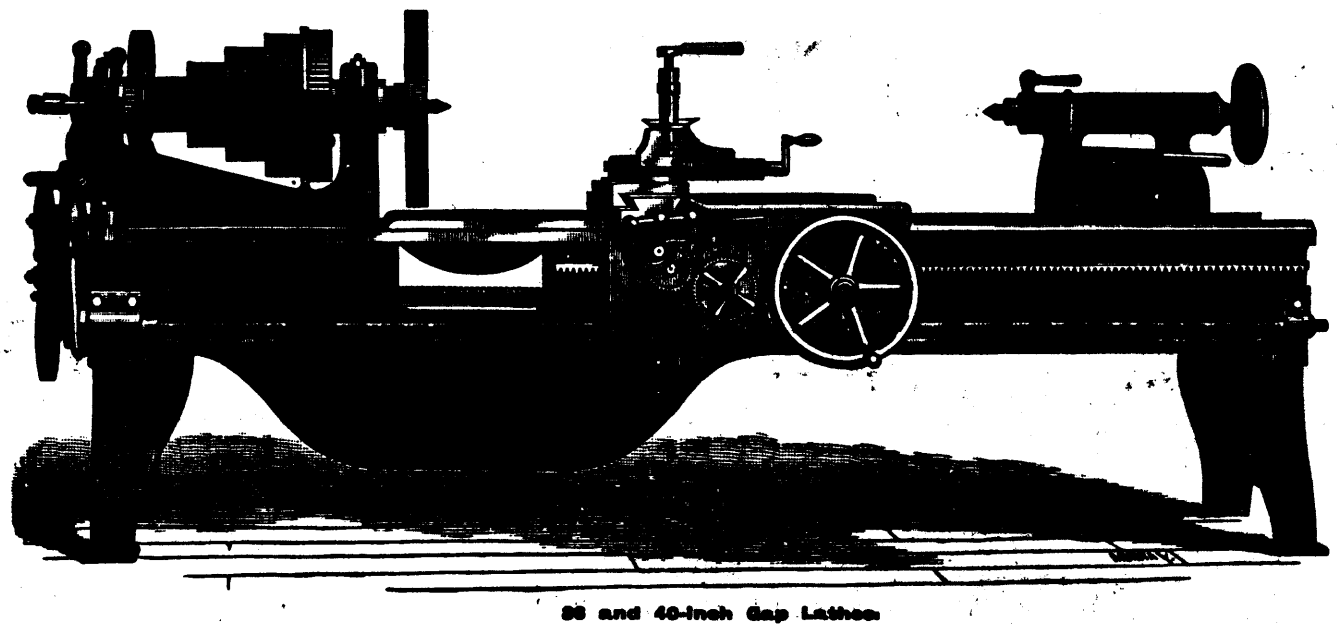

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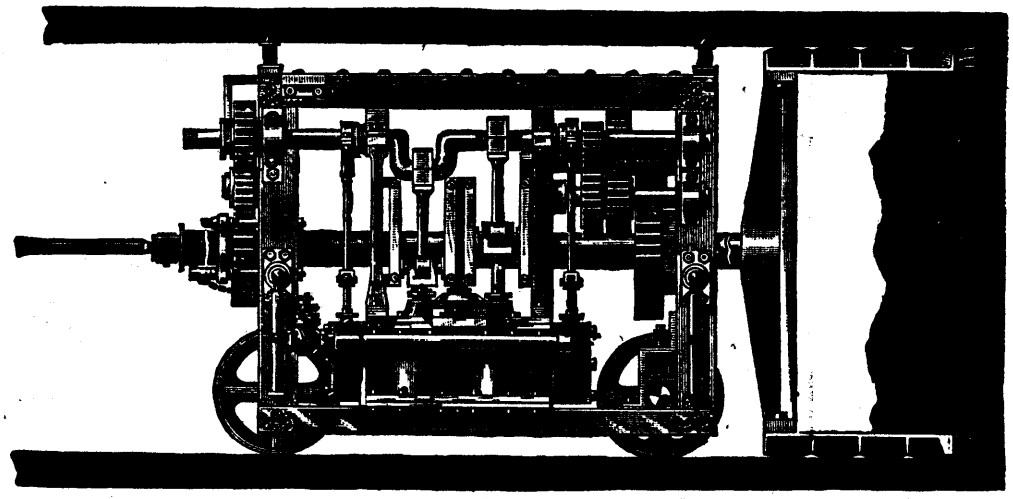

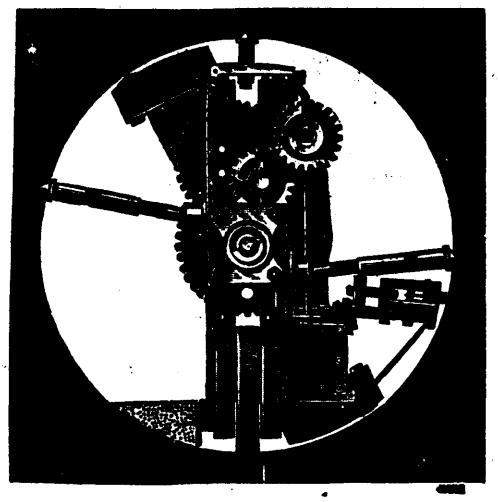

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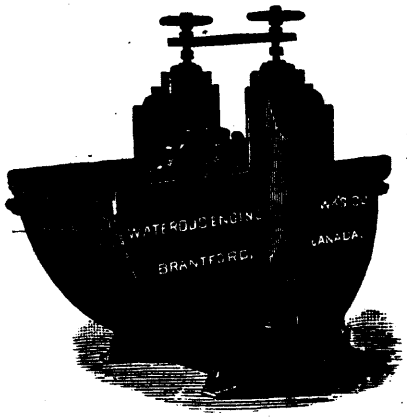

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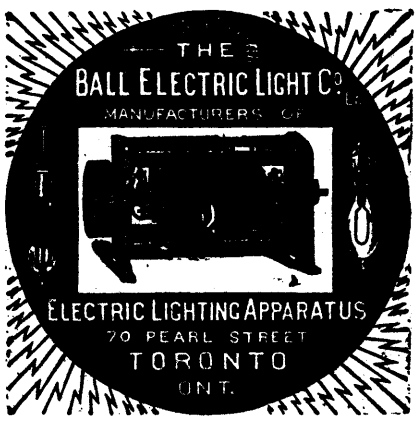

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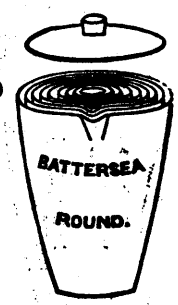

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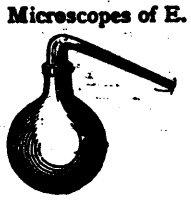

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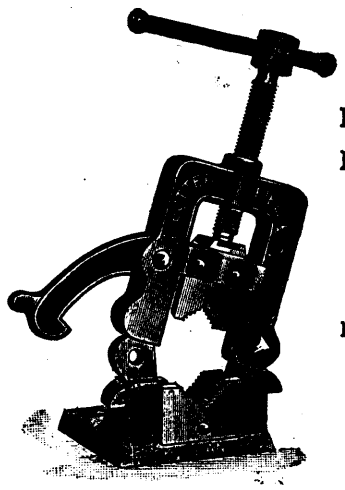

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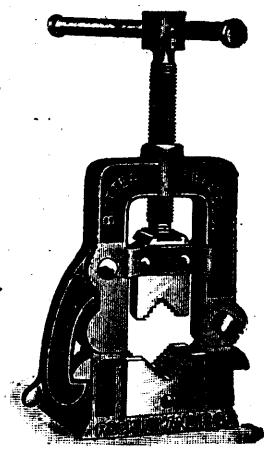

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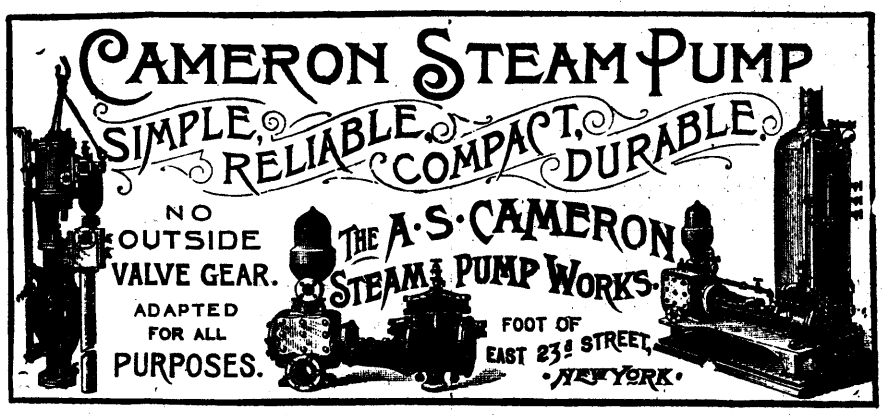

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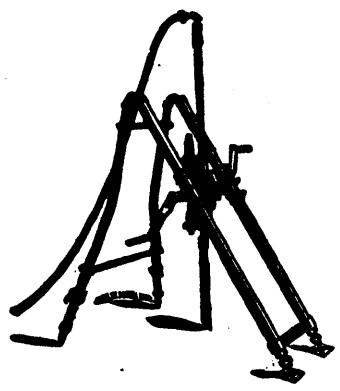

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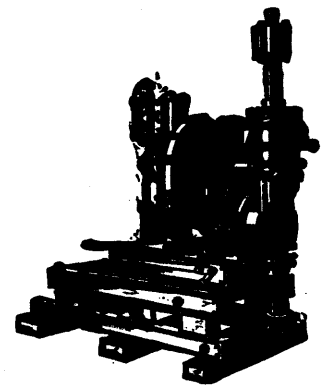

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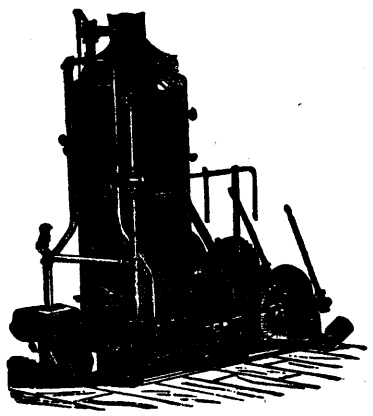

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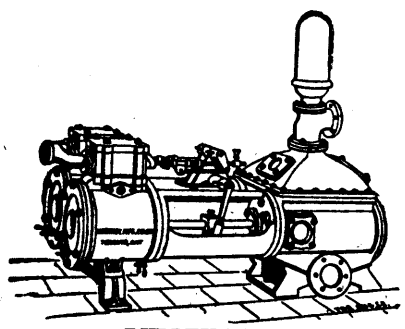

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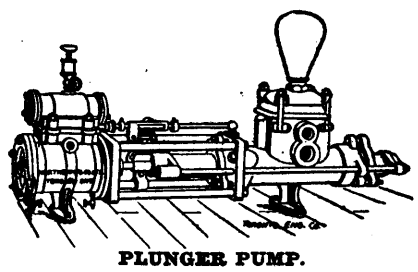

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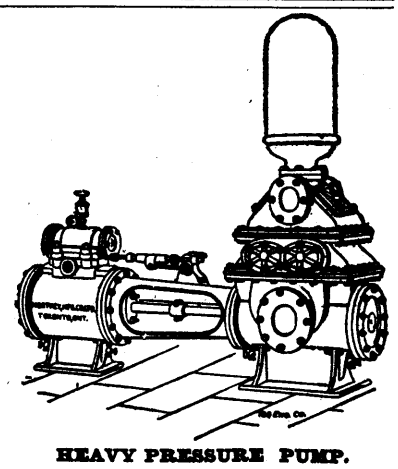

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OFFICES:
Victoria Chambers, 140 Wellington Street,
OTTAWA.

Vol. XII. SEPTEMBER, 1893. No. 9.

THE OFFICIAL ORGAN

—OF—

THE GOLD MINER'S ASSOCIATION OF NOVA SCOTIA.

THE UNITED MINING SOCIETY OF NOVA SCOTIA.

THE ASBESTOS CLUB, QUEBEC.

THE GENERL MINING SSOCIATION OF QUEBEC

THE following Resolutions of Council indicate beyond a peradventure the status of THE REVIEW as the exponent of the Canadian Mineral Industries:—

The Gold Miners' Association of Nova Scotia.

"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 rendered 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, 5th May, 1893, 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.*"

The Protection of Forests against Fire.

This subject is of no light importance to the mining interests of the country, whether the forest be looked upon as a storehouse of fuel for operating mining machinery, or for metallurgical use, or for timber for protecting excavations, and for mining structures and dwellings. The use of timber for all of these purposes in active mining operations is enormous, and especially so in the manufacture of charcoal. The destruction of the forest through recklessness has been so great in many localities as to render it impossible to entertain the project of smelting valuable ores found there, and along with this the cost of engine fuel, mining timber and lumber is so largely increased by the expensive haul over a rough and difficult country, that many ore properties, which in the presence of such a natural supply as existed thirty years ago would have been extremely valuable, are now actually worthless. The estimate of the loss is easily computed thus: Given a fairly valuable ore and flux at any point whence pig iron may be easily shipped, every well wooded acre of land will give fuel worth $100. An annual output of ten millions of dollars worth of charcoal iron is the approximately correct value of the American production, and the same figure stands for the Swedish production. When due regard is given to the valuable industries which use this production in the raw material of various manufactures, some conception may be attained of the value of forest fuel. There would be little use to call from the Trade Reports the figures which express our yearly tribute to the United States for coal if there was any adequate sense in the mind of the people or their law makers of the yearly increasing drain upon the wealth of the country through the criminally wanton destruction of the forest. Here is the coal bill paid to the United States by Ontario and Quebec in the years 1885 to 1892 inclusive, coke excepted:—

	ANTHRACITE COAL.	BITUMINOUS COAL.
1885	$3,644,264	$3,014,693
1886	3,777,804	2,414,267
1887	3,643,202	2,980,664
1888	5,021,985	3,421,363
1889	4,872,533	3,061,377
1890	4,261,810	3,339,520
1891	4,893,225	4,146,054
1892	5,289,992	4,031,611
Totals ...	$35,394,915	$26,409,549

or nearly sixty-two millions of dollars in eight years!

"The whole fire question in the United States," said Mr. Fenrow, Chief of the American Department of Forestry, in a public address, "is one of bad habits and loose morals." These terms sound like a strong indictment, but they do not sufficiently probe the seat of disease in the Canadian conscience. The instinct of the criminal, the *animus furandi*, marks the people of this country in their relations to forest administration. The charge can be brought home to Crown Lands Departments, lumbermen, farmers, municipal councillors, judges on the bench, and jurors. Senator McLaren had to contest step by step to the Supreme Court his claim that a railway company should bonnet their locomotives and use the best appliances for arresting sparks from passing through the smokestacks. In Phelps vs. The Canada Southren Railway Co., Judge Henry dissented from the ruling of the Supreme Court in favor of the plaintiff on the ground that a second fire caused by sparks from a fire kindled on the railway company's property by sparks from their own locomotive, is a damage too remote to be a tort in law. The railway companies though candidates for all kinds of municipal and government bounties, make no hesitation in fighting at every point their liability for damages caused by fires from their locomotives, while the fact is that their roadways are for many years after construction tinder beds of old stumps and rotting timber, the removal of which by contractors should be insisted upon before the payment of one cent of bonus. The government has failed to protect the property of which it is the custodian, and has suffered the railways to do incalculable damage in this way, or in the case of land held under timber license, has in years gone by shielded itself behind the wretched excuse that the protection of their limits was the business of the lumbermen. Now the expense of fire guardians is divided between the lumbermen and the government.

A small portion of the crime of which the wide spread brulees are the enduring record is the work of the railways. To the operation of the Free Grants Act must be ascribed the destruction of more timber, the waste of more public money, the loss of more individual capital and years of fruitless toil, than has attended any other ill starred enterprise in the Province of Ontario. The settlers have been distributed over an immense territory, along great stretches of ill-made roads. The latter have been of enormous value to the lumbermen, and the scanty agriculture which wins hay and oats from the burnt soil is chiefly of value in reducing the expenses of the forest kings. But we look in vain for the advantages which would have come to the settlers from being located in compact bodies on selected tracts where their united labors and taxes would have enabled them to maintain an efficient municipal and educational system. The roads are constant sources of expense; the settlement of the regions opened up makes no progress, the clearing up of tracts of new land, rendered necessary by the rapid wear of soil which has all been burned very deeply, exposes the forest everywhere that it has been penetrated by colonization roads to frequent and disastrous fires. Let a series of Crown Lands reports for 20 years be consulted and evidence will be found that "settlers' fires" have been a known cause of havoc. One will search in vain for a single prosecution, for one practical effort of any effective kind, to stay the destruction. Copies of the Act for the Prevention of Forest Fires have been circulated, but the settlers are perfectly aware of the innocent character of the warning. "What do you do," was asked of a fire guardian, "when you see a fire running from a fallow into the woods. Do you bring the offender to justice?" "No, I get an axe," was the answer, "and help him to put it out. I know better than to quarrel with settlers in the woods."

Strange to say, all efforts to obtain a practical investigation of the ravage going on and the consideration of efforts for its suppresion, have been resisted by the majority in the Provincial Legislature. The Royal Mining Commission of 1890, reported that they "were struck with the appearence of many scenes of desolation where forest fires had swept over wide districts, leaving blackened tree trunks and fire scorched wastes in the place of hills and valleys once covered with timber. The loss to the Province from this cause has reached many millions of dollars within the last thirty years." And again, "the destruction of timber by forest fires is complained of by several witnesses as inimical to the mining industry." A ready facility for acquiring testimony on the subject would be afforded by an Act similar to that for the investigation of accidents by fire to dwelling houses, with this necessary amendment, that as the law, by making the free-grant settler's property

exempt from execution, practically shields him from civil damages, the expense of an inquiry into the origin of a fire should not work the ruin of the injured party by compelling him, as does the Act referred to, to pay the expense of the investigation.

It is the crime of arson to set on fire a stack of hay, and probably such to fire a wood pile, but it has never been made such a crime in this country to set fire to square leagues of forest. It is an indictable offence when one, by such negligence as shows him to be reckless or wantonly regardless of consequences, sets fire to any forest or tree on this Crown domain or on private property, *on any creek or river or rollway beach or wharf*, so that the same is injured or distroyed. The words in italics taken from section 486 of Sir John Thompson's Criminal Code, seem to limit the range of the offence and to afford to the indigenous tramp or reckless bushwhacker the opportunity to kindle a flame regardless of legal consequences, if he will only keep away from the watercourses. And a further degree of protection seems to be afforded the wrong-doer in a case where the property first destroyed is his own, provided the wrong done was without intent to defraud.

The destruction of the forest by settlers' fires beyond the limits required for tillage, is more than reckless waste. It is crime. It is an invasion of the providential natural economy of the territory the nation is permitted to occupy. It injuriously interferes with terrestrial evaporation,—part of the providential climatic law: it interferes with the distribution of the rainfall, with the preservation of fertility in the soil for the food of future generations; and in view of these copious wrongs is a crime against the Divine Providence. The social crime is equally of portentous enormity. It robs the country of a source of wealth growing in value with every unit of population and which within itself contains a more independently active increment of growth than any other living principle in the economy of the world we live in. The mineral wealth of the country grows not,—only the means for converting it into wealth. The treeless soil is valueless without labor. But the tree wins from air and rain and sun a yearly tribute of nourishment which the falling leaf gives to the soil while the yearl··ng of wood-growth is enclosed w hin the bark for the future use of man.

The operation of the system of fire-rangers, paid in part by the Governments in part by the limit owners, is credited with a greater claim for efficiency than it is entitled to. It makes no provision for dealing with the wanton destruction of timber by the settlers themselves, who often look upon a fire which consumes their wood standing as a ready means for preparing the way for clearing and "getting the land into hay." Within a few years past a correspondent of the *Globe* called attention to the danger to forests in a remote part of the Nipissing district by giving location tickets for the settlement of land wholly unfit for cultivation. The worst fires, as a rule, are not those which break out on well timbered limits, but those which occur when a limit has been worked over a number of years. Lumbermen have been known to retain in their possesion when they have had no desire to cut these limits with only a residuum of blasted trees, and instances are not wanting where they have refused to sell such to settlers or jobbers, preferring to see the limit remain a ready victim for the lightning bolt or the wind-wafted spark from a clearing, than to allow any lumbering operations which might reduce the risk of fire.

Mr. Fernow, in his report for the year 1892, presents the draft of a measure for the protection of forest property, worthy, in its main features, of the consideration of legislators in Ontario and Quebec. It proposes the appointment of a commissioner to organize and supervise, and be responsible, under the provisions of the Act for the protection of forest property against fire Then follow clauses for the organization of fire service, for the creation of a fire indemnity fund, and for legal proceedings for the prosecution of incendiaries. It suffices here to draw attention to these suggestions for legislation. In many ways the people of the United States are helping the cause of forest protection by the organization of state forestry associations, among which must be noted the Pennsylvania Forestry Association, under the presidency of John Birkinbine, C.E. Its monthly bulletin, *Forest Leaves*, deserves widespread recognition. Chief of all, the labors of the former Secretary of Agriculture, and his successor, Hon. Mr. Morton, e eminent founder of the American Arbor day, and also of our own, and the profound studies and learned discussions of Mr. B. E. Fernow, an accomplished authority on all matters relating to forestry, have advanced the cause of forest protection to that point where its demands now meet with general accord. In Ontario, Mr. Phipps, as Clerk of Forestry, has issued many reports on the subject of planting trees, and on foreign methods of forest management, which have been of great interest to the public. His efforts, however, will only make the indictment stronger against the persons in power, who are responsible for the protection of the greatest endowment the country has, if speedy measures are not devised for the protection of private and public forests from fire.

The forest region is without any system of police, and probably needs none for any other than the purpose mentioned. Private injuries on this score abound, but the injured are too poor "to take the law" on those who are so mean as to break it. Municipal regulation of the season for firing log heaps is allowed, but the history of the country too well establishes that municipal prevention of wrong in this matter, where every municipal officer is more likely than not to excuse the wrong, is an utter farce. The popular conscience has been debauched by the universal incendiarism. No amount of warning or expostulations will be of any avail. Nothing but a vigorous policy will serve to protect, against this incendiarism, what remains of the great forests of Ontario and Quebec.

The Free Grant townships are 153 in number. In most of these the settlers are so widely scattered as to be unable to give each other any help in fighting fire for the purpose of saving "the bush." It is only when fences, crops or buildings are in danger that neighbourly help comes from far and wide. There is no reason, from the settler's point of view, why he should make the least effort to prevent fire from spreading beyond his clearing. As a consequence settlers' fires often run through hemlock, spruce and swamp timber in which the lumbermen have no interest, and for the preservation of which the present system of fire-ranging makes no provision. The hardwood timber is seriously damaged by the destruction of the soil and this means a greater loss to the country than the mere value of the hardwood itself. If the soil were left intact the indigenous growth would in two generations replace the average loss.

The subject invites the interest of the journalists of the country, without whose aid it is useless to look for any remedy in this matter. It must be remembered that the forest interest elects no representative to the legislature. Lumbermen, who make the largest fortunes in the community, when they retire from business invest in Virginia wild lands, Utah silver mines and Texas cattle ranches, or, in their wiser moments, in bank stocks. Not one of our forest kings has ever said in public one word in behalf of all that is comprehended under the word "forestry." The Crown Lands Departments are administered solely with a view to present revenue. The backwoods portions of the constituencies, with the exception of the Ontario districts of Nipissing, Algoma, Thunder Bay and Rainy River, are convenient fields for the exercise of lumbermen's patronage, and the patronage of the local member in securing government grants for poor schools and colonization roads, and all with an eye to—votes. That administration of Crown Lands in any province suits best the popular opinion which averts for the time the Canadian farmers' nightmare—direct taxation. The tax in the future of increased yearly subventions to the United States for fuel and of increased cost of building timber, deserves consideration, because the ratio of increase is amazingly rapid and likely to become ere many years go by the most burdensome of all charges on the industry of the country.

EN PASSANT.

A rather good story is going the rounds, which illustrates to a T, the penny wise and pound foolish policy that not infrequently characterizes the operations of our Geological Survey. While the Department was investigating the nickel resources of the Sudbury district, one of the largest operators, whose works are ordinarily a sealed letter, took occasion to show a great deal of kindness and courtesy to the officers in charge of the work. Every facility was afforded to inspect the mines and works, and the manager

went out of his way to obtain and give much valuable information respecting the industry. Sometime afterwards he had occasion to use a map of the district, and writing to the Survey, for whom he had done so much, was promptly informed that *on the receipt of ten cents* he could have the map. Such crass stupidity naturally bore fruit. When the Survey desired this Company's exhibit—by the way one of the finest to be seen at Chicago—for its collection at the World's Fair, they were very properly refused, and instead the exhibits were handed over to Mr. Boyle, the Ontario Commissioner. *Sic vos non vobis.*

Writing of the Survey reminds us that a much needed catalogue of the mineral exhibits in the museum at Ottawa, has just been issued. It has been carefully compiled in handy form by Mr. G. C. Hoffman, the curator. This, the latest work issued by the Department, will be found of great service as a reference to all interested in our mineral resources. The only wonder is that the Director should have been so tardy with its publication.

As showing the extent of popular sympathy for distress caused by colliery accidents in England, it may be stated that during the last thirty years there has been raised at the Mansion House, London, the noble sum of £117,025. At the same time these figures must not be taken as representing the full amount of financial help obtained through the Mansion House. There have been many instances in which, while the Lord Mayor's fund has been a comparative failure, the total sum raised has been sufficient for its purpose, and it is impossible to estimate the effect upon public charity of an appeal from the Chief Magistrate of the City of London.

The statistics just published by the American Iron and Steel Association show that the total production of pig iron in the United States in the first six months of 1893 amounted to 4,562,918 tons, against 4,769,683 tons in the corresponding period of 1892, and 4,387,317 tons in the second half of last year. These figures indicate that, compared with the first six months of 1892, the output this year declined by 206,765 tons, or 4·4 per cent., but, compared with the second half of 1892, it increased by 175,601 tons, or 4 per cent. Although the output for the six months ended June 30 was larger than in the preceding six months, it is expected in view of the present depressed condition of the American trade, and the remarkable decline in the output since June, that the total production of pig iron in 1893 will be much less than last year. The rate of production in the various States has undergone several important changes during the past half year. In Pennsylvania the output has increased from 1,976,673 tons in the second half of 1892 to 2,225,962 tons in the first half of the present year; the other increases being 40,000 tons in Maryland, 24,000 tons in Ohio, 16,000 tons in Colorado, 14,000 tons in Kentucky, 11,000 tons in Alabama, and 10,000 tons in Georgia. The principal decline was in the production of Illinois, where it fell from 471,489 tons to 335,771 tons, while in Virginia it decreased by 26,000 tons, in Tennessee by 14,000 tons, and in Michigan by 12,000 tons. The production of Bessemer pig iron in the first half of 1893 was 2,374,890 tons against 2,189,696 tons in the second half of 1892, and 2,254,345 in the first half of that year, the increase being 185,194 tons, or 8·4 per cent., and 120,545 tons, or 5 per cent. respectively. The number of furnaces in blast on June 30 was 225, against 253 on December 31, 1892, and yet the output of the fewer number of furnaces was increased by 175,000 tons. The stock of pig iron shows a large increase, indicative of a worse trade. There were 578,831 tons on June 30 last, against 535,616 tons on December 31, 1892, the increase amounting to 43,215 tons, or 8 per cent. It is intended, with a view of reducing stocks, to blow out more furnaces.

An interesting table has just been submitted to Congress by the director of the United States mint on the moneys of the great nations. The aggregate stock of gold, taking $5 to the pound, is placed at £716,521,000; silver, £808,540,000; uncovered paper currency, £527,174,600. Of the gold and silver France holds the largest amount, £160,000,000 of the former and £140,000,000 of the latter. The United States comes next with £120,800,000 gold and £123,000,000 silver; Great Britain is placed fourth on the list with £110,000,000 gold and £20,000,000 silver; Pussia last with only £50,000,000 gold and £12,000,000 silver. In the matter of uncovered paper money South America leads the world with over £120,000,000, Russia is second with £100,000,000, United States third with £82,400,000, and Great Britain last with only £10,000,000. Taking all classes of money, gold, silver and paper, the per capita circulation is given as follows: France, £8 2s.; Cuba, £6 4s.; Netherlands, £5 15s.; Australia, £5 7s.; Belgium, £5 2s; United States, £4 17s. 6d.; United Kingdom, £2 14s.; Russia, £1 8s. 6d.

Coincident with the visit of Dr. E. D. Peters, Jr., the well known copper metallurgist, to Australia, we read of a find of a deposit of nickeliferous pyrrhotite in that country. No information is given as to the probable extent and value of the new discovery.

The success which attended the mining exhibition in London in 1890, has encouraged the members of the Institution of Mining and Metallurgy, and the Mining Section of the London Chamber of Commerce, to take preliminary steps with a view to the holdidg of an International Exhibition of Mining and Metallurgy in London in 1894. We gather that the idea is to endeavor to secure for the coming exhibition the best part of the large collection of minerals, mining machinery and accessories now on view at Chicago. If the proposed Mining Exhibition in London comes off, as it probably will, we trust that Canada will make a special effort to be represented in a manner befitting its great mineral wealth.

Mr. J. S. Jeans, widely known to the engineering world as the able secretary of the Iron and Steel Institute of Great Britain, has resigned his position to assume control of his new monthly, the *Engineering Review*. The first number of Mr. Jean's venture is excellently gotten up, and contains a mass of information of interest to the profession. Considerable space is devoted to summaries of the more notable articles in the leading technical journals and reviews, the data being classified and arranged in such a way as to afford a ready reference. There are also biographical sketches of Sir Henry Bessemer and Robert Forrester Mushet, together with an illustrated supplement of forty pages, giving a description by Mr. Jeans himself of the World's Columbian Exhibition. A highly commendable feature of the new Review is its complete index, after the manner of the *Review of Reviews*, of current engineering literature. The REVIEW extends its congratulations and hearty good wishes for Mr. Jeans' success in his new field of labor.

The *Critic's* latest protege is Mr. C. Ochultree Macdonald, who claims to be a special Canadian correspondent to the *Colliery Guardian*, "with all rights of translation strictly reserved." Perhaps the management at Cow Bay could give the *Critic* a few pointers on the claims of this writer to be considered an authority on the Canadian coal trade. At our last acquaintance Mr. C. Ochiltree Macdonald's specialty was a corner in Canadian spruce gum and maple sugar.

In the Metallurgical Section of the Congress of Mining Engineers, held recently in Chicago, there was an interesting discussion on the paper of Mr. E. C. Potter on American Blast Furnace Practice. Mr. John Birkinbine referred to the fact that the bulk of advancement in blast furnace practice had been within the last 25 or 30 years; that to-day in this country there are active furnaces through all gradations from the cold blast charcoal furnace, with its square stone stack, blast cylinders and water wheel, producing only three or four tons daily, to the modern monster coke furnace, producing 100 times the amount of iron that its ancient prototype made. He credited technical knowledge with much of this advancement, and claimed that the chemist, the manager and the engineer had made the real advance by determining the composition of materials, by studying the reactions in the blast furnace, by applying labor saving machinery to operation, and by using skill in designing and construction. Mr. Birkinbine called attention to the demands for richer ores made by blast furnaces, and the development of the pig iron industry in new districts or sections of the country.

Replying to a question from President Howe, concerning the probability of the long expected

annihilation of the charcoal pig iron industry, Mr. Birkinbine expressed his belief that the United States will continue to produce from 500,000 to 750,000 tons of charcoal iron annually; that the restriction of this branch of industry is due to the difficulty of producing in one locality, or assembling at one point, sufficient fuel to support large plants, and consequently even with cheap fuel, good ores, etc., the charcoal furnaces have the disadvantage of having to divide fixed charges by smaller tonnages.

The metallurgy of lead formed the subject of an interesting paper by Mr. J. B. Hannay, before the last session of the Royal Society of Great Britain. The metallurgy of iron, he said, had obtained complete elucidation during the last twenty years, that of copper was pretty well known, whilst chemists to the Mint—notably Roberts-Austin—had made the metallurgy of the precious metals their special study; but the further great domain of metallurgy, that of lead, was still in the empirical stage. Percy, the greatest authority on metallurgy, admitted, after spending some years at the subject, that the chemical changes involved in the metallurgy of lead were still unexplained. Mr. Hannay proceeded to describe several new volatile compounds of lead, the discovery of which gave the key to the solution of many of the difficulties which had hitherto beset the path of the investigator, and by examining all the furnace reactions of lead compounds in the light of those discoveries he was enabled, he said, for the first time to present a true explanation of the metallurgy of lead founded upon accurate knowledge. By the aid of these discoveries he had devised an entirely new metallurgy of lead founded upon modern methods. The process consisted in passing a stream of air through the lead ore in a Bessemer converter, by which simple means the whole of the ore was converted into pig lead, or litharge, or sulphate of lead, as might be required, thus enabling the manufacturers to make the product bring the best price in the market. The oxidation of the ore supplied all the heat required to conduct the process, so that no fuel was required. The importance of this new process, Mr. Hannay declared, might be judged from the fact that not only was the whole of the lead obtained as finished products without loss, as against a 20 per cent. loss by the old method, but every ounce of silver was separated and collected without any expense, no matter how little silver might be present.

We are indebted to the Scientific Publishing Company, New York, for a copy of Prof. J. F. Kemp's recently published volume on the "Ore Deposits of the United States." In the last forty years enormous developments have been made in new mining districts in the United States, and those which were the chief sources of ores thirty, twenty, or even ten and five years ago, have in instances given place to regions then practically unknown. The older books are thus in large part ancient history. Great advances have also been made in our theoretical knowledge regarding origin and formation. Much that was vain imagining has been replaced by well founded deductions from observation and experiment. Not all the difficulties and uncertainties of exploration and development have been met, nor ever can be, but much greater confidence has been made possible and many unreasonable expectations have become preventable by this fuller knowledge. The present work has been conceived with these important considerations in view. Although its descriptive portion is concerned only with the ore deposits of the United States and Canada, its general and introductory discussion is based upon all the literature of the subject. English, German and French authorities have been studied during the author's residence abroad, as well as American at home. The ore deposits are taken up by metals, in the order shown by the accompanying table of contents. Where, however, two are characteristically associated, as in many deposits of lead and zinc, lead and silver, silver and gold, nickel and cobalt, the two are treated together. Wherever possible the endeavor has been made to pass from the well understood to the more difficult, as is most conspicuously done with iron. Its bog ore deposits are first treated, as the origin of these presents no difficulties, while the magnetic lenses are taken up last, for their method of formation is most obscure of all. So far as possible a definite impression is created by the arrangement of the ore bodies under examples. This term was preferred to that of type, which is used by Von Groddeck, because the arrangement by metals precluded this, and because the relations of ore bodies are often so obscure, poorly defined or ill described, that types cannot be sharply established. This arrangement has been found very serviceable in teaching, as it defines much more sharply in the mind of a student the features on which the instructor would wish to lay especial stress. The treatment is consistently geological and the principals of origin have been made as prominent as possible. The literature is cited in its completeness, but the references have been annotated as to whether they are specially recommended for general consultation, for their historical record, or for complete investigation. In the division of space, the more important regions have been naturally given the greater amount, and the effort has been made to preserve thus a proportion, and not to be too much influenced by purely scientific considerations. At the same time, it is believed that no district of any importance has been overlooked, and that, if it is given but passing mention, the references will place the full literature at command. It is fully realized that there are many important districts, especially in the West, of which our recorded knowledge is limited, and which need study and description. It is hoped that the book may emphasize these, and encourage the study of them. The materials for the book have been assembled for lectures and instruction in economic geology, which have been given by the author during the last seven years, five at Cornell University and two at the School of Mines, Columbia College.

In our next issue the REVIEW will commence publication of a series of illustrated articles on the Canadian mica mining industry, from the pen of Mr. F. Cirkel, M.E., Ottawa.

There has just been published by the Department of Customs a very handily arranged analytical index to the existing Customs Tariff, which our miners and manufacturers will find of the greatest utility. We are glad to note that the Act relating to the free importation of mining machinery is reproduced in the exact language in which it was adopted by Parliament. The words "class *and* kind" instead of "class *or* kind" often proved troublesome to importers when seeking an interpretation of the law at ports of entry.

On Thursday and Friday, 28th and 29th instants, the Mining Society of Nova Scotia will have as its guests the members of the General Mining Association of Quebec in a united meeting at Halifax. Excursions will be made to the gold mines of Waverley and Montagu, and the social features embrace a dinner and an outing on the beautiful harbor at Halifax.

Another big record has been put up by the Witwatersrand mines. The grand figures of 116,884 oz., representing the output of December last, stood unbeaten until May, when the previous record was just topped, the actual total being 116,911 oz. Now we learn that this record has been thrown completely in the shade by the returns for June, which give the magnificent total of 122,907 oz. Only the bare total for June is to hand so far, and we cannot therefore at the moment give any details for that month, but the particulars of the May output have been forwarded by the Chamber of Mines. The returns for the first six months of the current year were as follows: January, 107,474 oz., February, 92,352 oz., March, 111,474 oz., April, 112,053 oz., May, 116,911 oz., and June, 122,907 oz., making a grand total for the first half year of 673,161 oz. The total output for 1892 was 1,210,865 oz., and if the present monthly average is kept up the yield for the current year will top that for 1892 by nearly a quarter of a million ounces. The May returns show that 85,750 oz. gold were obtained from 174. 73 tons of stone put through the mills, the average product per ton being 9·85 dwt., that 5,536 oz. were obtained from concentrates, 21,278 oz. from tailings, 171 oz. from alluvial, and 4,174 oz. from other sources, making a grand total of 116,911 oz., worth £411,877. The principal mill yields were as follows:—Robinson Company, 9,062 oz. from 8,042 tons, New Primrose, 4,802 oz. from 12,200 tons, Langlaate Estate, 4,700 oz. from 18,689 tons,

Crown Reef, 4,666 oz. from 10,125 tons, Ferreira, 3,839 oz. from 4,446 tons, Geldenhuis Estate, 3,386 oz. from 4,841 tons, Jumpers, 3,222 oz. from 7,884 tons, Simmer and Jack, 3,142 oz. from 9,506 tons, Durban Roodepoort, 3,030 oz. from 6,531 tons, City and Suburban, 3,002 oz. from 4,259 tons, Meyer and Charlton, 2,938 oz. from 3,025 tons, Wolhuter, 2,724 oz. from 5,192 tons. The highest average yield was 30·03 dwts., obtained by the New Rietfontein Estate from 1,675 tons, New Heriot coming next with 28·61 dwt. from 720 tons, Nigel following with 23·22 dwt. from 2,059 tons, and Robinson being close up with 23·22 dwt. from the very large crushing of 8,042 tons. The lowest average was 4·54 dwt. obtained by the East Roodepoort and the Meyer and Leeb, and among the larger companies, the poorest average shown was that of the Langlaate Estate, with 5·02 dwt. per ton from 18,689 tons. The biggest yield obtained from tailings by any one company was 2,509 oz. by the Durban Roodepoort Company, the New Primrose Company coming next with 2,484 oz., Langlaate Estate following with 2,323 oz., and the Crown Reef Company being fourth with 1,922 oz. The whole of the gold obtained from tailings was recovered by means of the MacArthur-Forrest process.

The British Consul at Wenchow in his last report gives some interesting details respecting the manufacture of steatite or soapstone ornaments in China. The mines are distant 42 miles from Wenchow, and are reached by a boat journey of 35 miles up the river, followed by a land journey of seven miles over rough ground. The hills containing steatite are owned by 20 to 30 families, who in some cases work the mines themselves, in others engage miners to do it on their account. The galleries are driven into the sides of the hills and are often nearly a mile in length. The composition of the hills is soft, and the shafts require to be propped up by supports of timber; for the same reason the floors are full of mire and clay, so that the miners wear special clothing made principally of rhea fibre. They lead a hard life, living in straw huts on the hillside. The stone when first extracted is soft, hardening on exposure to the air. It is brought out of the mine in shovels, and is sold at the pit mouth to the carvers at a uniform price of about ½d. per lb. This would be when the purchaser buys it in gross, without first selecting it in any way. When picked over, the mineral varies very considerably in value—according to the size of the lump, its shape, and, above all, its colors. The colors are given as purple, red, mottled red, black, dark blue, light blue, gray, white, eggshell white, "jade," beeswax, and "frozen." Of these, "jade" (the white variety, not the green), and "frozen" are the most valuable. Indeed, so valuable is the latter that good specimens of it are said to fetch more than real jade itself. The industry finds employment at the present time for some 2,000 miners and carvers. A great impetus was given to it by the opening of Wenchow to foreign trade. Previously to that event the chief purchasers of soapstone were officials and literary men, and the article most often carved was a stamp or seal. When it was discovered that foreigners admired the stone, articles were produced to meet what seemed to be their taste. Such were landscapes in high or low relief, flower vases, plates, card trays, fruit dishes, cups, teapots, and pagodas. If left to his own devices, the native carver proceeds first to examine his stone, much as a cameo cutter would do, to discover how best he can take advantage of its shape and shades of color. There is for this reason room for wide difference in artistic quality, apart altogether from the intrinsic value of the mineral, and carved pieces vary in price from a few cents to $10 and upwards. And among the more purely native articles produced are, besides the seals, writing material, as trays for pens, slabs for rubbing ink, and the like; flower vases, square, round, or hexagonal; boxes for sealing vermilion, incense boxes of all kinds, but chiefly having the character for "long life" in open work on the cover; small sandalwood burners, flower baskets and balls, candlesticks, chessmen (or, as we should regard them, draughts), cups, bowls, and lamps: idols, as the Star of Longevity, the Eight Genii, Goddess of Mercy, lions, monkeys and other animals. Less ambitious workmen content themselves with polishing the stone and cutting in relief certain common emblems, as the sun, moon, clouds, mist, the lute, chessboard, books, scrolls; or the characters for happiness, promotion, old age and posterity.

CORRESPONDENCE.

Use of Peat Fuel in Norway and Sweden.

To the Editor of the Review:

SIR,—From time to time there have occurred in your valuable paper articles about peat fuel, and we have read them with much interest. In the July number, page 112, is a contribution by Mr. Dickson, who says: "It (peat) is extensively used in an air-dried state only in Norway and Sweden for the reduction of iron ores, and some of the finest brands of iron are smelted with peat." The fact is that some *experiments* with *charcoaled* peat were made some 30 years ago at one or two furnaces, but gave not good results; if *air-dried* peat was ever used in a blast furnace there are no records of it. Air-dried peat is, however, used quite extensively by those Swedish iron works who have boys in close proximity, but only for making gas in gas producers and generally together with wood or sawdust; it is giving excellent results used in that way.

In Norway peat cannot be used very extensively for making iron, as that country possesses only *one* iron works and a small one indeed, producing, according to the Official Statistics for 1890 (the latest accessible), only 517 tons of pig iron, 423 tons of bar iron and 268 tons of steel, which is scarcely 1 per cent. of the consumption of the country itself. Many users of Swedish iron on the American continent buy it as *Norway iron*; why it should go under this name any longer we cannot understand. It is about time to give the Swedes the credit for the Swedish iron.

Yours, &c.,

STORA KOPPARBERGS BERGSLAGS AKTIEBOLAG.

FALUN, SWEDEN, Sept. 1st, 1893.

Mining in the S'ocan District, B.C.

To the Editor of the Review:

SIR,—I returned a few days ago from a trip through the Slocan district, having visited the principal mines to the south of Kaslo Creek, and was much struck with the healthy appearance of everything.

It is true that there is not very much work being done compared with what everybody last year expected, but when one considers the deadness in all financial matters connected with silver, one cannot help being surprised that the Slocan country is not totally dead too.

With the unsettled value of silver, those monied men who have properties and can afford to wait in expectation of higher prices, are simply doing a little development work, opening up their ledges and generally getting things into shape, so that when the settling of the silver question justifies a larger expenditure of capital they will know where to put it to the best advantage.

On the other hand those owners of properties who have not the money to do any work on their claims but who are waiting for buyers, place a high value on their properties in the full belief of silver coming up again, and buyers are not over anxious to invest in silver properties, however promising the propositions may appear.

Consequently, on the majority of the claims there is not much work being done; but in a few cases the owners have deemed it advisable to commence active operations on their properties.

The Washington has 45 men at work, and is making arrangements to have from 50 to 60 or more at work all the winter, and have already let the contract for the shipping of 100 tons of ore. The Mountain Chief is also actively taking out ore; the Dardanelles having pumped their shaft dry are steadily at work; the Wellington is shipping regularly; the Bonanza King of the noble five group has 120 tons on the way to Kaslo; the Blue Bird is shipping 70 tons; the Idaho has just shipped 20 tons; and other properties are also shipping small quantities.

The waggon road has been completed to Three Forks, and is now being pushed on rapidly to New Denver, a distance of five miles. There are very good trails to all the more important mines, and the transport facilities are as good as they well can be without the railway.

I was much struck with the facility with which the mines may be developed. They are in almost every case high up on steep mountain sides where the opening up of the ore bodies by means of tunnels will be a very simple matter. Tramways and aerial ropeways will take the ores from the tunnel mouth to the railway or waggon road, as the case may be. Water power is plentiful everywhere, and with the facilities electric transmission now gives, power for concentration drills, etc., will be very cheap. I should think there would be a very good opportunity for a general power company for supplying the various groups with power.

It is needless for me to say anything of the ore showings—they have been written and talked of by everybody, suffice it to say that despite all I have heard of their richness and magnitude I was surprised indeed at their appearance.

The quantity and cleanness of the ore is extraordinary, in many cases most of the ore can be shipped after a little hand sorting, though in some of the properties the ore is largely a concentrating ore. There will be, no doubt, severe disappointment in many cases over the want of continuity of the ore bodies, but in so many properties does the veins, now that they have been exposed, show such a steadiness that there can be no doubt whatever that this country is going to be not only a great mining country with very many mines in it, but that the individual mines are going to be large concerns.

There are no drawbacks to this country whatever—the ore is of surpassing richness, the quantity is assured, the facilities for development are of the best, water power is plentiful, the natural contour of the country makes transport the easiest matter when the Crow's Nest Pass railway is built and we can have cheap coke. We are independent of anybody and everything. Silver may go as low as possible, these mines can produce when others have been long closed.

But this has been said often before.

Once let the silver question show signs of settling and the working of these mines will be commenced on a large scale.

As it is, there is a thoroughly wholesome and business-like air about the district. People have stopped talking and have begun to work.

What the country needs now is: the settlement of the silver question, a railway to the mines, a smelter in the neighborhood, and miners, *i.e.*, mining men with experience and brains. Many properties show woefully the lack of ability and experience in their workers.

With regard to new strikes this summer, it has been a puzzler to many outsiders that so few rich strikes have been reported this year.

It is quite true there have been few new discoveries of any importance, but to those who have seen the country this is not surprising.

The country is as a rule well covered with soil and vegetable growth, and it is only where the ledges have been exposed by snow slides, or else high up in bare places, that any discoveries have been made. Last year the country was overrun, and those ledges that were exposed were easily found, the others can only be found after most laborious and careful search.

But there have been new discoveries made, and these of great importance.

Much attention has been paid to the dry ore belt on the north of Carpenter Creek. I have not had the opportunity of visiting this district myself, but from the ores I have seen and the reports I have heard, I am confident that this will develop into a most important district. The ores are chiefly copper ores high in silver.

The Whitewater Basin, just to the north of Kaslo Creek and 18 miles from Kaslo, has been the cause of much excitement and disappointment.

It is the gold district of the Slocan, and there has been much dispute as to whether gold really existed there

in paying quantities. The Basin is a net work of quarry ledges, many barren, some carrying copper and iron pyrites, with traces of gold. Others with gold up to $200 and $300 in hand specimens, and just lately has been found a quarry with free gold easily seen by the eye. This last was looked upon as a "fake," but samples brought down by Mr. Backe, the assayer, the genuineness of which he vouches for, prove beyond a doubt the existence of a rich quarry Further developments are eagerly looked for.

Not much has been heard from the Lardo-Duncan country to the north of Kootenay Lake. The Golden Eagle, from which so much was expected last winter, has proved worthless, and beyond one or two really satisfactory finds, not much has been done. This does not show the country to be deficient in mineral; it is very difficult at present to travel in, and not much good prospecting has been done in it. There is still much faith in its future, but so far little has been done.

The St. Mary's country, to the east of Kootenay Lake, has attracted a great deal of attention during the last few weeks. Some very rich finds of copper ores high in silver caused a rush to the country, which resulted in some very fine samples of dry ore being brought in. The samples assayed from 100 ozs. up to the thousands in silver. Some of the last to be brought in was by Mr. McLaren, of Burgess, Ontario, whose sample of his ledge ran 130 ozs. silver and 10% copper. Not enough of the district is known as yet for me to say anything further.

There is still another month of good prospecting weather, and we may look for very important discoveries during that time. The best of the men are now in the hills.

There is much talk about work commencing on the Kaslo-Slocan railway, but beyond the clearing of the right of way for the first five miles and the building of the Kaslo station, nothing has been done.

Very little will be heard about this country until the silver question begins to settle, then *results* will surprise the world.

Meanwhile, now is the time for those who know anything about mines to invest. Cash is very scarce here, and its purchasing power is much greater now than it is likely to be again.

Yours, &c.,

FREIBERG.

CANADIAN COMPANIES.

The Slough Creek Mining Company.—This company, organized about two years ago with headquarters at Tocoma, Washington, and which recently has been opening up alluvial ground at Slough Creek, in the Cariboo district, B.C., has just been registered under the Foreign Companies' Act, B.C.

The Kootenay Mining and Development Co. Ltd., is seeking incorporation. Capital $1,600,000, in shares of $100. Head office, Ainsworth, B. C., with a branch office at Minneapolis, Minn. Directors: Willis Baker, Minneapolis, Joseph B. McArthur and Thos. J. Lendrum, of Ainsworth, B.C. Formed to mine lands and operate mines in the Province of British Columbia. Operations are in the West Kootenai district, B.C.

MINING NOTES.

[FROM OUR OWN CORRESPONDENTS.]

Newfoundland.

Mr. C. E. Willis, of Halifax, who has been opening asbestos areas at Port au Port Bay in the interests of the Halifax Asbestos Co., has returned and speaks most favorably of the prospect of successful operations. The fibre is of good quality and is reported to be found in quantity.

Nova Scotia.

At the Coxheath copper mine, drifting on the vein has been commenced from the cross cut on the 320 ft. level of shaft No. 2, two power drills being run. There is apparently a swell in the vein on this level, the walls being over 40 ft. apart. Captain Granger reports that he has drifted east 25 ft. on an ore body, which so far fills the entire face of the drift.

Quebec.

Eastern Townships.

Mining operations are being quietly carried on at most of the asbestos mines.

In the Thetford district many of the mines are not working full force, mainly on account of the scarcity of labour.

Messrs. King Bros. are not operating all their pits, but we understand that their mill and crushers are yielding good results.

Nothing is being raised from the pits of the Johnson's Co., operations being confined entirely to their dumps, the product giving good results after being put through the mill. A good quality of No. III., and a fair quantity of No. II. is being won in this way, and it is being disposed of quickly. Extensive shipments of No. I. from stock are also reported.

Mr. A. S. Johnson, managing director of this company, who has been spending some time in the Western States, looking after his interests there, has returned and is now at the mine.

Messrs. Ward Bros. & Co. have not reopened their mine, and it is unlikely that they will do so this year.

The Bell's Asbestos Co. is pushing work energetically at their mine, and a large output is steadily maintained. It is expected that the output will this year be a record one.

The Thetford Mining Company has not done anything in the way of mining, but some needed improvements have been made to the storage capacity, with a view to resumption of work in the future.

The Beaver Asbestos Company, although not working to fully capacity, have a fairly strong force mining in their main pit. A second cable derrick has been added to the plant, which greatly facilitates the handling of material.

The American Asbestos Company are working their mines at Black Lake with their old-time energy, the only drawback being the scarcity of labor. It is gratifying to learn, however, that the depression in the States is acting beneficially, inasmuch as many of the miners who had left when the mines were closed down a year, ago are now returning to the district.

The United Asbestos Company employs, at last report, about 65 men and boys. The management is removing a portion of the dump from what promises to be very productive ground, and tramming it over the mountain. A new cobbing house 40 x 70 has been added to the buildings, together with a couple of Blake crushers, which are worked with a view to the recovery of the lower grade asbestos.

An excellent output is being made by the Anglo-Canadian Asbestos Co.

The Coleraine Mining Co. has started a small force to prospect that portion of their lands formerly operated by what was known as the Black Lake Mining Co.

Ottawa County.

The British Phosphate Co. have cleared their bins and completed their shipments to Europe. It is reported that an action has been entered against the Emerald Mining Co. to recover the loss in the value of the phosphate seized by injunction in the recent suit which the British Phosphate Co. won. The English company claim that the depreciation entailed by the collapse in the market since the injunction, has been considerable.

On the Russell mine, Calumet Island, a larger show of zinc blende has been uncovered than any previously found on this property. It is, we understand, to be tested with the diamond drill.

Mr A Benson, manager of the General Phosphate Corporation, shipped this month to Europe, several hundred tons of phosphate, mainly about 70% grade. The consignment was the result of cleaning up the dumps.

We understand that Messrs. Powell and Clemow, Ottawa, have purchased a very promising amber mica property at Aylwin, Que., and a small force is at work opening it up. $15,000 is the figure reported to have been paid. The mica is of large size, and in paying quantities so far as discovered.

Mr. John Poupore has some eleven men working for mica on the Judge lot on the Lievre river.

Messrs. W. A. Jamieson & Co., Ottawa, have 12 men working their Cassidy mica mine in the Township of Hull, and 17 men on the Cascades mine. Fifteen tons were raised last month, at least two of which will cut on an average 4 x 7. The quantity and quality of the mica from these mines, bears a high reputation in the district. A cutting and dressing works, at which a small force is employed, has been opened on Wellington street, Ottawa.

The Lake Gerard Mica Mining System continues to work a reduced force at Lake Gerard and other mines.

The American Mica Co., (Webster & Co.), have shut down production from their Templeton, Sydenham and Perth properties, claiming to have an abundant stock on hand for some time to come.

Beauce District.

A despatch from Quebec announces that the McArthur Bros., of Toronto, have sold a portion of their auriferous mining property in the Beauce gold district to a company of Portland and Boston capitalists for $130,000.

Mr. W. P. Lockwood, who holds a large area of alluvial ground at St. Francis, is also reported to have succeeded in making a deal with wealthy American capitalists. Mr. Dwight Crittenden, a mining expert, has recently been over the ground and has reported very favorably on the property.

Ontario.

The annual meeting of the Ontario Mining Association will be held at Sault Ste. Marie on Wednesday, Oct. 4th, for election of officers and other important business. There should be a full attendance of everyone interested.

An exchange says the big suit of Ritchie vs. The Canadian Copper Co. *et al*, is on again. Judge Burke put H. P. McIntosh upon the stand as a witness on behalf of the defendant and examined him, in chief, about half a day. Then General Butterworth, counsel for the plaintiff, cross examined him for five days and he is not through with him yet.

Belmont Township.

A gold bearing vein on east half lot 19, in 1st concession, Belmont, being the next lot south of the Crawford mine, is being developed by T. D. Ledyard, of Toronto. A shaft has been sunk to the depth of 36 ft., the vein varying from 3 to 6 ft. wide with distinct walls of talcose schist. The vein matter is composed largely of drusy quartz, from which the pyrites has decomposed, but as the vein descends the sulphurets are becoming more solid. The honeycomb quartz shows a good deal of free gold; the average of six assays made by the Balbach Smelting Co. showed $49 in gold per ton, and an assay of about half a shot bag full of small pieces from all parts of the pit gave $94 in gold to the ton. Different samples of the iron pyrites in which there was no visible gold have been assayed by Elliot & Chambers, of Toronto, showing the following amounts of gold per ton, viz., $117, $193, $195, $198, $318, $338 and $922 per ton. This vein shows itself 150 yards west from the shaft, with the same characteristics. There are numerous other veins upon the property, some of which also show gold.

Messrs. Ricketts & Bank, of New York, have lately been examining the Crawford gold property with a view to its being worked by a New York Company.

Lake of the Woods District.

A despatch from Rat Portage says: The largest gold brick ever produced in this district has just reached here from the Sultana mine. It is a magnificent proof of the richness of our ores, weighing about 100 ounces and valued at nearly $2,000. The brick was obtained from only sixty tons of ore.

There are many rumors in the air in reference to mining properties changing hands. If there is any truth in them, some of the most valuable locations in this district will shortly be operating under new management. Messrs. Barnes and Upton are expected here to-day. It is expected that their presence portends a more active movement in that section of the mining industry in which they are interested. These gentlemen have done much for this district, but have latterly been severely handicapped in their movements by the financial difficulties over the line. The English experts have returned to the old country after subjecting many of the neighboring locations to a severe and critical examination. Fortunately this examination has proved very satisfactory, and it is understood they will be back again within two months. It is in connection with the visit of these gentlemen that the rumored sale of mining property is associated.

The attempts to form a miners' union has not materialized to any appreciable extent. Several meetings have been held, but owing to the lack of interest displayed by the mining men very little was accomplished in the way of organizing. There is no doubt about the unpopularity of the royalty clause, and it will undoubtedly be pushed to the front later on, but the mining men are either too busy to engage in agitation just now or do not care to place themselves in apparent antagonism to the government. The local Conservative association are arranging for some of the leading Opposition members of the legislature to visit the district, when we shall probably hear the question argued from their standpoint.

North-West Territories.

The output of the Canmore coal mines (H. W. McNeil Co., Ltd.), is now 200 tons a day, every pound of which is taken by the C.P.R. At Anthracite they have 5,000 tons stored as a base of supply, all of which will be rescreened when loading on cars. The Canmore coal is now being washed and in future will have no dirt. New stores are being opened by the company at Canmore and Anthracite, and the business is being rapidly extended in all directions.

British Columbia.

Cariboo District.

(From the Colonist.)

There is every likelihood that next spring will bring a great improvement in the mining industry of Upper Cariboo. Two new companies of considerable capital have been formed to work Williams and Willow Creeks. Mr. A. D. Whittier, who has been in England for some time, has succeeded in interesting several British capitalists in Williams Creek, and is now on his way to Barkerville to complete arrangements. It is the intention of this company to work the deep ground of the creek below Barkerville, where were the richest diggings of early days. The ground will be worked by the hydraulic jetting process, having a pressure of 550 feet. The requisite machinery has already been ordered, and will be brought up during the winter.

Mr. Geo. F. Law, of Montreal, representing eastern capitalists, has leased one and a half miles of Willow river. The Government boring machine, that did service a few years ago on the Thompson river, will be used to test the ground, which will eventually be worked in much the same manner as Slough Creek. Operations will be commenced next spring.

Last season Mr. Edward Sheppard, on Sheppard Creek, eight miles northwest of Barkerville, took out $1,200. This year he has been making preparations for working on a more extensive scale. He has brought up a new flume to work the deep ground. There is any amount of good gravel in sight, and Mr. Sheppard now feels certain that fortune is not far away. His brother also has a good prospect on the same creek. The Tenderfoot claim, owned by some Nanaimo parties, adjoins that of Mr. Sheppard. They have run a tunnel for some distance, and are now in good pay gravel at a depth of 28 feet. Next to the last named company a number of Barkerville gentlemen have taken up 2,200 feet of ground. At present this company is paying into the Tenderfoot, in order to have that claim thoroughly prospected.

The Eye-Opener claim on Williams Creek, just opposite Barkerville, has this year shown itself to be a good prospect. Up to the night of the 3rd inst., 128 ounces had been taken out.

On Nelson Creek, the Ah Kow claim (Chinese) made over $6,000 for the work of five men. The Chinese company on Davis Creek have not been so fortunate, although they more than paid expenses, having made a wash-up of over 60 ounces.

The South Wales Company, on Lightning Creek, after a long and hard fight with slum and water, are at last feeling that success is about to crown their efforts. Every week is now bringing them a neat little pile of the yellow dust.

A party consisting of four men, with provisions for six weeks, started out recently on a prospecting trip from Barkerville to Goat river and vicinity.

Mr. Charles Ramos, superintendent Slough Creek Mining Co., returned to Slough Creek, together with Mr. W. J. Magee, one of the directors of the Slough Creek Mining Company. Mr. Magee, in company with C. H. Cobb, Albert Morris and John Hopp, has taken a contract to sink the main shaft. All the necessary machinery consisting of two 30 h.p. boilers, a large steam pump and one 12 h. p. hoisting engine, has been ordered from Toronto, and is due at Ashcroft by the last of September. Later on, a second pump will be secured.

Vancouver Island.

The New Vancouver Coal Mining and Land Company's coal shipments for August, amounted to 32,467 tons.

Miscellaneous.

The Slocan *Prospector* has strong faith in the effect of huge and loud utterance, and in addition to damning most vigorously the rival town and people of Nakusp, points in its last issue the following little editorial note in advertisement of the local mining resources: "It is not often that an editor may use a chunk of ore carrying 5,000 ounces of silver to the ton as a paper weight, from an inexhaustible mine less than three miles from the office. This is our paper weight, and indisputable evidence in favor of the future of New Denver."

The cost of shipping the last consignment of ore from the Bon Ton to Tacoma, with smelter charges, duty, etc., amounted in all to $99.50 per ton; comprised as follows: Freight charges from the mine to Kaslo, per ton, $30; sampling, per ton, $1.20; freight from Kaslo to Tacoma, per ton, $10; duty, 43 per cent., lead, per ton, $13; smelter charges, Tacoma, per ton, $21; discount on lead, per ton, $8; discount on silver, per ton, $15; total, $99.50. The probable returns will be about $290 per ton, leaving a profit of $190.50.

(Vancouver Enterprise.)

Capt. M. McLeod returned a day or two ago from Cayuse Creek, where the Enterprise Hydraulic Mining Company, of which he was one of the promoters, are working their claim. He brought down three splendid nuggets, aggregating 8 ounces, picked from the sluices. In addition to this he has two specimens of coarse gold, also taken from the sluices, though the cleanup has not taken place. The result is very encouraging, as they are now only cutting their way into where they consider the best paying earth lies. The Company has a splendid head of water, which was turned on about a week before Capt. McLeod left. The dump for the tailings could not be improved upon, and with such admirable results shown for the first week, the shareholders are beginning to feel hopeful of good returns on the money invested. The Company began operations three years ago, and after driving two tunnels, both of considerable length, they only now are able to get the first returns. The cleanup will not take place till the close of the season by frost, probably about the end of November, while it is confidently expected that March 1st of 1894 will see the mines again working.

(Nelson Tribune.)

The Kaslo sampling works were to begin this week on a lot of ore from the Idaho mine. After this ore is sampled, the Mountain Chief product will be run through. George Hughes is improving the road between the town and the sampler at his own expense.

D. J. Hughes, of the O K, was in town on Friday ordering supplies for the mine. While here Mr. Hughes sent $1,300 worth of gold to Spokane, which he and his two partners had taken from their mine in one week. The new strike in the O K is about forty feet higher up the mountain side than the main tunnel, and the ledge of free gold quartz has been uncovered to a width of thirty feet. In most of this quartz gold can be seen with the naked eye, and some of it is so rich that it pays the owners very big to extract the gold from the rock with a hand mortar. The owners not having any machinery on the ground, only the richest of the ore is worked; but we are informed that a stamp mill will soon be erected, and then all the ore can be worked at a large profit. A small creek, not more than a foot wide, runs within two feet of the ledge, and in the clay and pieces of broken quartz, which are washed from the seams and gathered in buckets, gold nuggets of considerable size are found. In one bucket of this clay and broken rock, we had the pleasure of seeing the owners extract $120 in gold. Messrs. Hughes, Cole and Oudin, the lucky owners of the O K mine, are very jubilant over their new strike, and we are sure they are deserving of all they find, as they have worked steady and hard to make their mine one of the best in Trail Creek district.

(Continued on page 165)

The Limitations of the Gold Stamp Mill.

By T. A. Rickard, Denver, Colorado.

(Chicago Meeting, being part of the International Engineering Congress, August, 1893.)

Milling is one of the metallurgical arts whereby the extraction of the largest possible proportion of the value in an ore is effected at the least possible expense. Stamp milling* is that particular process in which a heavy body of iron is caused to fall upon the ore so as to disintegrate it and thereby induce a separation between what is valuable and what is worthless. The latter is usually less in specific gravity, and is therefore, by the further aid of water, removed from the former, which is then collected by the use of mercury.

Several similes have been employed to describe this process. The stamp has been likened to a hammer of which the stem is the handle and the die the anvil. The ore upon which the stamp falls has been compared to a nut awaiting the descent of the hammer whose blow is to separate the valueless shell, the quartz, from the valuable kernel, the gold.

When we begin to pursue our inquiries, however, we find that the analogy is just sufficiently true to emphasize the departures from it. The hammer falls, the anvil is fixed; so with the stamps and the mortar. The anvil is made of softer metal than the hammer; so also the die is often, and should be always, of steel or iron less hard and more tough than that of the shoe. The movement of the hammer and the drop of the stamp are both intermittent.

In regard to their intermittent action, as in many other respects, stamp mills arrange themselves under two types, which, though apparently contradictory, have both been evolved from a common original, and are united by a great variety of intermediate modifications. The slow speed and the high drop of the mills of Gilpin county, Colorado, appear to have very little in common with the fast speed and short drop of those of the main gold belt of California; yet the practice of the one was largely derived from that of the other, and each has been adapted to the treatment of the ores of its particular region.

The first and most apparent difference is that of speed. In Colorado the drop is regulated at 30 per minute, while in California it averages from 90 to 105. The more rapid drop gives a less intermittent action, and in this respect more nearly approaches the ideal machine.

The work done by the hammer is, however, dependent not only on the rapidity of its blows but also upon its weight and the distance through which it falls. Keeping to the two types, which we have chosen as representatives of the two systems of milling, we find that in Colorado the stamp weighs 550 to 600 pounds and falls a height of 18 to 20 inches, while in California the stamp weighs from 750 to 850 pounds and drops only 4 to 6 inches. Upon multiplication of these three factors—weight, drop, and speed—we find that the theoretical work done is nearly equal and is about one horse-power.

In milling, however, the efficiency of the stamp as a crushing machine is gauged by the quantity of ore which it can reduce, and we find that this does not at all correspond to the theoretical equality of the mills. In Colorado the stamp crushes 1 ton per twenty-four hours, while in California, with an ore of similar hardness, the amount is from two and a half to three times as much. Why is this difference? To explain it we must suppose the hammer to fall not upon the dry and wide surface of an anvil, but upon a face of iron confined within a narrow box and under water. This box corresponds to the mortar or coffer of the stamps. It has no opening* save in front, where a metallic grating or screen permits the escape of only that part of the material which has been crushed sufficiently small to pass through the openings. The ore upon the die is under water, the depth of that water depends upon the level of the bottom of the aperture occupied by the screen-frame. In Colorado the depth of discharge, as measured by the distance from the bottom of the screen to the top of the die, is 14 inches, but in California it is 4 inches only.† Herein lies the key to the difference in the crushing capacity of the two mills. Though the same amount of power be expended, and though the screen used be of similar mesh, yet in the Colorado mill the stamp falls through 10 inches more of water and has to discharge the pulp at a level 10 inches higher than in the California mill. The greater depth of discharge deadens the effectiveness of the blow of the stamp and weakens the force of the splash. Another result is obtained. While the screen does not in either case succeed in sizing the material discharged through it, yet it will be found that, though provided with similar screens, the pulp issuing from the deep mortar has a fineness much greater than that discharged by the shallow one. The pulverized ore is retained by the deep mortar long after its particles have been crushed to a size permitting their passage through the screen-openings, and they therefore become repulverized to a further degree of fineness.

This touches upon one of the points in respect of which the stamp-mill is most faulty. By actual test it is found that, though using a 40-mesh screen, for instance, with the theoretical supposition of crushing to that particular size, yet in a Colorado mill fully 70 per cent. of the pulp, and in a California battery about 50 per cent., will pass through a 100-mesh sieve. The percentage varies with the character of the ore, but these figures may be considered fairly representative. Two causes are chiefly responsible for this. The most important in its effects is the pause which occurs between the successive drops of the stamp. In a Colorado mill the interval is two seconds; in California it varies from three-fifths to two thirds of a second. Particles of ore, which have been pulverized to a fineness which would permit of their exit through the screen, are enabled to settle towards the bottom of the mortar. It would be expected that the heavy metallic minerals occurring in the ore would, because of their greater specific gravity, be most affected by this feature of the treatment. In practice this is found to be so. The fine slimes contain a large proportion of metallic sulphides, generally valuable on account of their close association with the precious metals, while the coarsest particles to be found in the tailings usually consist of quartz and other minerals forming the less heavy gangue.

The want of any proper control over the regular sizing of the pulp is also due to the unequal and irregular splash of the water in the battery and the haphazard way in which the particles of pulverized ore strike against the screen. In the case of any single particle, for instance, it is a question of hit-or-miss whether it may be thrown against an opening or a blank. If it fail to pass through, it is thrown back by the recession of the water and undergoes a further agitation and probable pulverization.

In practice this feature of the stamp-mill is recognized by both the California and the Colorado millman. On the Pacific coast the mortars are made narrow, thereby diminishing the opportunities for the settling of the particles of ore, and, by increasing the force of the splash, adding to the chances of its exit through the screen. In late years there has also been a tendency to use wire-cloth in place of punched iron, for the reason that the former,

*I shall confine the discussion to simple goldstamp milling.

* The feed-hole is higher up and does not concern us here.

† In making the comparison between the two systems of milling, I have purposely chosen extreme types.

though having openings of indentical size, yet has more of them per square inch than the latter, and, therefore, presents a greater area of discharge. By giving an inclination of 10 degrees to the screen-frame, the exit of the pulp is further assisted.

In Colorado, this defect of the stamp-mill has been utilized, and has been made an assistant to the millman. The *mortars of this district are wide and roomy*, the splash of the water inside the battery is weak, and the pulp remains inside until pulverized to a fineness much exceeding that required for its passage through the screen. There is a reason for this apparently contradictory feature of the milling practice. To explain it we must glance at the ore. We find it to contain an average of 15 per cent. of pyrite. The gold is very fine and intimately associated with the pyrite. To separate them it is necessary not only to crush to a certain degree of fineness, but also to obtain conditions which will permit the gold when once separated to settle upon amalgamated plates placed inside. The deep discharge causes the pyrite to remain in the mortar-box long after it has been pulverized to a size smaller than the screen-openings; the long drop gives the interval of time required to allow of the settling of the fine gold, while the roomy character of the mortar aids the deep discharge in affording a chance for the gold to get out of the way of the falling stamps and to become amalgamated *upon the two copper plates* inserted at the back and front of the mortar. In this way about two-thirds of the total yield of amalgam is obtained inside the mortar. In California the production of plates is not admissible, in mortars having so shallow a discharge as 4 inches, because the more constant and more violent agitation of the pulp prevents the settlement of the gold and would cause the abrasion or "scouring" of the surface of amalgamated plates. A certain varying percentage of gold is, indeed, usually arrested inside, partly by the aid of mercury added to the ore as it is fed into the battery, but this is of such a coarseness that gravity alone would serve to keep it within the mortar.

We have now entered into the discussion of the effects produced by the action of the stamp upon the ore. In many respects it departs from the analogy of the hammer which cracks open a nut. While being lifted the stamp also turns. This is effected by the friction of the cam-surface against the under side of the tappet. In a slow-drop mill *the stamp makes a complete turn each time it is lifted*, but with an increased speed this action is more uncertain and from 4 to 10 drops are required to make a whole revolution.

This feature of the stamp-mill breaks the analogy to the hammer and anvil, and causes it to resemble the pestle and mortar. The turning of the stamp in rising is communicated to the ore when it falls and induces a grinding action, which has important results. The mere impact of the stamp upon the particles of gold has the effect of hammering it, of increasing its density and of preventing its amalgamation, while the turning of the shoe upon the die causes the abrasion of the surface of the gold and the rubbing off of any film of foreign matter, which, by preventing contact between the gold and the mercury is prejudicial to amalgamation. In grinding the ore the stamp, however, also tends to convert it into slime. The hammer which cracks open the nut liberates the kernel without smashing it, but in pursuing the simile we *find that the stamp not only breaks the shell, but* both the kernel and the shell are further crushed, and their particles become confused together. The stamp which frees the gold from the quartz has to deal with a material in which the valuable and the valueless constituents are so uneven in size and so intermixed that the one is often crushed too much and the other too little.

I have seen auriferous quartz* which very nearly approached our simile of the nut. The gold occurred in seams and cavities in a quartz which had a honeycombed character. With such an ore there is just a certain blow which will break the brittle quartz and liberate the ductile gold. Such ideal conditions are very rare. The different parts of the same ore usually vary both in hardness and composition. The same work done on two pieces of mill-stuff will produce entirely dissimilar results. In the stamp-battery the heavy sulphide minerals are pulverized to a greater fineness than the siliceous gangue. When the gold is not too closely associated with the pyrite, coarse and rapid crushing will produce an adequate separation; but when the metal is in a finely divided condition and very intimately mixed with the pyrite, then fine crushing is demanded and can, unfortunately, only be obtained by the production of a very undesirable excess of slimes.

We have glanced at the results produced by the turn of the stamp upon the ore. Upon the mechanism itself the results are beneficial. The revolution of the stamp equalizes the wear upon the shoes and dies. It tends, also, by maintaining an even crushing-surface, to prevent that decrease of efficiency which occurs when either hammer or anvil has an irregular face.

Water is the vehicle used for the removal of the valueless portions of the ore from those which are valuable. Its low specific gravity as compared to both the metal and its enclosing gangue enables us to use it as a medium for their separation. A liquid having a specific gravity greater than that of water, and intermediate between that of the gold and its gangue, would be more effective if its use were practicable, which it is not.

In the mill, however, specific gravity is not the only factor we have to consider. The water discharged from a stamp-mill often transports the heavy pyrite further than the light quartz. This is due to the fact, already referred to, that the pyrite remains inside the mortar longer than the quartz and becomes pulverized to a further degree of fineness. It therefore, presents a larger surface to the water. Again, the metallic sulphides commonly occurring in gold ores have a cleavage more highly developed than that of quartz; therefore, while the latter finds its way into the water in irregular and angular grains, the former will be found in thin plates and flakes, which readily float upon a running stream.

Water is the fluid used, but air also plays its part. During the time of its violent agitation under the falling stamp, the water entangles a certain amount of air. Such air exists in the form of small bubbles which hold the finely-pulverized ore in suspension and thus become the main agent in the floating of the slimes. Warmth causes the air to expand and the bubbles to become dissipated; therefore any rise in the temperature of the water, such, even, as is caused by the impact between the stamps and the ore upon the die, is favorable to a diminution in the amount of slime.

When the pulp is discharged from the mortar-box it runs down copper plates covering long sloping tables. The copper, whether plain or silver-plated, is provided with an amalgamated surface, and it is this amalgamated *surface which is supposed to do the work of arresting the* gold. Mercury unites with gold forming a heavy amalgam; but, in practice, it is found that a plate which is covered with a good coating of gold-amalgam will serve to arrest gold much more effectually than a clean surface of either amalgamated silver or copper.

The amalgamating-tables have a slope varying with the amount of water used, the heaviness of the pulp, and the rapidity of the crushing. A gradient of ¾-inch per foot is common in Australia, while in Colorado the inclination is over 2 inches per foot.* The colonial mills consume 5 gallons of water per stamp per minute, while those of Colorado use less than 2 gallons. Theoretically, the use of the least possible quantity of water, and the spreading of the pulp over the largest possible surface, will give the best separation of the gold from the gangue. In practice, the varying composition of the ore prevents a nice adjustment of the conditions. You may readily determine an inclination which will be most effective in causing a separation of the gold from the quartz, but, it may be such as to cause the pyrite to settle. On the other hand, the slope may be so adjusted that the pyrite is carried away; but, such conditions may then be obtained as will also permit of the escape of the gold.

The amalgamating-tables are attached to the framework of the mill. The vibration set up by the falling stamps causes a pulsation of the water flowing over the plates similar, in a way, to the action of a jig. This assists the work of gravitation. The vibration has, however, another effect, namely, that of crystallizing the iron of the working parts of the mill, making them brittle and decreasing their time of service. In this, as in other respects, the stamp-mill presents contradictory features.

At the outset, we described milling as the art of treating ore so as to extract the maximum of value at the minimum of expense. Let us apply the description to the two types of mill to which particular reference has been made. In Colorado, a stamp crushes 1 ton of the ore of the Gilpin county mines in 24 hours, and the cost, using free water power, is 70 cents. In California, the best equipped large mills crush at the rate of rather more than 2½ tons at a cost, also using free water power, of about 35 cents per ton. The extraction in both regions will be, by amalgamation alone, about 70 per cent. We will omit the amount extracted by the concentration of any valuable pyrite, because the percentage of such material is very variable, and it forms a by-product, the value of which depends largely upon local conditions.

The ore of the Gilpin county mines carries about 15 per cent. of pyrite, and other heavy sulphides. The gangue is more feldspathic than quartzose, and is the product of the alteration of the country-rock,—granitoid gneiss—and of the dikes† which penetrate it. The gold is not only present in a state of very fine subdivision, but it is also intimately associated with the pyrite.

On the other hand, the mill-stuff treated in Amador, Calaveras and Tuolumne carries from 1 to 2 per cent. of pyrite. The gangue is quartz, but the ore also contains a very large proportion of the country-rock, which in this case is slate, augite schist, and diabase. Of these, slate predominates. The gold is coarser than that of the Colorado ore, and it is not so closely associated with the pyrite.

Let us now consider the results to be obtained by an interchange of treatment, using California batteries on Colorado ore, and *vice versa*.‡ The Gilpin county ore is of medium grade, say 8 dwts., or $8 per ton. The local methods extract $5.60§ at a cost of 70 cents. A California mill would give an extraction of only $4, but would crush such soft ore fully three times as fast, so that the cost would be, say 25 cents, giving a net yield of $3.75 as against $4.90 obtained by the methods of the district. Here, the slower mill gives the best results with a particular ore, and the Colorado millman considers the Californian very stupid because he does not use Colorado methods. Let us go to California and use the Gilpin county mill upon an ore of simpler character and of lower tenor. We will consider the treatment of an ore containing 6 dwts., or worth $6 per ton. The California mill would extract 70 per cent. at a cost of 35 cents, leaving a balance of $3.95 per ton. The Colorado battery would extract an increased percentage, say 75 per cent., but the ore being much harder than that of the Gilpin county, the crushing capacity would be less and the cost per ton greater than when treating county ore, say, therefore, $1.00 per ton, leaving a net yield of $3 50 per ton. The California mill, if crushing 100 tons of ore per day, would, therefore, show a profit $45 per day greater than that of the Colorado mill. As a matter of fact, there are other practical considerations which would render inadvisable the interchange of methods, among which may be mentioned the smaller size of the ore-bodies of Gilpin as compared to those of California; while it must also be remembered that the construction of a Colorado mill of a capacity equal to that of a California plant would require twice as much capital.

The comparison just made will serve as an illustration of the fact that milling is a business for getting money, and not a scientific pursuit directed to the obtaining of a perfect metallurgical treatment.

The contrast between the methods in use in two mining districts in the same country, illustrates the first axiom of all successful ore-reduction, namely, that the treatment must be suited to the character of the ore. Colorado methods in California would probably fail just as surely as California ways has been unsuccessful in Gilpin county. This is a truism not always remembered by machinery firms, who do not desire to be bothered by the making of new patterns. Too often, the ore is required to bend to a certain treatment in a mill of a particular design, instead of the mill being modified to suit the necessities of a particular ore.

The stamp-mill has presented to us many contradictory features. It is seen to be compounded of good and ill. It may be simple, but it is clumsy; it may be crude, but it is effective. As a machine, it has undergone an evolution common to all human inventions. It was founded on the first stone implement of the prehistoric savage; it became modified into the *matate* of the Mexican and the tilt-hammer* *of the Chinese; it progressed until running* water was called in to aid human muscle, and in the machine of the Hungarian peasant, it reached the primitive type from which our present mills were envolved. How great has been the comparatively recent improvement can be seen by stepping from Hungary to California.

In the valleys around Verospotak, in Transylvania, the larger mills† consist of twelve stamps, in coffers holding four each. The power is derived from an overshot water-wheel 10 feet in diameter. The cam-shaft is of iron, and revolves on agate bearings, lubricated with water. The lifter, or cam, is iron-shod. The stamp weighs 250 pounds, and has an agate head. The stem, the coffer, and all the rest, are made of beechwood. Each stamp drops 30 times per minute, and crushes about 300 pounds of soft ore per 24 hours. These machines have changed but little since the time of the Roman occupation under Trajan, when this district was a part of the province of Dacia.‡

Let us now go to California, whose record is little more than the record of a generation. Among the foothills of the Sierra Navada we find mills containing 80 stamps, weighing 750 to 850 pounds each, dropping 95 times per minute. Those of the working parts which are not of iron are made of steel. At single mills, 200 tons of ore are crushed per day. The mill building has a height of 70 feet, and the ore is never touched by manual labor from the moment that it arrives at the top in the mine-cars to the time when it is discharged at the bottom as waste.

In Transylvania, the individual shareholder often has his own mill; in California a thousand unite to operate one, which can, in 24 hours, treat as much ore as the Hungarian mill crushes in 100 days. The little machine of the Hungarian has been tapping away like a woodpecker for eighteen centuries, and yet has not produced as much gold as has been contributed in the brief time of one generation *by that* completer mechanism whose muffled thunder echoes among the canons of California.

What has been done may serve as a measure of what can yet be done. Perfection is as unattainble in milling as in any other branch of industrial art; otherwise progress were soon ended. We can compare the old mill with the new, not only with a complacent satisfaction at the advance that has been made, but with the consciousness that where so much improvement was possible much room for improvement must remain.

It is not for me to attempt to foretell what place the stamp-mill is destined to hold in the metallurgy of the future. Let me, however, in concluding, suggest the reflection that though the appliances of to-day may show a great advance upon the older more imperfect type from which they were evolved, yet there is no mining district that possesses a mill which cannot, in some essential, be improved upon.

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* At Clunes, Victoria, Australia.

* An Australian mill usually crushes 2 tons per stamp per 24 hours.

† The "porphyry" of the miners: really, quartz-andesite.

‡ In making the comparison the cost of motive power, being very variable, is left out of the count.

§ Amalgamation only, omitting concentration afterward, is here included.

* "A Chinese System of Gold-Milling," by Henry Louis, *Trans.*, xx., 324.

† Modern American mills have been lately introduced, and can be seen working side by side with those dating back to 100 A.D. For the particulars above given, I am indebted to Mr. E. H. Liveing.

* Well-preserved gold coins of the time of Trajan have been found in the mine-dumps.

Mining in Ontario.

Mr. A. Blue, Director of Mines, and his capable assistant, Mr T. D. Gibson, have issued their annual report of the mining operations in Ontario for the year 1892, being the second volume published since the Bureau of Mines was established. The volume comprises nearly 300 pp., is excellently gotten up, carefully and handily indexed, and the mass of information it gives cannot fail to be of great benefit to the Province, not only in attracting attention to its mineral resources, but also as a medium for reference to those engaged in mining enterprises. The opening pages are devoted to statistics, from which we gather that in 1892 a revenue of $15,273 was derived from the sale of 65 mining patents, covering 6,200 acres in various localities, the district of Thunder Bay yielding $5,598 for 2,391 acres. No fair comparison can be made with the previous year, for the reason that in 1891 a large number of patents were issued under the provisions of the old Mining Act. From the next table we find that a rental of $12,314 was derived from 13,122½ acres leased in the districts of Thunder Bay, Rainy River, Algoma, Nipissing and elsewhere. The leasing clause went into operation on 4th May, 1891, when 47 leases were issued, embracing an area of 4,998 acres, and the first year's rental paid was $4,886. As evidence of the continued growing favor of the system with miners in the Province, we are told that the number of leases issued to 6th May of the present year has increased to 54, covering 2,912 acres, so that it is very probable there will be a substantial increase over last year. Regarding the mineral production of the province in 1892, we cannot do better than quote the concise review given by the report.

"About one hundred quarries were worked during the year for building stone material, chiefly limestone and sandstone. It was not possible to procure returns from all of them, but a careful estimate gives the following statistics of quantity and value for the different classes of material:—

Dimension Stone,	cu. ft.,	2,600,000	$680,000
Heads and Sills,	cu. ft.,	50,000	26,000
Coursing Stone,	sq. yd.,	64,000	42,000
Rubble, etc.,	cu. yd.,	730,000	132,000

making a total value of $880,000. The amount of wages paid to workmen was $730,000.

"Much the greater portion of the cement made in Ontario is the product of natural rock, but although the quantity was 7,977 barrels more than in the preceding year, the value was $839 less. Portland cement began to be made in 1891, when the output was 2,033 barrels, valued at $5,082. The quantity and value of both classes produced last year are given in the following table:—

Natural Rock, bbl.,	54,155	$38,580
Portland, "	20,247	47,417

making a total of 74,402 barrels, valued at $85,997. The amount paid for wages was $53,151.

"The returns received of the quantity of lime burnt last year are not complete, but an estimate places it at 2,600,000 bushels, valued at $350,000, with amount for wages of $120,000.

"The following table gives the quantity and value of drain tile, common and pressed brick, roofing tile and terra cotta made in the Province last year—drain tile and common brick being an estimate based on 161 returns.—

Drain Tile,	No.	10,000,000	$100,000
Common Brick,		175,000,000	980,000
Pressed Brick, plain,		20,342,000	198,350
" fancy,		1,323,000	32,253
Roofing Tile,		383,000	8,613
Terra Cotta			20,119

"The pressed brick works have added largely to the output of 1891, the increase in the number of pieces being 8,431,000, and in value $102,636. One new establishment was put into operation during the year, that of the Thomas Nightingale Pressed Brick Co. at Port Credit. The brick at these works is made from the red shale of the Medina formation. The amount paid for wages during the year by the pressed brick companies was $88,865. The amount of wages paid for making common brick and drain tile was $445,000.

"The value of pottery made during the year was $80,000, and the amount of wages paid to workmen in the business was $25,000.

"The gypsum mining industry has been quiet during the year, and production was only 72 per cent. of the previous year's. There has been, however, a considerable increase in the manufacture of alabastine and plastico. Following are the figures for the year:—

Gypsum,	tons,	3,870	$14,100
Alabastine and plastico "		108	11,800

The amount paid for wages was $10,465.

"The depression in the phosphate business still continues as a consequence of the low price at which Florida phosphate is sold in the European markets. Only three of the Ontario mines were worked last year, and these to much less than their full capacity. The total quantity raised was 2,381 tons, valued at $23,810. The amount paid for wages, including some development work on other mines, was $9,400.

"The total quantity of salt of all kinds made during the year ending October 31, as reported to the Bureau by Mr. John Ransford, Secretary of the Association, was 45,387 tons, valued at $162,700. It has not been possible to get information in detail, but the following figures are compiled from returns made by the owners of six salt works:—

Coarse Salt, tons,	2,550	$ 9,005
Fine Salt, "	8,221	35,461

"The cost of wages for this quantity of coarse and fine salts was $9,885. Computed at the same rate the cost of wages for the total make of the year would be about $37,800.

"The salt producing territory of the Province was proven last year to extend as far south as Windsor. A well drilled at the Canadian Pacific Railway station struck a bed of salt 30 feet in thickness at a depth of 1,138 feet. In the township of Orford, in Kent county, a deep well drilled in 1890 for natural gas by Mr. Hiram Walker, of Walkerville, went through a bed of clear white salt 171 feet in thickness, reaching it at a depth of 1,510 feet.

"The salt beds of the Province are proven by borings and producing wells to extend under the whole of the counties of Huron, Lambton, Kent and Essex, as well as portions of Middlesex and Bruce, and to cover an area of about 4,000 square miles. Near the borders of the formation the salt thins out to one bed, but in Huron there are usually to be found three distinct beds, separated by shale, whose aggregate thickness is about 90 feet The greatest known thickness of a deposit is in the southern limit of the field where, as shown by the record of Mr. Walker's boring in Orford, there is one bed 171 feet in thickness.

"Only one of the mica mines was worked last year and it produced but seven tons, valued at $1,500. The amount of wages paid for labor was $150.

"Four companies carried on mining and smelting operations in the Sudbury district last year. The quantity of ore raised was 72,349 tons, and the quantity smelted was 61,924 tons. Three of the companies have erected bessemerizing plants in connection with their works, employed to enrich the matte; but only a portion of the matte is treated by this process. The quantity of ordinary matte produced at all the furnaces was 6,278 tons, and of bessemerized matte 1,880 tons. The following table gives the estimated metal contents of these mattes and their values at the works:—

Nickel, tons,	2,082	$590,962
Copper, "	1,936	232,135
Cobalt, "	8½	3,713

"The total value of the metal contents therefore was $826,750, the nickel being calculated at $284 per ton or 14.2 cents per pound, the copper at $120 per ton or 6 cents per pound, and the cobalt at $437 per ton or 21.84 cents per pound.* All the ores yielded nickel, the average being 3.36 per cent.; the ores of three companies yielded copper, the average being 3.19 per cent.; and the ores of one company yielded cobalt, but the average was only .1007 per cent.

"At the mines there was employed underground an average of 197 men, and above ground of 243 men over seventeen years of age, while of boys under seventeen years of age there was employed an average of only 10, all above ground. The average number of men employed at roasting and smelting was 240—the average of all classes of workers being 690. The mines of one of the companies were worked 310 days, of another 261, of a third 173, and of the fourth 155. The smelting works of one company were in blast 337 days, of a second 290, of a third 67, and of the fourth 32. The aggregate of time of labor in the mines may therefore be computed at 105,890 days, and at roasting and smelting 52,428 days, making a grand total working time of 158,318 days for the 690 employés. The amount of wages paid for labor by the four companies was $339,821, and the average wage per day would therefore be $2.14¾.

"Gold mining has been comparatively active during the year, but the work carried on has been mostly of development character. Locations have been worked in the county of Hastings, in the district of East Algoma and in the region of Lake-of-the-Woods. Nine companies have made returns of work done during the year ending 31st October, which show that 3,710 tons of gold ore was mined, the value of which is estimated at $36,900. The number of men employed above ground by these companies was 85, and the number underground 40. The aggregate working time of the men was 12,932 days, and the amount of wages paid was $22,750. The average wage per day would therefore be $1.76.

"Mills for treating the ore were being erected at a number of mines, several of which are now in operation. New processes of treating ore are being adopted, and interesting results are looked for this year.

"In the month of December eight properties were in course of active development on Lake-of-the-Woods, the number of mines and laborers employed upon them being 159. Since then reduction mills put up at two of the mines have, it is reported, been treating the ores very successfully. According to accounts published in the Rat Portage newspapers, gold bricks of the value of $1,000 are produced by each plant weekly.

"The Ophir mine, north of Thessalon, was purchased last year by a Duluth syndicate for $100,000. Several shafts have been sunk on the vein and the show of gold has aroused lively expectations. Treating works are being erected at the Ophir, and it is expected that they will be started in the month of August.

"The Creighton Gold Mining Co. is developing a location of much promise in the township of Creighotn, west of Sudbury. Sixty-three men were employed on the works in February, at which time a shaft of 8 by 9 feet was sunk upon the vein to the depth of 110 feet. Steam drills and hoists were in operation at that time, but air compressors, crushers and other machinery had been ordered and suitable buildings were in course of erection.

"Three mines are being worked in the county of Hastings one of which has reached a depth of 140 feet. The pyritic ore at this latter mine is being treated in a Crawford mill, and the yield of gold is stated to be very satisfactory. At one of the other mines a new process of treating mispickel ore is going to be tried, which is claimed to give good results in the laboratory.

"Nearly all the silver mines in the Lake Superior district have been idle during the past year, and the work done on five or six locations had for its chief object the opening and proving of veins. This is one of the results of the depreciation of silver. An accompanying result is the activity noticed in gold mining, which is also a feature of the industry in the United States and elsewhere.

"At one of the mines six men were employed underground and one above ground for 306 days, and the amount of wages paid for labor was $3,942, or at the rate of $1.84 per day. Ten tons of ore was taken from this mine, the value of which is put down at $732.

"The quantity of crude petroleum produced in the Petrolea and Oil Springs fields was 800,000 barrels (28,000,000 imperial gallons), valued at $1,000,000. This is 94,647 barrels less than for the preceding year.

"Full details of the industry have not been obtained, as only five refineries have made returns to the Bureau. These refineries treated 11,929,446 gallons in the year, being 42.6 per cent. of the whole yield, the product of which is given in the following table:—

Illuminating Oil, imp. gal.,		4,627,593	$391,628
Lubricating Oil, "		1,472,924	58,918
All other Oils, "		3,260,912	116,118
Paraffin Wax,	lb.	276,027	29,922

"The amount of wages paid for labor at these five refineries was $40,517. On the same basis, the refined product of the total crude yield of the year would be—

Illuminating Oil, imp. gal.,		10,862,894	$919,315
Lubricating Oil, "		3,457,570	138,304
All other Oils, "		7,654,723	272,577
Paraffin Wax,	lb.	647,950	70,239

"This would give a total value of distilled products of $1,400,435, and at the same rate the amount of wages paid for labor would be $95,110. This does not of course include wages paid to workmen employed in the production and storage of crude petroleum. The total number of employees maintained by the industry is estimated to be about 1,500, and the amount of wages paid for labor of all kinds about $650,000.

"In the Welland gas field forty-nine wells were bored last year, of which thirty-six are gas producers. The total number of producing wells in the district is sixty-five In Essex two new producing wells were bored last year, and there are now eight in that district. There are about one hundred and fifty miles of pipe laid for the delivery and distribution of gas in both districts, and the value of gas sold to consumers last year was about $160,000. The total amount of wages paid for labor was $55,000, a large proportion of which was for drilling new wells. The returns received from gas companies have not been very satisfactory, especially those made by companies delivering to consumers in Buffalo.

"No iron mining is reported for the year, but several properties were prospected with a view of proving the quantity and value of their ores.

*The quantities here given are the estimated contents of the respective refined metals in the mattes, but values are computed on the selling price of mattes at the works and not on the price of the metals after they have been refined in Great Britain, the United States or elsewhere. London quotations for nickel ruled steadily at 42 cents per pound, and New York quotations at 48 to 52 cents during the latter half of the year—the higher price in the United States being maintained by the protection of the customs duty. But it would be very misleading to make the value of nickel contents in the matte at Sudbury the same as the value of refined nickel in New Yorkor London.

Quantity and Value of Mineral Production (in Ontario) and Amount of Wages Paid for Labor in 1892.

Product.	Quantity.	Value. $	Wages. $
Dimension Stone	cu. ft.	2,600,000	680,000	
Heads and Sills	"	50,000	26,000	
Coursing Stone	sq. yd.	64,000	42,000	730,000
Rubble, etc.	cu. yd.	730,000	132,000	
Natural Rock Cement	bbl.	54,155	38,550	
Portland Cement	"	20,247	47,417	53,151
Lime	bu.	2,600,000	350,000	120,000
Drain Tile	No.	10,000,000	100,000	
Common Brick	"	175,000,000	980,000	445,000
Pressed Brick, Plain	"	20,342,000	198,350	
" Fancy	"	1,323,000	32,253	
Roofing Tile	"	383,000	8,613	88,865
Terra Cotta	"		20,119	
Pottery	"		80,000	25,000
Gypsum	tons.	3,870	14,100	
Alabastine and Plastico	"	108	11,880	10,465
Phosphate of Lime	"	2,381	23,810	9,400
Salt	"	43,387	162,700	37,800
Mica	"	7	1,500	150
Nickel	"	2,082	590,902	
Copper	"	1,936	232,135	339,821
Cobalt	"	8½	3,713	
Gold Ore	"	3,710	36,900	22,750
Silver Ore	"	10	732	3,942
Petroleum	imp. gal.	28,000,000		
Illuminating Oil	"	10,862,894	919,315	
Lubricating Oil	"	3,457,570	138,304	650,000
All other Oils	"	7,654,723	272,577	
Paraffin Wax	lb.	647,950	70,239	
Natural Gas			160,000	55,000
Totals			5,374,139	2,591,344

"The total value exceeds the production of last year by $668,466; but the principal increase is in nickel and copper, in which there is a different basis of values for the two years. The table, it may be explained, gives no account of properties upon which exploratory or development work was done during the year. Of these there are a considerable number, especially in the gold and nickel fields. In some cases numerous test pits and shafts have been sunk and several hundred tons of ore raised; a work which, though not included in statistical returns of quantity, value or wages, may come to have an important effect on the future of mining operations in the Province."

The other features of this very excellent report are: a review of the history of iron making in Ontario, followed by an interesting description of the known iron resources of the Province; a chapter of facts and opinions on the iron industry garnered from various well known authorities, the subject terminating with a reproduction from the *Engineering Magazine* of Mr. John Birkinbine's paper on the subject of "Locations for Pig Iron Production." In concluding his presentation of the subject Mr. Blue says:—

"The long story of invention is not closed, and in so far as the art of iron making is concerned it is not likely to close while impurities in ores and fuels continue to baffle the ingenuity of man. But the iron masters are in the line of improvement, and aided by science they are making headway in the face of many difficulties. The iron ores of Ontario are no worse than ores elsewhere; indeed it is almost certain that they are freer from at least one objectionable element, phosphorus, than those of other countries in which supplies are mostly found in the more recent rock formations. Better ways of treating ores in preparation for the blast furnace, and better ways of improving and refining iron and converting it into steel, as well as of strengthening it in combination with other metals, are being found out by skilled men in the laboratory, the furnace and the workshop; and every advance so made is a gain in which the whole world may share. There is not a process in the preparation and smelting of ores, not an improvement in the blast furnace, not a method of refining or working the metal, not an economy in any operation from opening the mine to the last touch of finish in the workshop, but is as free and open to us in Ontario as it is to the people of any country or state in Europe or America. Why then should not effort be directed to utilize one of the most valuable of all the raw resources of our country, converting it into wealth by the wisely controlled agencies of capital and labor, and making it an instrument for the production of greater wealth by ways and means almost without limit and number? A talent kept buried in the earth will be no more than a talent a hundred years hence, while it rightly utilized it may reproduce itself a thousand fold in a hundred years.

The nickel industry also finds prominence in an able paper, which we reproduce in this number. The memoir of Mons. David Levat, in the *Annales des Mines*, on the "Metallurgy of Nickel," from which we quoted last month, is given in full and is sure to prove of interest, and there are also papers by Dr. Stephen Emmens and others. In Section XI is given "A Pioneer's experiences on Lake Superior and Lake Huron, by Mr. Walter W. Palmer, an interesting paper of value as throwing light upon an epoch in Canadian copper mining now well-nigh forgotten (year 1848). Dr. C. W. Volney contributes a paper on "Lithographic Stone," and Prof. Coleman, of the School of Science, Toronto, describes the admirable mineral exhibit made by the Province this year at the Worlds Fair. The paper on the "Utilization of Peat," read before the General Mining Association of Quebec, by Mr. T. W. Gibson, and that on the "Mining Laws of Ontario," read by the Director at the recent Montreal Mining Convention, are also reproduced. The report is concluded by Mr. A. Slaght, the Inspector of Mines, who describes the nature and progress of mining by the various operators during the year. We heartily commend the report, not only to those who may be interested in the great mineral resources of this Province, but to all our readers, feeling sure that they will be the gainers by its perusal.

Nickel and Copper in Ontario.*

The Sudbury district continues to be searched for copper and nickel, and discoveries of the ores of these metals continue to be made in various localities. The area is now shown to be of large extent; but the limits of it are not defined; neither is it certain that every body of ore even in territory most familiar to prospectors has yet been discovered. The close growth of small timber on tracts swept over by forest fires twenty or twenty-five years ago hide out-croppings of ore, or the familiar surface signs by which its presence is indicated, from any but the most careful examination, while the alternation of rocky range and swamp land greatly increase the difficulty of traversing the country. It is not unlikely therefore that the diligent prospector will be rewarded by new and perhaps important discoveries of ore for some time to come at points convenient to existing railway lines, and that it will be many years before the whole of the nickel and copper-bearing formations are delimited on the maps of the country. But what is already known of the extent of the ore bodies, both by deep workings in the mines and the test pits of exploring parties, leaves no doubt in the minds of practical men who have examined the district that nickel and copper are there in illimitable amount; and the strong probability is that a hundred years hence the supply will appear to be as inexhaustible as it is to the miners and explorers of to-day. It is likely too that other parts of the Province besides the Sudbury district will be found to yield both nickel and copper. The Huronian belt, in which the known deposits lie, extends from the north shore of Lake Huron across the Province to the Quebec boundary at Abbitibbi Lake, a distance of 300 miles, the breadth of which is about 75 miles,—but embracing some Laurentian areas. On the shore of Lake Huron copper and nickel were discovered in this belt nearly fifty years ago, and far to the northeastward of Sudbury prospectors report that they have observed indications of the same ores. Of course the character of the Huronian rocks is not uniform over a wide extent, and great local differences may be looked for in an area of 22,000 square miles; but it is certain that all the chalcopyrite and nickeliferous pyrrhotite of this great Huronian belt are not confined to one or two townships in the vicinity of Sudbury. During the past year too, a discovery is reported on Lake-of-the-Woods, which may be only the beginning of valuable finds there. At any rate, further prospecting in that region ought to be encouraged by the history of exploration in the Sudbury district. Interest has also been recently revived in the Bruce mines locality, and possibly the old workings there which were carried on with so much spirit for thirty years—beginning with 1846 and ending with 1876—may once again become the scene of an active industry. It is by no means certain that those mines could not be made to pay under modern methods of working and with the facilities for transportation which are now provided.

COPPER ON POINT MAMAINSE.

A locality of bright promise is Point Mamainse on the east coast of Lake Superior, where development work has been undertaken during the past year, and to which reference is made in the Report of the Inspector of Mines, who visited the place last summer. The following interesting account of this property and the nature of the work undertaken upon it was furnished me last November by H. S. Sibley, of Detroit, in the course of an interview:

"I am one of two trustees holding for a syndicate the Mamainse copper locations on the east coast of Lake Superior. They consist of 11,200 acres, which were purchased from the Crown by the Montreal Mining Company in 1856. A little prospecting was done by Joshua Coatsworth about 1858, and afterwards by the Ontario Mineral Lands Company in the winter of 1881-2. Two small exploring shafts were sunk in the conglomerate on the Pancake location. This bed is 9 to 14 feet thick and carries one to two per cent of native copper. No further work was attempted until the autumn of 1891, when a party with Captain T. H. Trethewey in charge, was sent up to explore with a diamond drill outfit. Drilling was carried on upon five veins to the extent of 3,643 feet, and to 357 feet on a conglomerate bed; the cores showed native copper to depths of 40 to 320 feet in the veins. The veins vary in width from 3 to 12 feet, and consist of calcspar and fragments of wall rock (conglomerate and trap) cemented by native copper. Jasper pebbles are also found in the veins. In 1892 drilling was continued until July, but in June work was commenced on an exploring shaft 7 by 9 feet, which was carried down upon one of the veins to a depth of 32 feet. A stream runs along the course of this vein, crossing and re-crossing it at intervals, so that some difficulty was experienced in keeping the shaft free from water with the methods at control. The ore was found to be rich throughout the whole depth of the shaft, and so satisfactory was it that the men were set at work to strip the vein and make open cuts upon it at various points for a distance of 1,600 feet; the width varies from 3 to 6 feet. The course of this vein is a little west of north, and lies between amygdoloid trap on the west side for foot wall, and conglomerate on the east side for hanging wall, showing a lateral thrust of 90 feet. About five tons of ore was taken out of the shaft, from which fair samples were selected and sent to the St. Louis sampling and testing works in August. Following is the report made to me by the manager of these works:—

"'ST. LOUIS, MO., Sept. 20, 1882.

"'*H. S. Sibley, Esq.*,

"'*So Griswold Street, Detroit.*

"'DEAR SIR,—We have just wired you results of tests of the two lots of copper ore sent us, and we herewith present more fully the details of these tests. The larger sample lot, weighing 1,196 lbs. net, was crushed in the jaw crusher and run through our three-stamp battery to separate the rock material and finer copper from the coarse metallic copper. The former as tailings were carefully saved in settling tanks, weighed and sampled and assayed for copper and silver. The coarser metallic copper was carefully sampled down three times to secure three separate samples in order to secure a better check on a difficult material to sample. These three samples were assayed for copper and silver separately, and the average taken. As a result of all these operations we find the lot to contain 22.78 per cent. metallic copper and a trace of silver. The other sample lot marked gray ore was crushed in a jaw crusher and rolls until it was fine enough to quarter down to sample. An assay for copper and silver gave the following results: Copper, 18.84 per cent.; silver, 1.08 oz. per ton. We regret that owing to the great difficulty in handling such obstinate material we have not been able to give results sooner, but trust they will be in time to serve your purpose. Yours truly,

"'ST. LOUIS SAMPLING AND TESTING WORKS,

"'WILLIAM B. POTTER, Manager.'

"The gray copper ore is found generally throughout the vein, but chiefly on the foot wall. The native copper ore is generally disseminated from wall to wall. The trustees have given an option on the property to a Detroit syndicate, by whom operations to sink the shaft to a depth of 500 feet will be carried on through the winter. This work it is hoped will be finished in ten months. Air compressor, hoisting engine, boilers, drills and all necessary supplies were delivered at Point Mamainse on the 17th of November."

The geological formation at Point Mamainse is the same as that of Keweenaw point on the south shore, where are located the great copper mines of Michigan.

THE PRODUCTION OF NICKEL.

The quantities of ore mined and smelted in the Sudbury district last year are given on page 8 of this report. The product of the furnaces, consisting of ordinary and bessemerized matte, held of metallic nickel 2,082 tons, of copper 1,936 tons, and of cobalt 8½ tons. These figures of metallic contents are estimates computed from the analyses of sample lots, and are no doubt as accurate as such estimates can be made; they are so accepted by sellers and buyers of the matte. The whole matte product of the several furnaces is sent out of the country to be refined, some of it to Great Britain, some to France, but the greater portion of it to the United States. There is in the latter country an extra demand owing to the use of nickel as an alloy with steel in the manufacture of armor plate for battle ships. In 1891 the quantity of nickel contained in Canadian matte smelted in the United States was 2,000,000 pounds, some of which went into the general market, but a considerable amount of it was the matte purchased by the Navy Department. This latter is worked up by contract, the copper being taken out and the nickel and iron being left as oxide, in which form it is delivered to the steel works at Bethlehem and Homestead to furnish the nickel for armor plates.† There are at present four smelting or refining works in the United States for treating nickel and copper mattes, viz: The works of Joseph Wharton at Camden, New Jersey; those of the Orford Copper Co., at Constable Hook, in the Same state; those of the Emmens Metal Co., at Youngwood, in Pennsylvania; and those of the Canadian Copper Co., near Cleveland. Until recently, Joseph Wharton had a monopoly of nickel production in the United States, and his mine at Lancaster Gap, in Pennsylvania produced the bulk of the ore treated at his refining works. But since the beginning of 1889, Sudbury has been brought into competition with it, and the result has been the closing at the end of 1891, of the Lancaster Gap mine. So that in 1892 the product of the nickel smelters will be all from Canada, except occasional small amounts from Mine LaMotte, and from Nevada, Oregon and the mines near Webster, North Carolina.‡ The following table gives the total nickel product of the United States for the sixteen years 1876-91, together with the value of the same and the value per pound:—

YEAR.	Quantity. Lbs.	Value. $	Value per lb Cents.
1876	201,367	523,554	260
1877	188,211	301,138	160
1878	150,890	165,979	110
1879	145,120	162,534	112
1880	233,893	257,282	110
1881	265,668	292,235	110
1882	281,616	309,777	110
1883	58,800	52,920	90
1884	64,550	48,412	75
1885	277,904	179,975	64.4
1886	214,992	127,157	59.14
1887	205,566	135,200	64.75
1888	204,328	127,032	62.46
1889	252,663	151,598	60
1890	223,488	134,092	60
1891	118,498	76,024	64
Totals	3,087,554	3,043,509	98.57

The nickel contents of the matte produced at Sudbury furnaces last year, therefore, are greater than all the nickel produced by United States mines in sixteen years by 1,076,446 pounds. It will be observed also that the price of nickel as computed from values of the United States product has fallen very materially since 1876. This drop is due chiefly to the working of the New Caledonia mines, by which the world's production was largely increased. Canadian nickel has had a less noticeable effect, but no doubt for the reason that price is determined now mainly by the cost of refining. Yet the ruling price in the London market last year was about 42 cents per pound, while in the New York market in the latter part of the year, quotations when given ranged from 48 to 52 cents—the protection afforded by the United States tariff of 15 cents per pound serving to keep up the higher rate in that country. But these prices are presumably for commercial nickel, which is not pure fine.

METHODS OF EXTRACTING THE METAL.

There are numerous methods already patented for

* From the Report of the Bureau of Mines, Ont., 1893.

† Mineral Resources of the United States, 1891, p. 167.

‡ Ib. p. 167.

treating ores containing nickel, copper and cobalt, but almost all of them follow the wet process. In a subsequent section of this report details of treatment are given in a paper by Mons. Levat, and here it may be interesting to give a general description of the process from the pen of Prof. Roberts-Austen, of the Royal College of Science, England:—

"The wet method for the extraction of nickel and cobalt from a complex regulus or arsenide consist, in the first place, of a roasting operation having for its object the volatilization of the sulphur and arsenic, and it may be antimony, and the conversion of the iron, nickel, cobalt and other metals present into oxides. Ferric oxide formed in this manner at a high temperature is but little soluble in acids, whilst the other oxides may be readily dissolved. On treating the roasted material repeatedly with hydrochloric acid or with dilute sulphuric acid, a residue is obtained containing but little or no cobalt or nickel, and consisting mainly of ferric oxide. Some iron will, however, have passed into solution. Should the solution contain lead, bismuth or copper, these metals may be precipitated by sulphuretted hydrogen; but it is customary to precipitate the copper at a later stage of the operations. The bismuth too, may be precipitated from a hydrochloric acid solution by dilution with water.

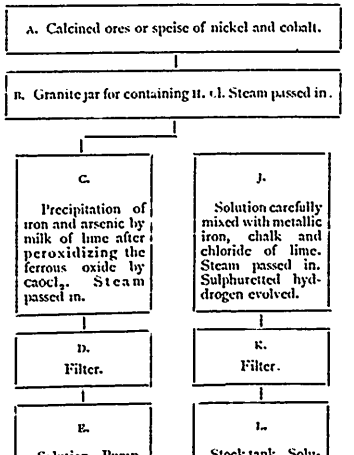
"The next operation consists in the precipitation of the iron. Any ferrous oxide which may have passed into solution is converted into ferric oxide by careful addition of chloride of lime, followed by the addition of lime, which precipitates the iron. Arsenate of iron is at the same time also precipitated i. arsenic is present. Should the temperature of the solution exceed 40° c. some nickel and cobalt are precipitated, as also is some copper.

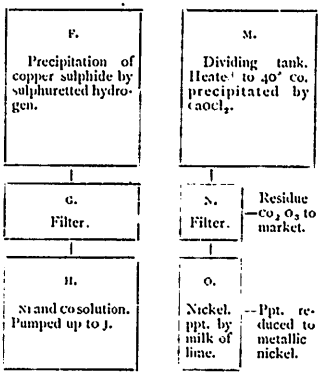
"Instead of an addition of lime as the precipitant, caustic soda or sodium carbonate is occasionally employed to prevent the precipitation of calcium sulphate when working with sulphuric acid solutions. Care must be taken to avoid using an excess of the precipitant, as the precipitation is a fractional one, and as soon as the iron has been precipitated, oxides of the other metals present begin to be thrown down.

"The next stage of the process consists in the precipitation of the copper. This is effected by raising the temperature of the solution to 70 c., and then precipitating the copper by the careful addition of either calcium carbonate, milk of lime, or a solution of soda. If an excess of the precipitant is employed, nickel will be thrown down. When a test with potassium ferro-cyanide shows that the whole of the copper has been thrown down, the cobalt is precipitated from the filtered solution by the careful addition of a solution of chloride of lime to the perfectly neutral, hot and not too dilute filtrate. If too much chloride of lime is added the precipitate becomes nickeliferous, and this must be carefully avoided. The nickel is next precipitated either by calcium carbonate, milk of lime, or soda. The nickel hydrate is filtered, dried, he.. ed with sodium carbonate, to decompose any calcium sulphate that may be present, washed with acidulated water, and finally dried and reduced by carbonaceous materials to the metallic state.

"This process being dependent on the fractional precipitation with the same precipitants of the several metals present in the ore or metallurgical product under treatment, is frequently subject to slight alterations of procedure, and the following is a description of the process as carried out at a works in the United Kingdom:—

WET PROCESS FOR EXTRACTING NICKEL AND COBALT.





"About 3 cwt. of fine ore or speise A that has been thoroughly roasted is charged with hydrochloric acid in granite jars, into which steam is passed. The mass is kept boiling for twelve hours. It is allowed to settle and run off into tubs C. Steam is conducted into the tubs, and when the liquid begins to boil, bleaching powder (chloride of lime) is added to peroxidize the iron, and the mass is allowed to boil for about three hours. The arsenic and iron come down together. If no iron be present in the solution some must be added. The liquid is then run off through filters D, to underground tanks E, whence it is pumped to tanks F, in which the mass is treated with sulphuretted hydrogen. Adjoining these tanks, of which there are six, there are also three lead retorts, in which sulphuretted hydrogen is produced. In these tanks the copper is precipitated and the nickel and cobalt solution is strained through filters G, and drains into a second underground tank H. It is then pumped into a tank J, and there successively mixed with iron, chalk, chloride of lime, and water from tubs placed above the tank, with a view to precipitate first, any copper that may have passed into solution during filtration, and then the iron which has taken the place of the copper. The charge is first boiled by the aid of steam pipes so as to expel the sulphuretted hydrogen. It is then run off to a tank L for stock. It is next pumped up into a dividing tank M, and heated with chloride of lime, the cobalt being precipitated as oxide at a temperature of 40°. The solution containing nickel is allowed to run off into another tank O, in which milk of lime is added, and the nickel precipitated as hydrate oxide. The liquid is allowed to run off as waste. The oxides are pumped into presses, and the water is drained off. The nickel oxide is dried on the roof of a muffle, heated and crushed. It is then mixed with charcoal and heated in a crucible in a reducing furnace for eight or twelve hours. A rough powder is obtained and in this form the metal is sold, or the nickel oxide is mixed into a paste with flour and water, which is heated and cut into cubes. These cubes are placed in crucibles with charcoal and heated to a temperature above the melting power of copper. The nickel oxide is reduced by the charcoal and by the carbonized flour. The metal does not melt, but preserves the form of cubes. The cobalt oxide is removed from the dividing tanks to stone jars and treated by a process similar to that described so as to remove the last trace of nickel. The cobalt is finally sent to the market in the form of oxide."§

It will be readily understood from the complexity of this process that it must be an expensive one; hence the high price which fine nickel has maintained. But there are various methods of the wet process, some of which are of recent invention, and possibly the cost of production may be somewhat reduced by them. One of these is soon to be tested at the village of Port Colborne at the head of the Welland canal, where advantage will be taken of the supply of natural gas there for fuel. Gypsum supplied from mines in the adjoining County of Haldimand is to be largely used under this method, and hope is entertained that the sulphuric acid obtained as a bye-product will very considerably reduce the cost of producing the refined metal. The results of this method are awaited with much interest.

As to dry processes, including reduction of oxide by carbon in furnaces or crucibles and concentration in sulphide or arsenide and subsequent smelting in reverberatory or blast furnaces, there does not yet appear to be absolute certainty that such methods can be successfully and economically applied to the treatment of nickel ores through all stages to the refined metal; but the metallurgy of nickel is so recent a subject of investigation and experiment that no one will be so bold as to say that the last word has been spoken upon it.¶

§ An Introduction to the Study of Metallurgy pp. 268-71.

¶ While this report is going through the press an interesting correspondence is being carried on upon this subject in the *Engineering and Mining Journal* of New York, between Robert M. Thompson, President of the Orford Copper Company, and Dr. Stephen H. Emmens, President of the Emmens Metal Company. The following letter from Mr. Thompson, is printed in the *Journal* of June 17th. "In your issue of June 3rd, I note a very interesting letter from Professor Emmens, headed 'Nickel Winning,' in which he says, 'No wholly dry process hitherto employed is capable of separating cobalt, or even (to a thoroughly satisfactory extent) copper, arsenic and manganese from nickel;' and referring to the Canadian pyrrhotite ores, 'The metal produced by dry methods from such a raw material is not fitted for fine uses.' In reply let me say that the following assays were made by the same chemist for nickel: Wharton's grain nickel, 99.39 per cent.; Martino's disc nickel (finest foreign nickel), 99.76 per cent.; Orford nickel, produced by exclusively dry process from Canadian pyrrhotite ores, 99.21 per cent. As to the quality of the Orford nickel, while I do not claim it is yet as perfect as we hope it soon will be, yet one of the largest consumers of nickel in the country writes me: 'In some respects your nickel is superior to any we have ever used. The metal is very white and remarkably soft and ductile, both of which points are of the greatest value.' Knowing Professor Emmens interest in the metallurgy of nickel, I am sure he will be pleased to see what progress has been made in the dry process for treating this metal." But notwithstanding this assurance, Dr. Emmens does not appear to be wholly satisfied as to the merits of the process.

* Report on Mineral Industries in the United States, at the 11th Census, 1890, pp. 269-71.

PRODUCTION AND PRICE.

Seventeen years ago, nickel in the United States was worth $2.60 per pound. Twelve years ago it had fallen to $1.10, the New Caledonia mines having been discovered and opened in the interval. At that time the world's yearly production of nickel was about 1,000 tons. Last year the price fell in the United States to fifty cents per pound, and in Great Britain to 42 cents. But the world's production had then increased to 6,000 tons, of which Ontario produced about one-third and New Caledonia two-thirds. Should increase continue at the same rate for the next ten or twelve years we shall doubtless see great activity in mining, smelting and treating operations in this province, especially should improvement continue to be made in processes, and prices fall as a consequence. It will not be surprising if in less than ten years prices have fallen to 25 or 20, or even 15 cents per pound, and in that event a large increase may be expected to take place in consumption. Assuming that no larger or better deposits of the ore are discovered elsewhere, what are the prospects of nickel mining in this Province in the event of a growing demand? The answer to this question may be found possibly in the words of the last United States Census Report on Mineral Industries. Referring to nickel and cobalt mining in that country in 1889, the writer says the great feature of the year was "the diversion of all attention in nickel mining to the nickel-bearing copper ores of the Sudbury region in Canada:" and he goes on to say: "The course of development showed conclusively that nickel can be produced there for a less cost than anywhere else in the world, so far as the present capacity of the known mines permit of an opinion." And referring to the New Caledonia mines farther on the same writer says: "At present the mines are less influential than those of Canada, for although the ores are fully as rich, labor is not so good, and for imported laborers the climate is bad. The ores are found in v-shaped pockets in serpentine, which is found over two-thirds of the island. Many of the pockets are large, but narrow with the depth. The cost of mining is considerable, and the transportation facilities to the sea coast are poor. It is not probable that the mines can compete successfully with the Canadian." *

Whether the working of manganiferous iron ores on that island containing cobalt and nickel will or will not change the condition in its favour cannot yet be foreseen, but it is hardly probable. Nearness to market, abundance of ore, and a supply of competent free labor and facilities for quick transportation are advantages which the Sudbury district is likely to continue to possess over its New Caledonia rival for all time.

THE FUTURE OF NICKEL.

The future of the nickel industry depends on the distinctive attributes of the metal, on the quantity and cost at which it can be supplied to consumers, and in a less degree on the quality of appearance. Twenty years ago pure nickel was not known in the arts; up to that time it was nothing more than an alloy with other metals combined with it in the ores, from which at best it was only imperfectly separated; and it was not indeed until after the pure metal began to be produced—the first examples of which were shown by Joseph Wharton at the Philadelphia Exposition of 1876—that its most valuable uses began to be found out. Some of these will be mentioned here as evidence of the growth of the nickel trade, and as an indication of the lines upon which it is likely to develop.

The experiments conducted four years ago by James Riley, of the Glasgow Steel Works, with alloys of nickel and steel, made a profound impression when the results were published; and although this may not prove in time to be the most valuable or useful of all the applications of the metal, it is the one which at present most strongly arrests attention in America. The explanation of this fact is found in the tests which, during the last three years, have been carried on by the Navy Department of the United States to determine the sort of material for armor best suited for the battle ships under orders of construction by the Government of that country. Mr. Riley's paper, read at the May meeting of the Iron and Steel Institute in 1889, contained no more than a speculative suggestion of the application of nickel steel to the armor plating of ships, but Secretary Tracy of the United States Navy Department regarded the promise held out as "too great to be ignored by a government requiring 20,000 tons of armor for its new fleet." Accordingly he began a series of trials to prove the suitability of nickel steel for the purpose in view, and not only so but to settle the question of the best armor plate in relation to the best ordnance—the strongest defence to match the most powerful attack. The following extract from the Secretary's report for 1891 shows the progress of the trials up to the close of that year:—

ARMOR PLATE TRIALS IN THE UNITED STATES.

"The experiments made last year at Annapolis, described in the annual report for 1890, consisted of a test of the two principal foreign types of armor, the English compound plate and the French all steel plate, and an entirely new plate also made in France upon the special order of the department, of nickel steel. The result of the trial showed that the compound plate was decidedly inferior, and that as between nickel steel and all steel the former had distinct and positive advantages, the all steel plate being broken into four pieces, while the nickel plate remained absolutely uncracked.

"A series of tests made during the following spring and summer confirmed the conclusions formed at the Annapolis trial as to the superiority of nickel steel, and the department accordingly decided to adopt it, and made arrangements with the contractors looking to that end.

"It remained however to give a thorough trial to the first armor of domestic manufacture before beginning to place it upon the vessels, and for this purpose it was decided to order typical plates which should be made the subject of an experimental test. This trial was to ascertain two points, first, whether our domestic manufacturers could produce an armor that would stand competition with the material manufactured abroad; and second, which of the various modes of treatment suggested would give the best results. In reference to the latter point the questions to be considered were the relative merits of rolling and forging in the manufacture, and the effect of a new method of treatment, named from its inventor the Harvey process, designed to harden the surface of the plate while retaining the toughness of its body.

"Of the six plates tried three were furnished by the Bethlehem Iron Co., and three by Carnegie, Phipps & Co.

"In these trials, which took place at Indian Head on October 31 and November 14, the plates were subjected to tests more severe than had been applied at any foreign government trials. Four shots were fired at each plate from a 6-inch gun with an impact velocity of 2,075 feet per second, and an energy of 2,988 foot tons, using the Holtzer projectile of 100 pounds. One shot was then fired at the centre of each plate from an 8-inch gun, with an impact energy of 4,988 foot tons, using Firmany and Carpenter projectiles of 210 and 250 pounds weight respectively. The plates were placed normal to the line of fire.

"The results of the trial were in the highest degree satisfactory. Each of the six plates manufactured in this country was superior to the English compound plate, while the nickel Harveyed plate and the high carbon nickel plate were superior to all the foreign plates of the Annapolis trial. They may therefore be pronounced in advance of the best armor hitherto manufactured in Europe.

"Further light was thrown upon the question of the relative merits of all steel and nickel steel armor, and any doubt which may have remained upon that subject was finally set at rest. Of the three plates made by Bethlehem, two were of nickel steel, one treated by the Harvey process, the other not; and the third was of all steel, Harveyed. Both the nickel plates proved to be far superior to the all steel Harveyed plate, notwithstanding the advantages which it may have derived from the special treatment; and both proved superior to the French all steel plate tried at Annapolis.

"A third nickel plate, manufactured by Carnegie under the rolling process, also showed a marked superiority over the all steel plate of this year, and both it and the corresponding Bethlehem plate manufactured under the hammer showed a capacity of resistance to perforation fully ten per cent. greater than that of the French all steel plate. In this respect the results furnished by the two American plates manufactured by the different processes (forging and rolling), proved to be remarkably uniform, the 6-inch shots that were fired at them differing in penetration but an inappreciable amount.

"The trial thus definitely establishes the fact that armor of excellent quality may be produced by the rolling process, and that forging by means of the hammer, the greatest source hitherto of expense in manufacture, is no longer to be regarded as an absolute necessity. The importance of this fact can hardly be over-estimated, for it raises a probability that within a year or two the armor-producing capacity of the United States may be quadrupled in case of necessity, and that if we had 10,000 tons to let and could give 18 months from date of contract to commence delivery, the cost of manufacture would be reduced from 25 to 33 per cent., while the work hitherto confind to two firms would be thrown open to a large number of competitors."

In his report for 1892 Secretary Tracy reviews the steps which had been taken by his department for the development of armor, and after special reference to the trials at Indian Head in October and November, 1891, he goes on to say:—

"As a result of this trial improved methods were introduced in the Harvey process and further tests were ordered of new plates. The first of these tests took place July 26, 1892, at Indian Head. The plate used was a 10½-inch plate of nickel steel made by the Bethlehem Iron Company, the plate having first been forged to 12½ inches and then Harveyed, and finally reforged to its former dimensions. In the two previous trials the corner shots had been fired from the 6-inch gun, and the 8-inch had been used only upon the centre of the plate. In this trial the 8-inch was used for all the shots. The result was that three of the projectiles were broken up upon the surface of the plate, while the two right hand shells penetrated to a depth of 13 inches. It was evident that there was a want of uniformity in the hardness of the surface, and that some special cause must have softened the right hand side of the plate. Upon investigation it became apparent that this was due to the process of reforging, resulting in a lower temperature and consequently reduced carbonization upon this side of the plate. Notwithstanding the penetration of the two right hand shots, the result by which the plate had remained free from cracks after receiving five blows from 8-inch projectiles was an extraordinary confirmation of the expectations that had been formed as to the possibilities of nickel steel treated as described.

"It remained for a final trial to demonstrate the wisdom of the steps which had been taken, and to crown the efforts of nearly four years with the highest degree of success.

"This trial took place at the proving ground of the Bethlehem Iron Company, July 30, 1892. The plate was of nickel steel, Harveyed, of the same thickness (10½ inches), as that of the previous trial, but unlike its predecessor it had been forged to its final thickness before the Harvey process was applied. As in the previous trial the 8-inch gun was alone used. Five Holtzer forged steel shells, weighing 250 pounds each, with a striking velocity of 1,700 feet per second, and each with an energy of 5,000 tons to the square foot, were fired at the plate at a distance of 30 yards.

"Never before these trials had any armor plate in the world been subjected to such a test as was represented by these five blows of a total energy of 25,000 foot tons.

"The result may be told in a word. All five of the projectiles were smashed upon the surface of the plate. The plate showed no signs of injury further than the opening of a slight temper crack four inches in length from one edge, and a wale less than one inch in thickness on the back of the plate opposite each point of impact. The striking ends of the projectiles appear to have been splashed on the face of the plate, filling the slight indentation made by the blow with new material which became welded to the substance of the plate itself and left it as before a flush surface. The remainder of the projectiles could only be found in the shape of innumerable scattered fragments.

"The result above described has never been equalled or even approached before by any armor plate, American or foreign. It has demonstrated that the United States, in the reconstruction of its new navy, which ten years ago had no existence even on paper, is enabled to place upon each and all of its armored vessels a material the like of which the world up to this time has not seen; and that while vast sums have been spent in plating the sides of foreign men-of-war with an inferior material, this country will employ for the purpose an armor which is not only far more efficient, but which represents unquestionably, having reference to the dimensions of plates thus far tested, the highest development of modern science, and a development reached by its own independent efforts."*

As early in the course of these trials as September, 1890, the Secretary of the Navy was so well convinced of the superiority of the nickel steel plate that he asked and obtained from Congress an appropriation of $1,000,000 for the purchase of nickel matte. At this time an apprehension existed in the minds of United States authorities that the world might not be able to produce enough nickel for their wants, and they feared that prices would take a bound upward. They accordingly purchased from the Canadian Copper Company 4,536 tons of matte, containing about 900 tons of nickel. "The terms of the contract provided that the material should be delivered on board cars at Sudbury, Ontario, for transportation to such points as might be designated. Deliveries were to begin within three days from the date of the contract, and final deliveries were to be made within one month thereafter. Provision was made by means of competent assayers for ascertaining the quantities of nickel and copper contained in the matte, and that no carload should be shipped in which there was less than an average of 15 per cent. of nickel."† The payments to the Canadian Copper Company for matte amounted to $321,321.86, while freight cost $31,134.88, duty on the copper contents $9,547.40, and refining by the Orford Copper Company (in part estimated), $97,582.30, making a total expenditure under the appropriation of $459,586.44. "Of the nickel oxide produced by the Orford Company, by whom the refining is done, we are now using 40 per cent., while 60 per cent. is sold in Europe. Our material, after the payment of all charges, including the price of the matte and of the subsequent reduction, costs us 24 cents a pound, while that of other consumers costs them at least 38 cents."‡ But this is the cost of the oxide. The quantity of armor plate required for an ordinary war vessel such as the United States is constructing is about 3,200 tons, and as the contract with the makers calls for only 3¼ per cent. of nickel in the plate, the quantity of nickel used for one vessel is only about 104 tons, or say 135 tons of nickel oxide. Obviously therefore there is a modest limit to the quantity of nickel required for the manufacture of armor plate for the United States navy, unless the government of that peaceful republic should seek to emulate the naval greatness of all the European powers, which is as improbable as that she should follow their example in the creation and maintenance of a standing army.

*Report of the Secretary of the Navy for the year 1891, pp. 11-13.

†Report of the Secretary of the Navy for the year 1892, pp. 17 19.

‡Secretary's Report for 1892, p. 21. The first contract appears to have been for 536 tons, and the second, under date of June 15, 1891, for 4,000 tons.

NICKEL STEEL FOR HEAVY ORDNANCE.

But there is some likelihood of nickel steel being used in the manufacture of heavy ordnance as well as for armor plate, and at the present time experiments are being conducted to test its suitability for that purpose. The following extract from a lecture delivered before the Franklin Institute, of Philadelphia, last January, by Mr. W. H. Jaques, Ordnance Engineer, will show what is being attempted as well as what has been done in this direction.

"The increasing use of nickel in steel suggests a few words concerning this element, particularly as it is about to make its debut in a large calibre service gun (a thirty-five calibre eight-inch B.L.R.), the forgings for which have been made by the Bethlehem Iron Company.

"In this connection it is most seriously to be regretted that circumstances of a discouraging character should have intervened to prevent Mr. Riley's continuing the excellent metallurgical work he so happily and ably commenced in connection with the alloys of nickel and steel, particularly since the publication of his lecture to the Iron and Steel Institute, May 4, 1889, so many of his views have been proved by further experience and practice.

"Bethlehem's part in this work is so well known by the practical results she has obtained, the gun forgings and other products supplied, and the superior resistance of her armor, that I need make no detailed statement here of our accomplishments. Further, they have already been referred to by the chiefs of the Bureaus of Steam Engineering and Ordnance in their last annual reports.

"As you will no doubt recall, Riley, Dick and Packer commenced their experiments with samples of French crucible nickel steel, containing three per cent., five per cent. and twenty-five per cent of nickel; were subsequently assured by personal investigation that the desired products could be obtained with certainity, not only in the crucible, but with perfect control in the open hearth, and that nearly all the nickel would be found in the steel Riley, in the lecture referred to, described the action of the steel in the mould, its appearance, value of scrap, and the care and temperatures required to work it. He made a sufficient number of tests to show the marked increase of tensile strength and elastic limit produced by certain increments of nickel without impairing the elongation or contraction of area to any noticeable extent. He pointed out the effects of a variation of the proportions of carbon and manganese with the same percentage of nickel, the point where the increment of nickel changed its hardening influence to one of softening ductilizing, its neutralizing effect upon carbon, the difficulties of machining, and crowned his report by giving due credit to the patentee, French steel makers, his assistants and the authorities

"Together with other conclusions he said: 'I am glad to be able to state that before the region of extreme difficulty of machining is reached, we have qualities of nickel steel available which will be of the utmost value for a very large number of purposes.'

"Comparing ordinary steel with nickel steel, he adds 'I think there will be no hesitation in deciding that there will be a very great advantage gained by the use of the latter—advantage either in reduction of scantling or in increased strength and ductility. In the very important matter of corrodibility, it is with the greatest satisfaction I can state that the steels rich in nickel are practically non-corrodible, and that those poor in nickel are much better than other steels in this respect. Some samples of the richer nickel steels which have been lying exposed to the atmosphere for several weeks will show an untarnished fracture.'

"These experiments to test the non-corrodible qualities of the various percentages of nickel steel, it will be remembered, were made in connection with Abel's corrosive liquid and hydrochloric acid water.

"I have cited Riley's conclusions to show how accurately they have been verified by the results since obtained, which give abundant testimony of the care and faithfulness with which his experiments were made.

"Mr. Hall, of Sheffield, claims to have made the first nickel steel gun, which instrument is reported to have burst at the first round, the rupture being due to the absence of suitable transverse strength. Whether this was due to the poor steel, poor construction, or the presence of nickel, was not stated.

"Many other nickel steel guns have been experimented with, but Krupp's comparative tests of two three and a half inch field guns, one made of ordinary Krupp steel and the other of nickel steel, appear to be the first trials of much importance that have been given publicity.

"Each gun was loaded with shell containing 170 grammes of picric acid, the centre of the shell in each case being 300 millimetres from the muzzle.

"When the shells were exploded the crucible steel gun burst into many pieces, while the nickel steel gun remained entire, showing an increase of the bore of 7.4 millimetres at the site of the projectile, but no cracks anywhere.

"The trial was continued with another shell containing 180 grammes of picric acid. Its explosion caused an enlargement of 9.50 millimetres and a longitudinal crack 80 millimetres long. No particle of metal was detached from the gun."*

*Present Development of Heavy Ordnance in the United States, by W. H. Jaques, pp. 25-27. Lieutenant Jaques, who has served 4 years in the U. S. navy, is the author of a valuable essay on "The Establishment of Steel Gun Factories in the United States," published in the Proceedings of the United States Naval Institute for 1884 (pp. 527-999). It was largely upon his recommendations that the Government of the United States undertook to promote the manufacture of armor plate and ordnance at home instead of depending for supplies upon European makers, and when the Bethlehem Iron Company six years ago resolved to undertake the manufacture of guns, shafting and armor plates, the position of Ordnance En-

In connection with the foregoing extract from Lieut. Jaques' lecture, the following account from the *London Iron* of further experiments by Herr Krupp are worthy of notice (unless indeed it is only a different account of the same experiments):

"A new nickel steel, the secret of the manufacture of which has been secured by Herr Krupp, of Essen, has been experimented with at Meppen. Two 3.4 inch shells, each containing 6 oz. of picric acid were placed, one in a gun of ordinary Krupp steel, and the other in a gun of the new nickel steel, at a distance of 12 inches from the muzzle. Upon the shells being exploded, the muzzle of the gun of ordinary steel was blown into a number of pieces, but the only effect produced upon the nickel steel gun was a local enlargement of the bore to the extent of a quarter of an inch. In the next experiment a 3.7 inch shell, containing 6.3 oz. of picric acid, was burst in a nickel steel gun at a point 19.5 inches from the bottom of the bore. The results were an enlargemeni to the extent of one-third of an inch and a fissure of three inches in length. Trials of plates of this nickel steel have also been made and are stated to have given satisfaction."*

It is not improbable therefore that nickel steel will soon be utilized in the making of heavy ordnance as well as armor plate; and the frequent accidents which have recently occurred in the breaking of shafts of the great ocean liners will doubtless suggest the manufacture of shafts, cranks, and indeed all important parts of the machinery of passenger ships, as well as battle ships of nickel steel.

ARMOR PLATE IN EUROPE.

We know much less of the purposes to which nickel steel is applied in Europe, for the reason that the governments of that continent are much more secretive in the trials they are carrying on than is the Government of the United States. A year ago the British Secretary for the Admiralty informed Parliament that nickel steel had been experimented with largely, that extensive orders had been placed for nickel steel armor forming the secondary defence of battle ships now in course of construction, and that several are fitted with this kind of armor, which has been proved sensibly superior to ordinary steel when used in thicknesses of three or four inches. But the officials of the British Admiralty have been much slower to acknowledge the superiority of nickel steel for armor plate purposes than were their brethren in the United States, although the first suggestion of the usefulness of the alloy for this purpose was made by James Riley. But the astonishing results obtained in the United States last year at Indian Head and at the Bethlehem proving grounds could not any longer be ignored, and on the 1st of November a test was made at Portsmouth on board the target vessel Nettle. Up to this date tests in Great Britain had been confined to all steel and compound armor plates manufactured by English makers; but in this instance the experiment possessed a two-fold novelty, the plate submitted to the ordeal being of a nature new to Europe and having been manufactured in accordance with an American patent. The London *Engineer* furnished this account of the trial:

"The plate was made of high carbon nickel steel Harveyized, or Harveyed, by carbonizing the face and hardening it with jets of water. We may state at once that we are not in a position to report trials of this class from independent observation. The series of trials on board the Nettle are carried out by Admiralty officers, and are in all respects trustworthy; but in the interest of makers who in various stages of these trials might submit plates of an entirely experimental character, no officer or other official is allowed to treat the results as public property. In point of fact they are regarded as confidential unless the manufarturers wish to publish them themselves. There is we think no reason to find fault with this system. Certainly manufacturers have been thereby encouraged to make experiments which they might otherwise shrink from attempting, and although doubtless the effect must be that the public hear only of successful results they hear of them on trustworthy authority, and a very fair idea is obtained of all such work as is sufficiently good to be admitted into the service; and this is what mainly concerns the public, and when the photographs officially taken are published little is left to be desired as to completeness of information.

"The trial in question is an important one. Photographs of the best Harvey plates tested in America have been printed by us. We pointed out then that the shape taken by the remarkable result achieved was the holding together of the plate under the wedging strain of five 8-inch projectile heads, which penetrated to a considerable depth. In fact, the hard face due to the Harvey process caused the projectiles to break, and though the heads had impressed energy enough on the plate to penetrate to a considerable depth the plate, as we suggested, probably thanks in a great measure to the nickel in its composition, held wonderfully well together. Tresidder's plate, which was naturally compared with it, performed a slightly different feat. It broke up 6-inch projectiles in its face with very insignificant penetration. Thus the projectiles were more completely defeated, but they were much smaller. The Tresidder plate, be it observed, was in consequence of the complete defeat of the projectiles not submitted to the wedging strain which fell on the Harvey plates, and there is no evidence as to how it would have behaved under it.

"Clearly the link required from Harvey's point of view was to show that the plate face was capable of defeating the lighter 6-inch projectiles with as little penetration as in the Tresidder plate. This was needed, for the last Harvey plate attacked by 6-inch shot had certainly allowed their points in two cases to penetrate deeply; one side of the plate was in fact softer than the other. There was an explanation for this, but no explanation is as good as a successful performance. The success at Portsmouth therefore is, we venture to think, just what we want at the present moment, and we are endeavoring to obtain permission to publish the photographs, which as yet we have not obtained.

"A competitive trial at Ochta, near St. Petersburg, is expected to take place shortly, when the Harvey, Tresidder, St. Chamond and Schneider plates will be tested in a strictly comparative way by 6-inch forged steel Holtzer projectiles, fired with about 2,000 feet velocity. The Nettle trials consisted of an attack of three 6-inch Holtzer and two Palliser chilled iron shot, striking at a velocity of about 1,976 feet per second. The Palliser projectiles are expected to break up as a matter of course with comparatively slight effect. It is only latterly that the Holtzer shot have been similarly defeated. In the present instance they have, we understand, broken into small fragments with but little penetration."*

Another account was published in *Iron*, and this paper, after citing the statements of the U. S. Secretary of the Navy and the Chief of the Bureau of Ordnance on the trials conducted under their direction, went on to say:

"However much these positive statements might be discounted, it was impossible for the British Admiralty, considering the official authority on which they were published, to discredit them entirely. It consequently determined to submit them to a practical test, and with this object in view, it entered into negotiations with the agents of the Harvey Steel Company of New York. Eventually Messrs. Vickers & Co., of Sheffield, were commissioned by the Government to manufacture a nickel steel plate and to treat it according to the the Harvey process, by which extraordinary hardness is communicated to the surface, together with a proportionate amount of toughness, so that the increased brittleness which commonly attends the hardening of steel is prevented. This was the plate that was tested on board the Nettle. The experiment was in no sense a manufacturer's, but an Admiralty test. It is the only trial of a Harveyized plate which has yet taken place in Europe, for although a similar plate has been manufactured by the same makers for the Russian Government, it will not be fired at until next week.

"The trial, which was conducted by Captain Hugo Pearson, of the Excellent, was witnessed by W. H. White, C.B., Director of Naval Construction, Admiral Colomb, General Geary, R.A., Captains Jenkins and McKechnie, of the Ordnance Committee, Colonel W. W. Barlow, late of Woolwich arsenal, and other officials. The Harvey Steel Company was represented by Mr. Edwin W. Fox and Mr. Joseph H. Dickinson, of New York, and the manufacturers by Messrs. Albert and Thomas Vickers. The plate measured 6 feet by 8 feet, with a thickness of 10½ inches. Its dimensions were consequently the same as those of other sample plates tested on board the Nettle, and though the representatives of the steel company expressed a wish that it might be attacked by a gun of larger calibre and greater ballistic properties than the one usually employed, the test for purposes of comparison was of the ordinary character consistent with Admiralty conditions. This consisted of discharging five rounds at the target from the six-inch breech loader. The charge was 48 lb E.X.E. powder, the weight of projectile 100 lb., and the muzzle velocity 1,975 feet per second. The rounds were fired in the following order: (1) Holtzer steel shell at bottom right-hand corner; (2) Holtzer at upper left-hand corner; (3) Palliser shell at upper right-hand corner; (4) Palliser at lower left-hand corner; (5) Holtzer in the centre.

"The result of the firing was an astonishing success, and completely verified the accuracy of the reports received from America with reference to the merits of the Harvey hardening process. Contrary to ordinary experience the Palliser projectiles appeared to do as much execution as the French shells, for although they splashed upon the plate on impact they made indents of about 1½ inch in depth. The Holtzers, on the other hand, appeared to weld their points into the target before bursting into a thousand incandescent fragments. Every one was completely pulverized. The most remarkable feature of the trial however was the fact that the plate withstood its punishment so well that not a single crack was produced – a quite unprecedented circumstance in armorplate experiments. Further trials with thinner plates are to be prosecuted at Portsmouth, and should these prove correspondingly invulnerable many of our obsolete armorclads might easily be brought up to date by superseding their thin iron protection by the new armor of equal thickness and weight, but of greatly superior impenetrability."*

It is not known what decision, if any, has been reached by the British Admiralty authorities with respect to future construction, following this trial of armorplate on the Nettle, but it is not likely that the value of the lesson will be wholly lost. The *Engineer*, in commenting upon the First Lord of the Admiralty's memorandum on the naval estimates for 1893-94, says: "Doubtless advantage will be taken of the increased resisting power to penetration afforded by the Harveyized nickel steel plates; and, as a diminished thickness of armor can now be carried, it will probably be distributed over a greater area. We have slowly but surely been emancipating ourselves from that curious predilection for a small patch of enormously thick armor, of which the Inflexible was the earliest example."†

It is not likely that a pre-eminently naval power like Great Britain, which is now expending over $70,000,000 a year to maintain a navy adequate to her requirements, and building battle ships at a cost of $3,000,000 to $4,000,000 each for those of the first rank, will long be content to use any other than the best of material. Nickel steel plate will cost more than all steel plate, perhaps much more; but it will in part make up the extra cost in greater lightness and increased efficiency, and in the construction of battle ships efficiency is the point of first consideration. Referring to the cost of nickel steel armorplate to the United States Government, the *Engineering News* of New York, says:

"Prices obtained for armor plates by the Carnegie and Bethlehem steel companies, who are the only manufacturers in the country, may well excite the envy of steel makers who hunt for customers for best structural steel at prices under $40 per ton. Bids were opened on February 5th at the Navy Department for about 7,000 tons of nickel steel armor plate. The prices bid by the two firms ranged from $520 to $885 per ton for the different sizes and kinds of plate specified. About $56 per ton extra is asked for treating the plates by the Harvey process. Making a very liberal estimate for the cost of manufacture, it looks as if the profits on this order alone ought to go a long way toward repaying both the companies for their original expenditure on their armor-making plant. It is of interest to notice also that at an average price of $600 per ton, the armor for the new line battle ship Massachusetts will cost about $1,225,000. The total cost of the vessel was estimated at $3,020,000."

The total quantity of armor plate required in the construction of this ship is 2,042 tons, the nickel contents of which would be at 3¼ per cent. (if gross tons are meant), not quite 150,000 pounds. Assuming the price to be 50 cents per pound, the cost of nickel contents in the plate will not exceed $75,000 (or $46,750 at the cost of nickel oxide). Unless then the cost of making nickel steel is vastly greater than of other alloys the question of cost of nickel steel plate will not long stand in the way of its adoption by governments which are persuaded of its superiority. Nor is it likely that the Carnegie and Bethlehem works will long continue to enjoy a monopoly of supplying this plate to the Government at $600 per ton.

The tests conducted by the Russian officials at Ochta were made upon one French and two English steel plates and a Vickers-Harveyed nickel steel plate, and in commenting upon this trial the London *Engineer* reports the latter "to have altogether beaten its competitors."‡

With all this evidence to demonstrate the value of nickel as an alloy with steel in the construction of war ships, the chances would appear strongly to favor its being so used by the navy building powers. Yet the demand for the metal would not be enormously increased if all the navies were to be reconstructed with nickel steel for armor plate; it would not be necessary perhaps to more than double the present production.

OTHER USES FOR NICKEL.

Whence then is an increased demand for nickel likely to arise? What other purposes give greater promise of consumption than the making of armor plate and ordnance? A few of these may be indicated.

As an alloy of steel the greatest use of nickel may be found in the making of boilers, engines and locomotives and structural material generally, where it is of vast importance to combine lightness and strength. In a large Atlantic liner, for instance, the plates of the boilers are one and a half inches thick, and enormous force is required to bend and rivet them, in which operation the plate is likely to be weakened by fracture, the lines of

gineer was offered to Lieut. Jaques. The object of the Company was, as stated by Mr. Jaques in an article descriptive of the works, published in the Proceedings of the Naval Institute, "to erect a plant long needed in the United States to make the country independent in the possession of the means of supplying the nation with the most powerful guns, and of equipping her ships with the most efficient shafting and armor." To this end a number of new and large buildings have been erected on the Company's grounds along the Lehigh river, which have been furnished with the best of modern machinery, and new buildings are still going up, which, when completed, will no doubt make the Bethlehem works the largest in America. Upon a visit to Bethlehem last October, I was shown through the various departments by Mr. Jaques, and a note of the armor plate and ordnance branch of the works may be fittingly made here. Four Siemens open-hearth furnaces are employed in the production of nickel steel, two of which have a capacity of 40 tons each per day of twelve hours, one of 20 tons and one 10 tons. The process of alloying the metals is claimed to be a company secret, and to give better results than is obtained elsewhere. During my visit the 20 ton and one of the 40 ton furnaces were tapped and run into a mould, casting an ingot of 60 tons nickel steel. This contained 3¼ per cent. nickel, which is the Government requirment for armor plate, or a total of very nearly two tons (1.95). For a portion of the time the Siemens furnaces are employed in making all steel, the ingots of which are compressed into cylindrical shape by hydraulic power. Two of these, still warm from the press, were lying on cars ready to be taken to the forging shop. They looked like two great saw logs, being 4 feet 6 inches in diameter and 15 feet in length. The ingots are forged under powerful steam hammers into any required shape, some for armor plates, some for guns and gun casings, and some for shafts, cranks, etc. The armor plates are heated in low furnaces, forged flat, requiring frequent reheating before the process is completed, and afterwards shaped by hydraulic power and tooled by machinery. After being finished in this way they are fitted together on platforms so that when sent to the shipyards each piece is ready to be put into the place designed for it without further machining or shaping of any kind. The specifications are furnished by the Navy Department, and hardly any two plates of the same ship or of any two ships are alike. Many of the plates weigh 30 tons and upwards. The long guns are heated in an upright furnace, some of the forgings being 25 to 38 feet in length, and weighing 25 to 45 tons. They are forged under a steam hammer weighing 125 tons.

Iron, February 24th, 1893.

**The Engineer*, London (England), November 4, 1892.

**Iron*, London (England), November 4, 1892.

†*Engineer*, March 10th, 1893, p. 211.

‡The *Engineer*, March 24, 1893, p. 256.

which are not always visible. If made of nickel steel alloy the plate would require to be little more than half the thickness, and while the boiler would be more easily and securely made, it would be but one half the weight—a very important item where there are twelve or thirteen huge boilers in the hold of one ship. Its strength would be as great, and it would be less liable to corrode. It would cost a little more, but its life would be lengthened.*

In the making of parts of locomotives and steam engines, as well as in the manufacture of cranks and shafting, nickel steel has also decided advantages over all steel. A locomotive is worth perhaps $100 per ton, and where the cost is so largely made up of the wages for labor, as it is in the case of a locomotive, a small addition to the cost of raw material is of little consequence. Many parts of locomotives, such as axles, of which everybody is so much afraid, tires, framework, etc., could be made of not much more than half the present weight and just as strong.

There is a considerable quantity of nickel being used now in Great Britain and the continental countries, but the trade is carried on quietly, and perhaps the only persons who could give information about it besides the manufacturers are the refiners, who generally know for what purposes their customers are using the metal. It is quite possible that locomotive tires are being made out of nickel steel in Germany, and doubtless a big trade will be done in that line. It seems likely that these German nickel steel tires are displacing the tires of English make, but if so it will not be long before Englishmen use the same material.

The British government has been using a large amount of nickel in one way and another, but chiefly in making experiments. A firm in Glasgow got an order eighteen months ago which took up 20 tons of nickel, and this would have been regarded as an unprecedented order ten years ago. But the British government is conservative of new methods, and its officials must be well persuaded before advising a change from good to better.

Twelve years ago, when the production of nickel was 1,000 tons and the selling price about $1.20 per pound, the chief if not only uses of the metal were for German silver, body for electroplating and for coinage. Its present uses include these, with the difference that coins are now being made of pure nickel instead of nickel alloy as formerly. The Austrian government intends to adopt it for this purpose, and it is rumored that they have given the French nickel company an order for about 3,000,000 pounds. It is only a rumor, but those who profess to know say that the company has received the order, and that it is probably for a larger quantity, spread over five or six years. Twelve years ago this French company refined 300 tons a year; to-day it is refining about 4,000 tons, having got the bulk of the expansion. It has gone on steadily improving its processes, and a great factor in cheapening operations has been the increase of production. But of course many blunders have been made. That is inevitable in dealing with any new enterprise of this kind, the details of which must be mastered experimentally. The producer of pig iron, copper, gold or any other of the staple metals, can usually sell his metal as fast as it is produced to some person or other. If the price is made a little less than market rates, some one will take it; but the man who produces refined nickel must hunt up his own customers, and they are few in number. The demand to-day is not so great as the supply, but so soon as the metal is produced at 35 or 36 cents per pound instead of 42 the consumption may be expected to grow rapidly. And no doubt it is possible to sell nickel at these prices if the requirements of the market would justify operations on a larger scale than appears to be prudent to enter upon now. A thoroughly practical man says: "I can lay my hand on a mine tomorrow that would show a splendid result at these figures, but it is not every mine that can do so."†

Several years ago Mr. Wharton, of Philadelphia, as already mentioned, began the plating of material by rolling refined nickel into thin plates and then pressing or welding it on both sides of a sheet of iron or steel; but he does not appear to have developed this application of the metal into a regular business. The process gives a very good article, but it is a little troublesome. A slab of nickel and a slab of steel may be rolled together so as to show a steel face upon one side and a face of nickel upon the other; or nickel may be rolled upon both sides of the steel, and when planished it presents a very attractive appearance. But results almost equally good as regards appearance may be obtained by dipping or electroplating, and the rolling process has not therefore come into general use.

At the present time the most promising uses of nickel are for the manufacture of body for electroplating, and the making of white metal alloy, which does not require electroplating. If 25 or 28 per cent. of nickel is added to a white metal alloy the material is nearly as good as silver plate, and it can be kept clean with infinitely less trouble, besides being of uniform color and quality throughout the whole of its substance. A cheap electroplated article will cost as much as or more than a solid white metal one, and after the coating has worn it is an unsightly thing of patchy yellow. Door fittings if made of white metal would cost perhaps 10 per cent. more than brass; but they would always be bright and clean, and easily kept so. A gas bracket weighing 10 pounds, if made of white metal instead of brass, would consist of 2½ pounds of nickel and 7½ pounds of brass, the former costing $1.05 and the latter 75 cents, or $1.80 in all. There is perhaps $10 worth of labor on it; so that the increased cost through putting 25 per cent. of nickel into it would be only a fraction of the total cost, while a handsomer article and one more easily kept clean would be the result. Hotel bath and lavatory fittings, etc., are now being made of white metal, and one manufacturer in the old country is said to turn out $1,000,000 worth in a year. "There is a large trade growing up," a gentleman engaged in the production of nickel informs me, "in the displacing of brass for lamps, chandeliers, electroliers, door and railway carriage fittings, etc. White metal for these purposes is largely taking the place of brass. It is dearer, but it is ever so much brighter, prettier and easier to keep clean; it tarnishes very little and a light rub will restore its planished appearance, whereas brass requires continuous labor to keep it bright. I have seen a butcher's shop in the old country the walls of which were wholly lined with white tiles, and all the fittings, brackets, hooks and nails were of white metal. The effect as seen by gas light from the street was very fine, and it really enabled the butcher to add a little to the price of his beef. The white metal trade is the one we prefer."

Another use found for the metal in Europe is in the making of bullet casings for small arms ammunition. For this object an alloy of one part nickel and four parts copper has been adopted, and factories producing ammunition for military small arms are requiring now 500 tons of nickel annually in the manufacture of bullet casings alone.

No little misapprehension however prevails as to the demand for nickel. There are some who declare that there is no limit to the quantity which the markets are capable of absorbing, and that some cause of policy, or want of capital, or lack of enterprise is blocking the wheels of progress in the Sudbury mining district. If Sudbury was in the United States, we are sometimes told, the woods would be alive with prospectors, mining camps and smelting works; millions of capital would be invested there, millions of tons of ore would be raised and treated annually, refining works would be established, and Sudbury would supply the world with the pure metal. Such is the language of dreamers, and men who have mining locations to sell. But men who know the trade do not speak in that way; neither do men who have a knowledge of how industries grow. On this subject I have obtained a short statement from Mr. Ian Cameron, manager of the Dominion Mineral Company's works, and a man of large experience in nickel:

"The break in price which took place eight or nine years ago, when nickel fell from 2s. 6d. per pound to 2s.," Mr. Cameron says, "led to such an increase in the demand that we could not supply it. When I built the old smelting works for the French company at Kirkintilloch, in Scotland, I completed one furnace and was then instructed to put up other two. I actually erected five, and with twelve the company could not until the slackness of a few months ago overtake the work. The furnaces are small, and together they run about 4,500 tons per month. The ore is peculiar; it contains about eight per cent. of nickel and does not lend itself to treatment in large quantity. If it could be as easily fluxed as the Sudbury ore the furnaces could run through an enormous quantity. I think the supply of nickel is greater than the demand, and that this is the reason there is no greater expansion of the industry in this country or in New Caledonia. The demand is not by any means unlimited; we have got to make our trade as we go along."

Of course if there was an active and fast growing demand for nickel, miners and metallurgists would be found ready to supply it; and owing to the position of the mines in this Province and the great extent of the deposits, capitalists would easily be persuaded to invest money for mining and treating the ore if there was a sure prospect for unlimited sale of the product and of large profits being realized. There is no hindrance to investment in Ontario, and in the matter of large workable bodies of nickel ore this Province as far as yet known possesses a monopoly of it on this continent. There are drawbacks, but they are not insurmountable. As regards two or three of these I quote again from Mr. Cameron:

"The supply of nickel in the Sudbury district is unlimited, and there are a great many properties which have not been opened up. The New Celedonia ore, some of which occurs as a silicate and some as an oxide, averages as taken out of the mines from 5 to 6 per cent. of the nickel. I have got ore from there testing 25, 35 and 40 per cent. of nickel. This ore cannot be washed; it can only be cobbed or picked. The native laborers are set to cob it; they are good enough for that, and men, women and children may be employed at this work at a very low rate of wages. One trouble in this country is the dearness of labor, which costs as much as fifty per cent. of our whole expenditure. The duties up on stuff we buy also run up to a high percentage; for example, the duty on coke amounts to 8 or 10 cents per ton of ore. The net value of 3½ per cent. ore after paying all costs at present selling price cannot be more than $1 per ton, the royalty on which at 3 per cent. would be three cents per ton. The duty on coke therefore is three times as much as all that would be paid to the government for royalty."

As regards refining, Mr. Cameron says:

"I do not know that it would be a very great advantage to have the refining of nickel done in this country. According to present practices acids are required, and these cannot be bought as cheaply here as on the other side of the Atlantic, and there are other things we would have to import. Another disadvantage is that freight charges on refined nickel going to Europe would be greater than on matte. The rate on 100 tons of matte containing 50 per cent. of nickel would be $6 or $7 per ton; but owing to risk of carriage 50 tons of refined nickel would not be carried at $12 per ton. I do not think there is much hope of refining nickel in this country until the consumption here has greatly increased, or until chemicals and other necessaries of refining can be bought as cheaply as in England or France, or until a successful dry process has been introduced. We could not refine here according to present practices and under existing conditions and hope to sell the nickel in Europe, as there is a heavy duty on the fine metal in France and Germany as well as in the United States. There is of course none in Great Britain."

In the present state of the nickel industry there is no well founded cause for discouragement, except perhaps in the minds of extreme optimists with locations of unknown value on their hands to sell. Remembering that it is a comparatively new metal, and that until a few years ago its ore was scarce and hard to treat, the rank to which it has already attained is calculated to excite a feeling of wonder. The progress of operations in this Province in view of every circumstance, and especially of the fact that the largest refining concern in the world is also chief owner of the only mining properties which can compare in richness and extent with those of Ontario, has certainly been as active as the state of the market for the metal would seem to justify. Mining and smelting the ores had their beginning here less than seven years ago, yet measured by the number of men employed, the amount of wages paid for labor and the value of product last year, there are only six iron working industries of the Province, as shown by the census of 1881, which exceed this one; and among those are such old and stable industries as agricultural implements, blacksmithing, and foundry and machine shops. Of iron mines, there is not one that is worked, although we have iron ores in great abundance; neither is there one blast furnace to smelt iron ore, although we consume in the Province upwards of 300,000 tons of pig iron every year. All the indications point to a steady increase in the consumption of nickel; and the number and variety of new and valuable uses which are being found for it give assurance that the industry is firmly rooted and will grow.

A New Colliery Pick.—At the Derby Industrial Exhibition was exhibited a patent pick (Mitchell & Birkinshaw's) which has been brought out by the Union Pick and Tool Company. This pick consists of an ordinary shaft with a helve into which small blades or points are placed and renewed as occasion requires, each renewal being equal to an entireiy new pick of the ordinary type. A miner need carry only one shaft or head into the mine, but can take any number of small points, which may be carried without inconvenience.

*Mr. Ian Cameron, Manager of the Dominion Mineral Company's works at Sudbury, informs me that it was through smelting New Caledonia ore, which is free from sulphur, that the first nickel steel was made. "Garnier had a high furnace similar to an iron blast furnace, and he put his nickel ore through that furnace and smelted it as if it was iron ore. Every particle practically of the iron and nickel in the ore was got out—though there was a pretty heavy loss of nickel and iron in the slag—and the result was a very good ferro-nickel, which led to the making of nickel steel by Mr. Marbeau, then one of the Directors of Le Nickel, who started the Ferro-nickel Company in France, at or near the German frontier. This company induced the Steel Company of Scotland to experiment with nickel steel, and Mr. Riley, the manager, told me that if it had not been for his company stopping him they would now be making all the boiler plate in Scotland of nickel steel. But the trade got brisk and the company had enough to do without experimenting.

In a recent communication, Mons. Jules Garnier, the French metallurgist, who has been prominently connected with the development of the nickel industry, gives the results of a number of tests made in September, 1892, at the Cleveland Rolling Mill Company's works, to determine the relative quality of steel with and without the addition of nickel. The two steels differed only in the amount of nickel added to one of them, the quantity being about three per cent. The method of manufacture and the charges of both heats were absolutely identical. The ingots for both heats were rolled into boiler plates under ordinary conditions. The tests show the following general results: (1) Nickel steel has on an average a higher limit of elasticity of 11,400 lbs. per square inch, or nearly 31 per cent. (2) Nickel steel has an ultimate tensile strength greater by 10,400 lbs. per square inch, or an increase of about 20 per cent. (3) The ductility is not reduced by the presence of nickel. The nickel used was made from Sudbury ores at the Brooklyn Nickel Works, near Cleveland, a refinery built according to the plans of Mons. Garnier.

†The New York *Engineering and Mining Journal* of May 13th, 1893, says: "One thing definite may be said, we think, about nickel. The decline in its price which has taken place during the last two years will be maintained, and in all likelihood it will go still lower. There has been recently an industrial revolution in this metal equal in importance to that which followed the opening of the mines in New Caledonia. The discovery of the Sudbury deposits, and the Orford process by which nickel-copper matte can be cheaply and successfully treated, have made America independent of the world for its supply of nickel, and it now threatens the European markets, the cost of production having been brought below that of the metal of New Caledonia. European metallurgists have not been standing still however, for an improved process, the invention of M. D. Levat, formerly Director-General of the Societe le Nickel, has already been put in operation at Havre, France. This is a dry process; indeed, it may be said that the day of wet processes for nickel winning is past."

The *Engineer*, of London, Eng., of January 6th, 1893, also says: "The remarkable discovery of the volatility of nickel in carbonic oxide, due to Mr. Ludwig Mond, is, according to a statement of the discoverer, to be utilized upon a commercial scale, but it is not known whether the works have as yet been started. The older processes of obtaining the nickel have been improved by the adoption of continuous reduction furnaces, instead of crucibles, and in other details without much alteration of principle, and particular attention has been paid to the production of ferriferous metal for steel makers by Mr. J. Garnier and others; the modern practice of nickel smelting so far as it can be made public having been treated in considerable detail by M. Levat. In consequence of the large supplies coming from Canada and New Caledonia, the price of the metal has continually declined in spite of the new demand in Europe for military purposes, about 500 tons per annum being now required for the bullet casigns in the new small arms ammunition. The alloy, one of nickel to four of copper, used for this purpose seems to possess many valuable properties, and it has been suggested as a substitute for copper in locomotive fire box plates."

The Choice of Coarse and Fine-Crushing Machinery and Processes of Ore Treatment.*

By A. G. Charleton.

Part II—The Relative Scope of Rival Methods of Ore Treatment.

Having examined the metallurgical nature of the various ores and processes (which have been superficially touched upon in the briefest possible manner), we are in a better position to proceed to the still more complicated and difficult questions of the relative prime cost of plant, working costs, and the percentage of gain or loss in rival methods of ore treatment. These are liable to differ in different countries, and under varying conditions even in the same neighborhood, according to the nature of the ore, cost and quality of labour, material and supplies, as well as the economical or uneconomical manipulative or mechanical modifications in treatment, which can be introduced in each case, on which probably more than anything else, the individual economy or wastefulness (the profit and loss in fact) in works of the same class will depend.

To form an estimate of the prime cost of plant, we must either know the ordinary gross cost of a mill of a certain size and description in any particular locality, or, what is better, the actual quantities and prices of material of different kinds used, and the number of shifts worked by different classes of artizans at specific wages rates, in the construction of the foundations and superstructure of the building, and the erection of the machinery; as well as the price of the machinery itself, the weight of all the transportable material, and freight rates.

The collection of such facts is unfortunately too rare in mining operations to make it always an easy matter to form estimates of the kind applicable to different localities. It is only by piecing together fragments of information obtainable here and there that one can get anywhere near the truth.

Under the category of rival processes, the relative costs and results of treating the following classes of ore may be compared:—

1. Pyritic gold ore by chlorination in vats and chlorination in barrels, and by the new cyanide process, as well as by grinding (without roasting) in pans and arrastras.

2. Silver ores in general,† by wet and dry crushing and pan-amalgamation, the patio and other processes, as compared with the ordinary and Russel lixiviation processes.

3. Free-gold ores by battery amalgamation, both with and without grinding, and concentration.

The cost and loss in coarse-concentration and smelting have already been considered, and will not be referred to again.

There is no branch of ore treatment which admits of wider differences of internal detail than wet concentration (producing a corresponding effect on its cost ‡), but such points cannot possibly be entered into here; and as regards dry concentration, it cannot at present seriously be regarded as a rival to wet methods, and may therefore be passed over entirely.

The concentration of sulphide ores of gold and silver often depends on the relative proportion the sulphides bear to the gangue. No sharp line of distinction can be drawn between ores which are suitable for concentration or not, as average value local cost of treatment enter into the calculation, but roughly speaking, such ores as contain 40 per cent. of sulphides are not usually suitable for concentration. Frequently an ore which will average 20 to 50 per cent. of sulphides, coming from the mine, is best divided by hand selection into first-class ore (to be treated by smelting, or some other process), and a second and poorer class for concentration.

In a mine where the ore runs in seams and pockets of solid mineral, it may happen that 100 tons of crude ore will contain on an average 20 per cent. of sulphides, which can be separated by hand selection into 20 tons of 75 per cent. sulphides and 80 tons of 6¼ per cent. sulphides. When this can be done cheaply it is often better than subjecting the whole 100 tons to the costs and losses of concentration, whilst it renders commercially possible a more expensive but more efficient process than the original ore could bear.

A point to be remembered, however, in concentration is, that clean, that is to say pure concentrates, are often as important to obtain as clean tailings (which latter are essential for close saving). You may have the one without the other, and although a clean separation of the metallic components of the ore is almost always advisable, in some instances it may be desirable to leave a certain proportion of sand or gangue in the headings, either as a flux for smelting (as previously pointed out) or to lighten the pan-charges in amalgamation.

* *Trans. Fed. Inst.*, vol. ix., page 233.

† The term is applied to ores which do not contain more than, say to 15 per cent. lead. Ores with more than 15 per cent. of lead are known as silver-lead ores, and are smelted when circumstances admit of it, which is the only admissible proposition for their treatment. Carbonate of lead and galena are converted by roasting sometimes into oxy-chloride and sometimes into sulphate; the former goes into the amalgam, whilst the latter does not amalgamate, and this circumstance explains why some bullion of plumbiferous silver ores is free from lead, whilst other bullion sometimes contains 500 parts of lead in 1,000, according to the condition of the lead in the roasted ore.

‡ In western mining camps, the cost generally runs between 4s. 9d. and 22s. 6d.

Vat and Barrel-chlorination.

For working a few tons of concentrates per day the regular Plattner process, with fixed tanks and long exposure to gas, is as convenient and economical as any of the improved processes, because the plant is simple and cheap to erect, and very few hands are required to run it.*

The production of gas is a simple question of relative costs of different chemicals delivered at the mine. For working large quantities of ore daily, especially if of comparatively low grade, which requires economy in crushing, roasting, gas consumption, labour, and time, the use of barrels, in place of fixed tanks, effects a saving in time and labour, and makes special watchful skill less important in the whole process than in the Plattner method, so that one of the modifications of the barrel system would be naturally adopted on crude ore and in dealing with large quantities of concentrates.

The attrition of the ore particles and the thorough turning over of the charge in the presence of nascent chlorine in the barrels, has also some effect upon the results, especially if there be coarse-gold present which has to be amalgamated afterwards, as the gold, it is said, is attacked with much greater avidity by the mercury in consequence of the clean surface created by the action of the chlorine and attrition combined. It is necessary, however, that the tailings should first be washed, by continuing the leaching, till all trace of chlorine has disappeared, and that they should be treated by amalgamation at once. If left to dry, the gold particles assume a red colour and amalgamate with great difficulty.

The most successful furnaces in general use for chlorination-roasting appear to be of three types:—

1. Plain or step-hearth reverberatories furnaces, of the Fortschaufelung class, with a hearth surface of about 12 feet wide by 75 feet long.

2. Horizontal round-hearthed mechanical furnaces, of the English Brunton-calciner type, about 12 feet diameter.

3. A modified form of the Spence furnace.

To which may perhaps be added an altogether new modification of the Fortschaufelung furnace, which will be alluded to later on.

When battery-amalgamation and concentration precedes chlorination, Mr. A. Thies† recommends the use of brass-wire screens in place of slot punched sheet-iron ones, stating that when using 36-mesh brass-wire in place of 40-mesh slotted iron, at Haile, in North Carolina, he obtained a far more uniform pulp for concentration, whilst the average life of the wire was found to be six weeks as compared with the sheets, which had to be thrown out in fourteen days, a matter which is worth noting. German practice certainly supports this view so far as concerns the effect of wire screens on the concentration results.

Dr. Egleston states that the correct amount of charge, in roasting gold-sulphides in the reverberatory furnace, is usually 10 to 12 lbs. per square foot of hearth; an ordinary charge amounting to about a ton at a time on each division of the earth, of which there are usually three.

A furnace of this description, designed to handle from 3 to 4½ tons of concentrates per 24 hours, 75 feet long by 11 feet wide inside, requiries for its construction 40,000 common bricks, 8,000 fire bricks, and 5 barrels of fire-clay, and the iron work, tie-bars, etc., exclusive of T-rails, weighs 11,000 lbs. A furnace with a 14 feet by 60 feet hearth requiries 86,000 red bricks and 15,000 firebricks, and cost about £626 in Pueblo or Denver.

In vat-chlorination, the rest of the plant to correspond, covered in (as the furnace must also be), consists of a drier, a set of fixed or rotating leaching-vats, with (in some cases) silver-leaching tubs added, precipitating-tanks, and reagent tanks, well and pump, lead-generator, heating-pan and wash-bottle, a drying muffle and melting furnace, and a press and filters for precipitate, as well as filter-tubs for the base metals‡ in the waste-solutions, and cars for handling the ore, overhead tackle for lifting the vat-covers and tools, etc.

The cost of a plant of the kind in California, with a capacity of 6 tons in 24 hours, is stated§ to vary between 6,000 and 7,000 dols. (£1,250 to £1,458 6s. 8d.). A small plant would cost about half the former sum.

The Thies modification‖ of the Mears process (one of the most successful unpatented systems of barrel-treatment), requiries the substitution of rotating barrels for vats, the chlorine being generated inside the barrels, by the action of sulphuric acid (66 degs. B.) on bleaching powder, which is added to the charge of water and ore under ordinary circumstances in the proportion of 10 to 30 lbs. of chloride of lime to about 15 to 30 lbs. of acid per ton of charge of roasted ore in each barrel.

If copper is present more of these reagents are required.

The barrels must be run by steam or water-power, the latter being, of course, the most economical, when available.

The rest of the plant, though differently arranged, is substantially the same as that for vat-chlorination, and will cost not less than £620 for works with a capacity of 5 tons per day; the weight of the machinery will be about 17 tons.

* *Gold Amalgamation and Concentration*, page 28.

† "The Thies Process of Treating Low-grade Auriferous Sulphides."—*Trans. Am. Inst. Min. Eng.*, vol. xix., page 601.

‡ If present and worth the extra treatment.

§ "The Milling of Gold Ores in California," by John Hays Hammond. *Eighth Annual Report of the California State Mineralogist*, page 696.

‖ A description of this process is given by Dr. Egleston in *The Metallurgy of Gold and Mercury*, page 664, *et seq.*

The cost of the vat process at the works of the Plymouth Consolidated Company,* where 100 tons of concentrates is treated per month of thirty days (leaching taking twenty-four days), is given as follows:—

	£ s. d.	£ s. d.
Roasting—		
3 men at 10s. 5d. per day for 30 days	46 17 6	
13¼ cords of wood at 17s. 8½d.	46 9 8½	
54 lbs. of salt at 3s. 8d.	2 10 7½	
		95 17 10
Chlorine (employing two generators)—		
60 lbs. of manganese per day at £9 15s. 10d. per ton	7 1 0	
68 lbs. of salt per day at £3 2s. 6d. per ton	2 11 0	
120 lbs. of acid per day at £12 10s. 0d. per ton	18 0 0	
		27 12 0
Leaching—		
40 lbs. of sulphuric acid for settling-tanks for 24 days	6 0 0	
40 lbs. of sulphuric acid for making sulphate of iron for 24 days	6 0 0	
Wages of leachers (2 men at £1 2s. 11d.†) for 30 days.	34 7 6	
Wages of foreman	26 0 10	
		72 S 4
Total cost per month		£195 1S 2

or £1 19s 2d. per ton.‡

At the Providence Works two furnaces are used, which have a capacity of 9 tons in 24 hours. Each furnace consumes 1 cord of wood, and the cost per day can be reckoned as shown in detail on page 366. This makes the cost of treatment per ton of sulphides to be 14s 9½d. when the works are run at full capacity.

As the ore, however, only contains about 7 per cent. of sulphides, or 4½ tons in the 62 tons milled daily, this quantity does not keep the two furnaces running full time, though both of them are in constant operation. As most of the expenses remain the same, whether running at full capacity or not, the actual cost of chlorination, figured on a working basis of 4½ tons treated daily, approximates, therefore, more nearly to £5 13s. 10d. per day, or £1 5s. 3½d per ton of concentrates, as detailed below. Add to the above sum (£5 13s. 10d.) the cost of milling per day, viz., £11 19s. 7d., and it will be found to represent a total outlay of £17 13s. 5d. per day, or a total charge of 5s. 8½d.¶ per ton of crude ore raised from the mine.

This estimate makes no allowance for general supervision, interest on first cost, or deterioration. The conditions of treatment in these works are, however, very special, and can hardly be considered as a basis to estimate upon in most instances.

The estimated cost of the treament of 4½ tons per day is:—

	£ s. d.
Labour	2 13 1½
2 cords of wood at £1 0s. 10d.	2 1 S
14 lbs. of manganese at 1⅓d.	0 1 7
126 lbs. of salt at 1d.	0 5 3
104 lbs. of acid at 1d.	0 S S
Lime, sulphur, and calcium hyposulphite	0 0 7½
Illuminating	0 0 10
Extras	0 2 1
Total cost per day	£5 13 10

or £1 5s. 3½d. per ton.

At the Alaska Treadwell Company's works the cost for the year ending May 31st, 1891, was as follows, calculated on a basis of 3,568 tons of concentrates treated:—

Labour.

	Cost per Ton. (American money) Dollars	Cost per Ton. (English money) £ s. d.	Gross cost Dollars	Gross cost £ s. d.
Foremen	·5600		2,000·43	..
Engineers and Foremen	0·14		286·38	..
Gas generator	·0089		1,121·29	..
Salters	·0815		458·24	..
Floormen	·7604		4,080·83	..
Roasters	2·9490		15,782·49	..
Carmen	·2077		1,114·72	..
Carpenters	·0030		21·39	..
Labourers (white)	·0929		536·62	..
" (Indian)	0·309		166·00	..
Teamster	0·806		433·11	..
	$5·0312	£1 0 11½	$27,007·50	£5,626 11 3

* *Trans. Am. Inst. Min. Eng.*, vol. xv., page 305.

† Two men on day shift attend to all the work of handling the ore after it is leached. The head man receives 12s. 6d., the others 10s. 5d. Only three tankfuls are leached every four days; but the men are employed steadily. The sulphate of iron is manufactured on the spot.

‡ To this should be added for assays, repairs, supplies, insurance, taxes, water, interest on invested capital, and deterioration of plant, as well as proportion of general expenses and superintendence, about 16s. 8d. additional per ton, making the total cost of working £2 15s. 10d. per ton.—*Eighth Annual Report of the California State Mineralogist*, page 48.

§ *School of Mines Quarterly*, vol. v., and Egleston's *Gold*, page 657.

¶ 1s. 10½d. of this is chargeable to the chlorination.

Supplies.						
Acid	1·0220	..	5,486·38	..		
Wood	1·5230	..	8,175·93	..		
Coal	·0543	..	284·80	..		
Furnace supplies	·0270	..	145·19	..		
Manganese and salt	·8095	..	4,345·86	..		
Pipe	·0089	..	47·90	..		
Generator fittings	·0038	..	25·93	..		
Leaching tanks	·0638	..	339·05	..		
Miscellaneous	·1353	..	727·26	..		
Rake-heads	·0360	..	193·50	..		
Car wheels	·0037	..	27·50	..		
Repair account	·1352	..	720·08	..		
Electric light acct.	·1077	..	578·49	..		
Haulage account	·0549	..	294.77	..		
	$3.9852	£0 16 7¼	$21,392·63	£4,456	15	11½
Total cost per ton of sulphides	$9·0164*	£1 17 6¾	$48,400·13	£10,083	7	2½

	Cents.		s.	d.
Mining	65	=	2	8½
Milling and concentrating	33	=	1	4½
Chlorination	19	=	0	9½
General expenses (mine)	8	=	0	4
General expenses (in San Francisco)	2	=	0	1
Bullion freight, etc.	5	=	0	2½
	$1.32	=	5	6

per crude ton of ore, but the average for some time previous was 6s. 3d. per ton.

The roasting at these works is done in Spence automatic furnaces, each with four hearths, which roast 8 tons per day. On the hearth next the lower one, 3 per cent. of salt is added with a special spoon. The ore, instead of being as formerly stirred by fixed rakes, is now rabbled by oscillating ones, which tip every three minutes. On the upper drying-hearth they last a long time, but on the lower ones, where the heat must be great to drive off the last traces of sulphur, their life is only about three months.

Formerly the rakes stopped between the forward and backward motion just over the flue, now they are made to go beyond it, and are no longer exposed, as they were at this point, to the sulphurous gases and hot falling ore, which clogged the end of the shelves and gave such trouble at the Haile mine, finally causing the abandonment of the Spence furnace there for roasting fine ores, although admittedly a most excellent mechanical roaster for coarser grades of material in its original shape.

With the important modifications above alluded to it seems doubtful (judged by the above facts) how far Mr. Thies' condemnation of the Spence furnace† (in works wtth a capacity of 3 to 4 tons) for fine ores (where a dead sweet roast is required) is entirely justified.

The labour involved in vat-chlorination on an average may be taken at :—

1 man, who works 10 hours, to bring in wood and ore..
1 man at the furnace, who works 8 hours.
1 chlorinator, " 8 "
3 labourers (1 on shift by day, and 2 by night).

At Sutton Creek it takes 8 men for the whole 24 hours, one chlorinator, one helper, five men at the furnace, and one who wheels ore.

The consumption of chemicals per ton of ore is about as follows :—

Salt in the furnace	40 lbs.
" " generator	6 "
Manganese	6 "
Sulphuric acid generator (66 degs. B.)	20 "

The stock of chemicals ordinarily kept on hand, on the scale of operations of the Alaska Treadwell Company, seems to be :—

	£	s.	d.	£	s.	d.
Salt, about 53 tons, valued at	2	17	11 ..	153	9	7
Manganese, 13 "	9	15	10 ..	127	5	10
Sulphuric acid, 35 tanks at	8	18	10½ ..	313	0	7½
Total value ..				£593	16	0½

The works in Grass Valley, where vat-chlorination is most extensively used, guarantee an extraction of 90 per cent. of the gold, and 60 per cent. of the silver, but the saving more often amounts to between 90 and 94 per cent. of the gold in pyritic-concentrates, and over 60 per cent. of the silver, if the tailings are leached to obtain it.

The ore to be properly roasted ready for leaching should maintain a nearly vertical face when made into heaps on the finishing hearth, and cut down with a spadelle. It should show no bright specks, but be inclined to become black, which will generally be in 7 or 8 hours. The largest amount of gold has been shown to be in the best condition to be leached and to consume the least amount of chlorine in chlorinating it, when the ore falling in the furnace, in turning it over, has a slight violet colour. When the ore sparkles, and the sparks are numerous and bright, it shows that the roasting is not properly finished, and more salt has to be used.*

A ton of roasted ore will occupy usually 24½ cubic feet. This quantity is derived from 2,800 lbs. of raw sulphides, which occupy about 13⅔ cubic feet per ton (2,000 lbs.). A ton of sulphides will weigh from 1,450 to 1,700 lbs. after roasting, and occupy about 17½ cubic feet. The roasted ore ought not to contain more than 1⅜ per cent. of sulphur.*

At the Plymouth Consolidated works, the Fortschaufelungs-ofen used for roasting is 12 feet wide by 80 feet long, including the fire-box, the hearth being a continuous plane, but the charges, of which there are three in the furnace at one time, are kept entirely separate. They are called by the furnacemen the drying, burning, and cooking compartments. In the middle division the ore is spread out very thin, and occupies about double the space of either of the others.

The furnace is worked by 8 hours' shifts, a charge being drawn and added in each shift. The charges weigh 2,400 lbs. and carry about 10 per cent. moisture.

The ore averages about 20 per cent. of sulphur, and just before the sulphur ceases flaming in the second division of the furnace 18 lbs. or ¾ per cent. of salt is added to the charge. Care must be taken to keep concentrates damp until they are reduced into the furnace, or a decomposition of the pyrites begins, forming lumps which do not roast, and consequently cause a loss of gold in the residues from leaching. The roasted ore from each shift is kept by itself on the cooling floor until a tankful (about 4 tons) has accumulated from a single man's shift, and it is then worked by itself. This enables the foreman to better control the work of roasting, for if one lot out of three works badly, it points to the fault being with the furnaceman; whereas, if all three give unsatisfactory results, it may be presumed to be owing to a change in the ore, and the roasting must be modified.

The vats† for chloridizing the roasted ore are 9 feet in diameter by 3 feet in height; they are four in number, and are slightly inclined forward to drain them completely. The bottom of each tank is composed of a filter about 6 inches thick, consisting of light strips of ¾ inch wood laid on the bottom at intervals of about a foot. Across these are placed 6 inch boards, spaced an inch apart. On this loose floor coarse lumps of quartz are spread, and on the top of this again quartz-sand, until a depth of 6 inches is obtained. Finally, this sand filter is covered over with another loose floor, the boards lying cross-wise to the loose floor beneath and pretty close together. This upper floor is merely to facilitate shovelling the charge out when it has been gassed to permit the removal of the leached ore without disturbing the filter.

The ore to be chloridized must be damp (about 6 per cent. moisture). The working test is to take a handful of ore and squeeze it, then open the hand, and if the lump immediately begins to crumble and fall apart (not run) the ore has the requisite amount of moisture. The damp ore is screened into the tank so as to lie as loose as possible and thus facilitate the penetration of the chlorine. A coarse screen of one-and-a-half mesh is used for this purpose.

The tanks are only filled up to within about 3 inches of the top, (to ensure the entire contents being covered with water in the subsequent leaching,) otherwise there would be great difficulty in washing out the soluble gold. As soon as they are full they are gassed. The gas is introduced into the bottom from two opposite sides, and is continued until ammonia held over the ore gives off dense flumes of ammonium chloride, which usually happens in about 4 hours. When this point is reached, covers are placed on the tanks and luted on.‡

The two gas-generators§ which are employed to charge a tank are allowed to work on till nearly exhausted, when they are disconnected, and the holes in tank are plugged up. The tanks are usually charged in the morning, and left standing two days. On the third day the ore is leached. The tank is first filled with water, and allowed to stand a few minutes to permit the water to penetrate the ore. If no more water is absorbed, the liquor is drawn off at the bottom, care being taken to keep the tank full of water during this part of the operation, which lasts 4 to 5 hours.

For charging the tank a gunny sack is laid on the ore and held down with a couple of bricks where the wash-water is afterwards to be introduced, in order to better distribute the water in the tank, and prevent it washing out holes and packing the ore.

The liquor from the leaching-vats is conducted to settling or storage-tanks, where about 40 lbs. of sulphuric acid is added (66 degrees B.) and it is allowed to stand 2 to 24 hours. It is then run into the precipitating-vats, where the gold is precipitated with sulphate of iron; the iron solution being added until after stirring, a further addition produces no purple colour. After the gold is precipitated it is allowed to stand from two to three days to settle, when the supernatant liquor is drawn off with syphons into a second settling-tank, where any gold drawn off by the syphons has a second opportunity of settling.

The liquor stands in this tank until it is necessary to run it off to make room for a fresh charge. Very little gold is found in this tank, so it is only cleaned out about once a year.

In the meantime fresh liquor has been run into the precipitating-tanks on the gold already precipitated there. In this way the gold is accumulated till the semi-monthly clean up, the precipitating-tanks being kept locked and covered. In making a clean-up, the supernatant liquor is syphoned off, the gold gathered up, and placed in a filter of punched iron, lined with filter-paper, and washed with water till all the acid and iron salts are removed. It is then dried, melted in crucibles, and cast into bars.

Under unfavourable conditions the cost of the chlorination process may run up as high as £4 3s. 4d. per ton, but in California it may generally be taken as costing £1 17s. 6d. to £3 1s. 6d, per ton, £2 14s. 2d. being in all probability a fair average on a basis of treating 3 tons or more daily.

Mr. G. F. Deetken is responsible for the statement* that with favourable conditions of cheap wood and freight rates, not counting interest, insurance and amortization of a capital of 3,000 dollars, the working expenses in some parts of California do not exceed £1 0s. 10d., and are sometimes as low as 16s. 8d. per ton.

In locating works of this kind it is important to secure a good fall, and they should be terraced and so placed with reference to the prevailing winds that noxious fumes will not be carried in the direction of valuable land or house property.

There should also be a supply of water at hand, delivering 40 to 60 gallons per hour.

Barrel-chlorination.

Mr. Thies, in a letter to Mr. C. N. Aaron (a well-known Californian authority), gives the cost of the Thies process at the Haile mine, North California, as follows :—

Using a double reverberatory furnace, which furnishes 2 tons of roasted ore every 24 hours, with an average consumption of 1 cord of wood, at 5s. 2½d. per cord, and employing four labourers, the cost of roasting the ore amounts to 10s. 11¼d. per ton. Two men can easily treat 4 tons in 10 hours, elevate the ore, and clean out the filter-tanks, of which there are four to each barrel. Arranged on this basis, the cost of roasting and chlorinating amounts to 19s. 3¼d. per ton, as tabulated below :—

	Cost per Ton.	s.	d.
Roasting 2 tons of ore—			
4 labourers at 4s. 2d.	8	4	
1 cord of wood at 5s. 2½d.	2	7¼	
	10	11¼	
Chlorinating 4 tons of ore—			
2 labourers at 3s. 9d.	1	10½	
1 chlorinator at 8s. 4d.	2	1	
40 lbs. of bleaching powder at 1½d.	1	3	
60 lbs sulphuric acid at 1d.	1	3	
Sulphuric acid, for making ferrous sulphate	0	6¼	
Repairs, wear and tear	0	10	
Power	0	6¼	
	8	4	
Total cost per ton	19s.	3¼	

We thus have the sum of 19s. 3¼d. for roasting and chlorinating 1 ton of roasted ore, representing 1⅓ tons of raw iron pyrites.

Inside of 7 hours from the time the ore is in the chlorinator, the solutions are ready for precipitation and the tailings are clean.

At the Phœnix mine, in North Carolina, the cost for roasting† and chlorinating by the Thies process is estimated at :—‡

	£	s.	d.
Roasting	0	9	1
Chlorinating	0	11	2
	£1	0	2

2,353 tons of concentrates are said to have been successfully treated by this process at the Haile mine and 5,000 tons at the Phœnix mine between May, 1888, and September, 1890.

At the Phœnix mine, a 12 feet revolving pan-furnace is used, which roasts 1 ton of raw ore in 12 hours, with a consumption of ⅜ths of a cord of wood, and 3s. 9d. worth of labour. The cost of power does not exceed 1s. 0½d. per ton.

At the Bunker Hill works, the concentrates are roasted with 1 per cent. of salt, in a reverberatory furnace 40 feet by 12 feet on the outside, with walls 18 inches thick, the stationary hearth of which (7 feet by 18 feet by 2 feet in height, with a working door on each side) terminates in a horizontal revolving hearth, 12 feet in diameter, set at a lower level (giving a fall of 6 or 7 feet). The discharge hole or cub is in the centre of this latter hearth, from which the ore drops into cars.

At the Deloro mine,§ Canada, where the Mears process was formerly in operation, the ore was roasted (after drying in a revolving drier) in a pair of cylinders,‖ one

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* In the six months ending November 31st, 1892, this charge was reduced to $8·42 = £1 15s 1d. per ton of sulphides. As an instance of economical management, the total costs of mining and milling per crude ton extracted may be cited as follows, the ore being quarried in open benches :—

† *Trans. Am. Inst. Min. Eng.*, vol. xix., page 610.

* The heat on the finishing hearth must be maintained at a lively bright red, but not at a white heat, else the gold particles would melt, which, with a good magnifying glass, can be easily detected; after washing off the iron the gold appears then in minute globules, the chlorniation of which is more difficult.

* Egleston, *Gold*, page 622.

† The vats should be coated on the inside with asphaltum varnish or a mixture of pitch and tar applied hot, but the former is preferable, as it penetrates better into the pores of the wood.

‡ It is usual to provide the covers of the tanks with two pieces of 1¼ inches gas pipe 6 inches long, and a square hole, 6 inches by 6 inches, closed with a wooden cover. These pipes are closed with balls of clay during the impregnation of the ore with gas. After gassing, the clay is removed, and one of the pipes is coupled to the hose of the water tank, whilst the other is connected either with another tank ready for chloridizing, or the ashpit of the roasting furnace, partly to utilize the surplus chlorine, as well as to protect the workingmen from its injurious effects

* When practicable, it is a good plan to heat the generators by steam in place of direct heat.

* *Eng. and Min. Jour.*, New York, vol. lv., page 244.

† Removing the sulphur to within 0·25 per cent.

‡ Phillips, *Trans. Am. Inst. Min. Eng.*, vol. xvii., page 321.

§ R. P. Rothwell, *Trans. Am. Inst. Min. Eng.*, vol. xi., page 191.

‖ Different furnaces require, on the average, it is said, the following weights of wood to roast a ton of ore (the weight being calculated on the basis of 2,200 lbs. per cord as an average):—White furnace, 300 lbs.; Bruckner, 900 lbs.; reverberatory, 600 lbs.; Stetefeldt, 200 lbs.—(Report, *Tenth Census, United States.*)

30 feet in length by 5 feet in diameter, the other 20 feet by 4 feet, set tandem, jacked with mineral wool and then paper. It is claimed that 10 tons of concentrates have been roasted in these cylinders in 24 hours, so that extraction of gold has reached 93 to 98 per cent.

The tanks used in the process should be built of wood which has been soaked in linseed oil, dried, and painted with three good coats of white lead or tar.

Mr. Thies states that the cost of barrel-treatment depends chiefly on the number of tons chlorinated per day.

The wear on the inner lead-linings of the chlorinators is imperceptible; a chlorinator in use at the Phœnix mine for over five years does not show any wear. The lining is fastened on with bolts from the outside, as it has been found very difficult to burn on lead, when chlorine has acted on it, in making repairs.

At the Haile mine, the fire-assay and value of the ore delivered to the stamps is 4·50 dollars (18s. 9d.) per ton.

The mint returns of bullion have 16s. 3d. per ton of ore treated, of which 6s. 0½d. is to be credited to the battery, *i. e.*, to free-gold; whilst 10s. 2½d. was obtained from the sulphides.

Taking the assay-value of the ore at 18s. 9d., and the actual yield in bullion at 16s. 3d., there is an indicated loss of 2s. 6d. per ton, or 13⅓ per cent. Taking the yield in free-gold at 6s. 0½d. per ton from an ore worth 18s. 9d. per ton (or approximately 32 per cent. of the gross value by assay), we have 68 per cent. to be debited to the concentrates. But the total yield in free-gold, and in gold from the sulphides being 16s. 3d., the ratio of the free-gold saved, to the total amount saved, is approximately 38 per cent., and the combined gold 62 per cent., or a saving of about one-third free and two-thirds combined gold.

The term, combined gold, has been used to express the condition of the gold which is not free. Whether the gold that is not free is chemically or mechanically diffused in the sulphides or both is uncertain, in most cases.

Mr. T. W. T. Atherton * claims to have found gold as a natural sulphide in the pyrites of the Deep Creek mines of New South Wales. He gives an analysis of the ore and the method pursued in experimenting on it, from which his conclusions were drawn.

From 80 tons of ore stamped per day of 24 hours at Haile, 7½ tons of concentrates are obtained from 16 Embrey end-shake tables, which gives as the yield of each concentrator a little less than half a ton.

The average assay-value of the raw concentrates for the 12 months preceding the date of Mr. Thies' paper was £6 5s. per ton, and the percentage of sulphur they contained varied between 40 and 45 per cent. In roasting, this was brought down to 0·25 to 0·40 per cent., whilst the value of the material naturally increased; the raw concentrates worth £6 5s. becoming worth when roasted £8 6s. 8d., or about one-third more per ton.

The assay-value of the tailings thrown away, after chlorinating the roasted ore, was, on the average, only 8s. 4d. per ton, representing an extraction of 95 per cent.

The process had been in successful operation 2½ years, at Haile, when Mr. Thies' paper was written in 1890, and 36,000 tons of crude ore had been treated profitably during that time, prior to which nearly every process had been tried on the ore and failed.

The advantages of the process are:—The small amount of space the plant occupies, speed of operation, high percentage of yield, facility of ascertaining the condition of the charge at any time, † and very slight wear and tear. The only offsets against these advantages are the care and intelligence required to control it, and the need for a small amount of power.

250 to 300 gallons of wash-water are needed per ton of ore treated (an ordinary charge), the water being introduced into the barrel first.

It takes 2 to 4 hours to chlorinate each charge, the barrel revolving at 12 revolutions per minute.

The lead-lining is ¼ inch thick, and weighs 12 lbs. per square foot.

The filters must be flooded from below with 4 or 5 inches of water to prevent the ore packing as it falls into them.

The charge must be allowed to drain, and then washed with water as rapidly as possible till the wash-water show no gold, though still carrying traces of chlorine.

If lime is present, settling-tanks, called stock tanks, are required to settle the liquors which are drawn out of them into the precipitating tanks after standing for 14 to 16 hours.

The precipitating-tanks are large enough to hold the liquors from 3 tons of washed ore. The ferrous sulphate is syphoned into them. The solution must have a decidedly acid re-action in order to be certain that all the lime has been converted into sulphate.

The Providence works and those of Bunker's Hill may be cited, the former as showing exceptionally low cost by the vat process, working 9 tons per diem; the latter usually high cost by barrel-treatment, treating 2 tons in 24 hours. To compensate for this the loss in the tailings, which used to run as high as £1 9s. 2d. when worked by the ordinary vat process, has been reduced 50 per cent.

The cost at the Providence works:—

	£	s.	d.
1 foreman	0	12	6
1 white labourer	0	9	4½
5 Chinamen at 6s. 3d.	1	11	3
2 cords of wood at £1 0s. 10d.	2	1	8
29 lbs. of dioxide of manganese at 1⅜d.	0	3	4
260 lbs. of salt at ½d.	0	10	10
216 lbs. of sulphuric acid at 1d.	0	18	0
Lime, sulphur, and calcium hyposulphite.	0	1	3
Illuminating	0	0	10
Extras	0	4	2
	£6	13	2½

Per ton ..... 14s. 9½d.

The cost at the Bunker Hill works:—

Roasting—	s.	d.	£	s.	d.
2 roasters at 13s. 6½d.	13	6½			
⅝ths cords of wood at £1 5s.	15	7½			
			1	9	2
Chlorinating—					
1 chlorinator at 12s. 6d.	6	3			
30 lbs. of bleaching paper at 2d.	5	0			
36 lbs. of salt at ⅓d.	0	7½			
20 lbs. sulphuric acid, 66 B. at 1¾d	5	3			
Water-power	2	1			
General expenses and loss	12	6			
			1	11	8½
Total cost of 1 ton of ore roasted and chlorinated			£3	0	10½

Under efficient management and favourable conditions the cost of barrel chlorination will usually be found to vary between 12s. 6d. and £1 0s. 10d. per ton in America.

The results of treatment by another vat-process, the Pollock patent, are given in the *London Mining Journal*,* treating various ores as follows:—

	Ozs.	Dwts.	Grs.	Percentage Extracted.
Sheba mine tailings	2	7	21	96
Mixed lot of ore, Transvaal	1	3	22	97
Day Dawn P.C. quartz, Q. 6.	6	9	23	97
" concentrates, Q 1.	1	2	6	97
Swaziland quartz, South Africa	0	16	5	95
City and Suburban quartz, Transvaal	12	10	10	95
Crown ore, New Zealand	3	16	0	94
Transvaal Gold Extracting Co.	1	10	11	93
" " tailings	0	7	8	85
Mount Shamrock tailings	0	8	17	96

It is stated that the cost of the plant for treating 100 tons a day is about £10,000.

It is certain that ores like those of Meadow Lake district, California, composed of a species of siliceous hæmatite (which in depth will probably be found in an unoxidized condition, consisting mainly of pyrite) will not amalgamate properly, and attempts have been made with various devices and countless processes to work them, but so far without success.

They are said to average £1 9s. 2d. to £2 1s. 8d. per ton or over, and to bear a resemblance to the ores of Bald Mountain district, South Dakota. It is possible that if a sufficient quantity of concentrates could be secured to keep works of the kind running many of these ores could be advantageously handled by the barrel-chlorination process, without a previous roasting, if treated with an oxidizing agent such as nitre cake, and in working the surface-ores even concentration might at first be dispensed with.

An interesting modification of the barrel process (described by John E. Rothwell, *Eleventh Census*, United States, 1890) is to make the chlorination barrel also the washing and leaching-vessel. This is effected by fixing a diaphragm as a filtering medium, so as to form the chord of an arc of the interior of the barrel. The diaphragm or filter is made up of plates corrugated similarly to the ordinary filter-press plate, and perforated with holes every 4 or 6 inches square. These plates are supported on bearings bolted to the shell. On the top of the corrugated plates is placed the filtering medium—an open-woven asbestos cloth. It is about as coarse as the common gunny-sack, but the warp and woof are of much heavier thread.

Over this is placed an open grating, and the whole is held in place by cross-pieces, the ends of which rest under straps bolted to the inside shell. In this way, though the whole is rigidly held in place, it is very easily and quickly removed when necessary to change the asbestos cloth. Two valves on each end of the barrel above and below the filter, are provided for the inlet and outlet of the wash-water and solution respectively.

The barrel is charged by first filling the space under the filter with water, which at the same time is allowed to pass through the filteriug medium and wash it, then the required quantity of water is put in above the filter. There are two methods of charging the pulp, lime-chloride, and sulphuric acid. In one the lime is so placed in the ore-charge in the hopper over the barrel that it goes in with the ore and is completely buried with it. The acid can then be added with very little danger of generating any gas before the plate on the charging-hole can be put on and securely fastened. The other way, which seems still better, is to pour the acid first into the water, through which it sinks to the bottom in a mass, and does not mix. The ore is then let in, and the lime added last. The chances of generating any gas are stated in this way to be much less. A barre lso charged has been known to remain open 5 to 10 minutes after charging without generating gas, but it has been demonstrated that on the first revolution of the barrel the gas is at once liberated and creates considerable pressure. After the chlorination is complete the barrel is stopped, so that the filter assumes an horizontal position. The hose is attached to one of the outlet pipes, and conducts the solution to the reservoir tanks. A hose is also attached to the inlet pipe, water is pumped in under pressure, and the leaching commences.

The air in the top part of the barrel is compressed, and forms an elastic cushion, which gives the wash-water perfect freedom to circulate over the whole surface of the charge, and wash every portion thoroughly with the smallest quantity of water possible. By washing in this way no gas is allowed to escape into the building. The solution runs into a covered reservoir-tank from which an exhaust fan draws the excess of gas, and discharges it outside the building. The length of time needed to do the leaching, varies with the leaching-quality of the ore. Charges having been leached in 40 minutes with a pressure of 30 to 40 lbs. per square inch. With higher pressures the time can be materially shortened. As can be readily seen, the ore in the barrel is in the best possible shape for rapid and perfect bleaching. When the barrel is stopped the ore settles on the filter, the coarsest and heaviest on the bottom, graduated evenly over the whole surface up through the charge to the slimes on top. In order to facilitate the leaching of charges carrying an excess of dust, a valve placed in the casing of the head (on a level with the surface of the pulp) is opened just after the barrel is stopped, and the slime remaining in suspension is run off into an outside washing filter-press, where it it can be treated separately, and the charge washed in the usual way. The tailings are discharged into a car which will hold the whole charge of ore and water and then run out, or if water is abundant they are discharged into a sluice and washed away.

For leaching purposes the amount of water needed to wash a charge varies very little with the richness of the ore, going to show the perfect leaching-condition of the ore in the barrel. The amount required is about 120 gallons per ton more than the quantity used in the barrel for chlorination, which is about 100 gallons per ton.

In order to get a concentrated solution for after-treatment, and to reduce the amount of solution to be treated, a tank is placed over the barrel, and when the richest of the solution and wash-water has run out into the reservoir-tank the discharge hose is connected with a pipe leading to the upper tank, and the washing is finished into it. The solution collected in this way is used in the next following charge in the barrel. The quantity of solution to be precipitated is thus reduced to 120 gallons per ton of ore treated.

The advantages claimed for this method are: (1) the freedom of the building from chlorine gas; (2) the control obtained over the perfect washing of the ore; (3) the small amount of labour, especially skilled labour, necessary; and 4 the small amount and simplicity of the machinery for the great amount of work accomplished.

One man of ordinary intelligence and a helper, are able to look after three barrels—charging, leaching, and discharging them. If the tailings are sluiced out no extra help is needed, but where they have to be trammed, one man in addition is necessary. The disadvantages are due to the neccessary construction of the barrel, but do not interfere with its successful working. They are principally the amount of space taken up by the filter and the portion of the barrel underneath, and the fact that when the barrel is charged and running it is not perfectly balanced.

These disadvantages can be partly overcome by placing the filter close to the shell, only leaving sufficient space underneath to allow of free circulation, but bringing it up to the same height on the sides of the barrel as the horizontal filter; then, by using compressed air to displace the solution and wash-water, an equally good result can be obtained.

For the collection of the solution two tanks are necessary, each of ample capacity to hold a day's solution from all the barrels. Those for collection are placed on the same floor as the chlorinators (unless fall can be secured to place them below). On a step below are the precipitation-tanks, which should be of the same capacity and number as the collecting-tanks. The limit to size would probably be 50 tons capacity; where more is treated, another battery of tanks would be needed.

For a precipitant Mr. Rothwell recommends hydrogen sulphide gas generated from paraffin and sulphur or from iron sulphide and sulphuric acid as the cheapest and most satisfactory. It is generated, and then forced throngh the solution with a small air-pump, which at the same time forces air through, keeping the solution-tank in an agitated state and expelling any free chlorine gas. To save time the gas is turned into the tank while it is filling up, so that, when the tank is full, a few minutes finish the precipitation and collection. The tank is now allowed to stand two or three hours, when it will have settled sufficiently to allow of the supernatant liquor being drawn off through a filter-press. There is little danger of precipitating arsenic and antimony which may be present when the process is worked cold, as they do not commence to come down till some time after the gold has been precipitated and collected.

This precipitant would not be, however, desirable with any considerable quantity of copper or lead in the solution, but small quantities can be dealt with in the after-treatment.

The loss in gold is considerably less if the precipitate is allowed to accumulate in the tanks, and a clean-up made after six or ten precipitations than if it were filtered

* *Eng. and Min. Jour.*, New York, vol. lii., page 698.

† For this purpose a lead valve is arranged in the barrel, so that not only the pressure of an excess of chlorine gas but its actual presence can be ascertained at any time. It does not do to trust to the pressure test alone, other gases being sometimes given off.

* *The Queensland Mining Journal*, Nov. 5th, 1888.

through a press and collected after every precipitation. There does not seem to be any advantage derived from a continuous precipitation and collection on this account if hydrogen sulphide gas is used, as the filters will soon become so coated and clogged with the sulphides as to retard rapid filtration without extreme pressure, which is sure to increase the loss.

The handling of a large number of filter-cloths is also a source of loss, no matter how carefully done. The asbestos filter-cloth under ordinary conditions will last 100 charges, and can be changed in about an hour and a half; one cloth has been known to last 150 charges.

The life of the supporting plates and grating can be made to equal the life of the lining of the barrel, and with barrels that have several thousand charges to their credit this shows little wear.

The latest suggested modification of the chlorination process appears to be that patented by W. D. Bohm, described and illustrated in the *New York Mining Journal* of December 31st, 1892. Briefly stated, the principles involved in it are a forced upward circulation of the solvent solutions through the powdered ore placed in a suitable vat, of special construction.

The circulation is maintained until the precious metals are dissolved, when air-pressure is applied above the charge, to force out as much of the solution as possible, wash-water being subsequently forced up from below, or admitted above the charge, and then forced out in a similar manner, the previous constant flow upwards having caused (it is stated) such a deposition of the sand as to allow the liquid to be expressed rapidly and cleanly. It is claimed by using a solution of chlorine in water, and circulating it in closed pipes and vessels, that a considerable saving of gas is effected, and that as rapid results are obtained as with agitation, with much less power and wear and tear, while ores of different character can be treated in a short time and with little labour.

The plant is said to be equally applicable to cyanide treatment; the precipitation of the gold being effected on shavings of an alloy of zinc and sodium is claimed to be more efficient than zinc alone. The chlorine water is circulated through the ore in a manner similar to a cyanide solution. It is claimed for the electrolytic chlorine-producing apparatus, the invention of two Russian chemists (which is worked in connection with this process), that a great reduction in the cost of producing chlorine is effected; that common salt will supply the place of sulphuric acid and chloride of lime, that the machine is simple, requiring no skilled labour, and has been running with success at the El Dorado mine, Siberia.

This plant, in charge of an engine-driver, produces 40 lbs. of chlorine gas from less than 150 lbs. of common salt, utilizing 5 horse-power. The results are vouched for by M. Leon Perret, mining engineer to the Imperial Russian Government.

A diaphragm-pump of special construction prevents any emulsified grease or other undesirable matter from getting into the solution, and stops leakage of the gold solution through defective glands, etc.

The cost of working this process is stated to vary with the locality. Kaolin ores of Mount Morgan have been treated before the erection of the electrolytic chlorine generator at the following cost :—

	s.	d.
10 lbs of bleach, at 4 cents.....	1	8
8 " acid, at 2 cents.....	0	8
Labour and power.....	1	9½
	3	9½

The time occupied for each charge being 4 hours.

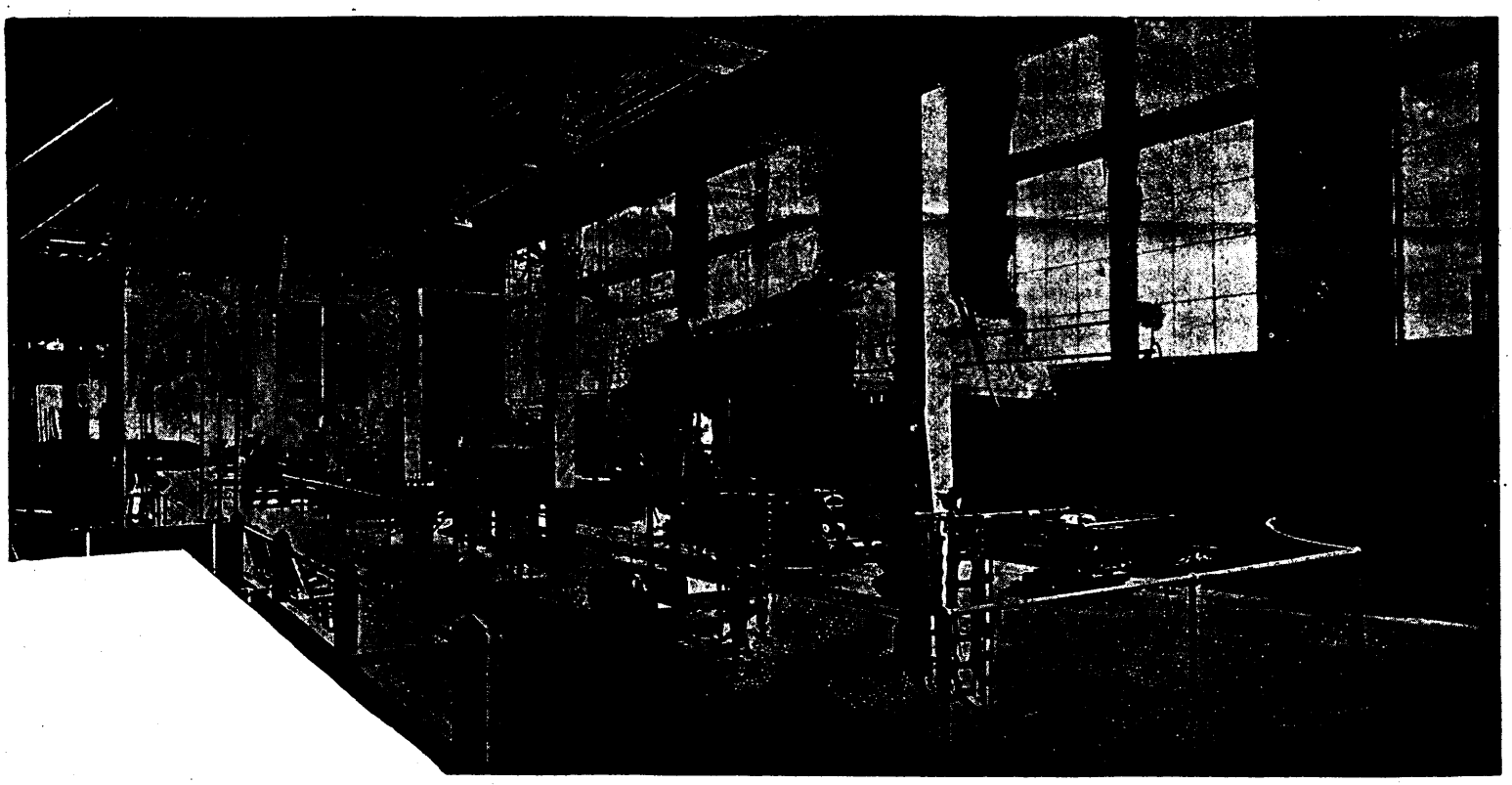
The extraction is not stated, but a proportionate increase in cost of chemicals would be necessitated in the treatment of ores requiring more chlorine.

Mr. Claude Vautin mentions, as recent useful innovations, glass-lined iron pipes, manufactured by Messrs. D. Rylands & Co.; enamelled iron diaphragm-pumps for conveying corrosive solutions, made by Messrs. Scott & Sons; and a compound containing upwards of 75 per cent. of available sulphuric acid, solid below the temperature of boiling water, which can be packed in iron drums, and shipped as ordinary cargo (obtainable from the Ore Dressing Co., 42, Old Broad Street); also chloride of lime packed in specially prepared iron drums. The form in which these two latter reagents are sold may be of utility to persons employing the chlorination process, especially in localities distant from a railway where transport has to be taken into account.

Mr. T. R. Rose,* commenting on Mr. Vautin's statement "that precipitated sulphide of copper is not to be recommended as a practical precipitant for gold, owing to its physical condition, and the facility with which it is oxidized to sulphate of copper," says :—"In accepting this statement as correct in a certain limited sense, it must not be forgotten that the suitability of the precipitant depends mainly on the manner in which it has been prepared. By adding a boiling saturated solution of sulphide (or rather a mixture of the polysulphides of sodium) to the equivalent proportion of a boiling saturated solution of sulphate of copper with vigorous stirring, sulphide of copper is precipitated in a granular form, which settles quickly in water. This substance is more active in the precipitation of gold than the fused sulphide. Its activity is due to the larger surface presented by the porous granules, and to the fact that it is easily decomposed. It is, as Mr. Vautin says, somewhate liable to atmospheric oxidation, but the loss, owing to this cause, is insignificant, because it is always kept covered with water, and can only take up such oxygen as may be dissolved in the latter. The granules of the sulphide of copper can be made the size of peas under favourable conditions, and there is no practical difficulty met with in precipitating gold rapidly and completely by their use. A point in favor of the fused sulphide of copper is the readiness with which it can be obtained, and as it has been proved to answer well, there is no reason why it should be rejected in favour of the precipitated salt."

(*To be continued.*)

* *Mining Journal*, March 11, 1893, page 276.



Mining Machinery at the Worlds Fair—The Exhibit of the Jeffrey Mining Co.

Situated in the North-east Section, ground floor, of the Mines and Mining Building, may be found the extensive exhibit of the Jeffrey Manufacturing Company, of Columbus, Ohio, who are acknowledged to be the authority on machinery for mining and handling coal.

This Company was organized in 1877, and have bent all their efforts towards the best and most economical methods of coal mining. Their space in the Mining Building comprises 1,500 square feet of floor, on which they have placed samples of their mining machinery. Their exhibit might properly be divided into two parts: First, the Mining Department, in which they show the Jeffrey Electric and Air Power Under-cutting Machines, Electric, Air Power and Hand Rotary Coal Drills, Electric Pump, Electric Truck, Dynamo, etc.; while in the other, or second department, they show complete handling device for the elevating, screening and conveying of coal. To better show the position and conditions under which their machines operate, they have erected an imitation of a coal bank showing the formation and strata of an ordinary coal seam. By this ingenious arrangement they have made it possible to show their machines in actual operation. As this Company was the first to build and now has the only successful electric mining machine, their exhibit is of special interest. Seeing the advisability of being able to show operators, and those interested in coal mining machines, at work, they made arrangements with the Exposition authorities, at considerable expense, whereby they might have ample amount of power continuously at their service.

To more clearly describe the coal cutting department of their exhibit, we beg to go over, in detail, some of the machines here shown. On a suitably arranged track extending the full length (60 feet), of their space, is a truck bearing a complete Electric Mining Machine, which mining machine is connected to trolley system of their own construction, by the means of which they are able to move mining machine with perfect ease. This device is shown to demonstrate the simplicity and ease with which the machine may be moved from one room to another in mines, after the machine is through making its cut and is ready to be moved to another room. At one end of track mentioned above, they have a movable Electric Pump on truck, which pump is admirably adapted to the purposes of pumping water in mines from dipping room or entries. To prove the practicability of this pump, the Jeffrey Manufacturing Company has placed a tank of water under floor, and by means of suction and discharge hose can keep a constant stream passing through the pump. Fastened to the roof of their mines they show Electrical Drill in operation, while along the front of their space on racks may be found both positive and air feed coal drills which are operated by compressed air, also several different patterns of hand drills.

To give a better description of the elevating, screening, and conveying devices shown, than can be gotten from the photograph, which accompanies this illustration, we give the following explanation: Located below the floor at one end of their space is a cast iron boot, from which, to the gallery above, extends a single chain elevator with malleable iron ore buckets placed on same about 24 inches apart. This elevator discharges into a revolving screen, which is hung from the gallery, which revolving screen is constructed in a substantial way and is covered by three different meshes of steel wire in order to make the proper separations of the coal. At the opposite end of screen, from elevator, the material is discharged into drag conveyor. From this conveyor the material is delivered into hopper, which, in turn, delivers it on to picking table and from there, by means of screw conveyor, the material is returned to boot. As all these devices are in continuous motion and running in unison, the material which they handle is constantly being passed from one device to another.

Thinking it might be of interest to those interested in this line of coal handling machinery, they have on display a large number of the different sizes and styles of chain belting for all conceivable purposes, such as conveyors, elevators, drive belts, etc.

In charge of this exhibit are men who are practical in their department and able to give information and useful hints to all who may be interested. They have, also, a large collection of blue prints of drawings showing special designs, which are of great interest to operators.

The foregoing description is extremely meagre, as it is impossible, in this limited space, to give any comprehensive description of the workings and construction of the different machines and devices shown, which descriptions are fully given in complete mining catalogue gotten out by this Company, and which will be mailed to all interested parties.

MINING NOTES.

(Continued from page 153)

After running through 300 tons of ore, the owners of the Poorman mill on Eagle Creek, near Nelson, closed it down until next spring. The reason given, lack of water. The 300 tons yielded gold bars valued at over $6,000.

Work has been suspended for a little time, but there is no knowing how soon the pick may be taken in hand again. Mr. Leslie C. Hill, the engineer, has given us a few notes concerning development work; the showing is extraordinary, and looks well for the future of silver lead mining in that country. "A cross cut run from 60 foot level in main shaft cut the vein 14.6 wide, nearly perpendicular. This is well defined but shows little mineral. There seems to be a horse of diorite at this point. North of shaft, vein is exposed for 257 feet by two surface cuts. Vein is about 30 ft. wide, carries carbonates and galena. The galena assays 70 oz. A winze is sunk thirty-six feet in and cut through carbonates and galena, and there is good galena in the bottom; 137 feet south of this shaft a drift is run across the vein. The vein is 63 feet from wall to wall; all carbonates and galena. There are four feet of solid galena in foot wall. The vein in this winze is straightening up, and there is from 6 to 10 inches of soft clay gouge in the foot wall. In the south drift there is about 20 feet of backs. Another drift is started 150 feet further south which will have about 50 feet of backs. This drift has not reached the vein yet but there are boulders of float, and indications show that the vein is not far off. The ore body is proved for 400 feet, with an average width of about 30 feet, and the lowest depth is 36 feet, with good ore on the bottom. Twenty thousand tons of smelting ore can be taken out now.

(From the Miner.)

The news from the Trail Creek country continues to be of a very encouraging nature. All of the principal claims are being worked to a greater or less extent, and generally with good results. On many of the properties preparations are being made to continue work all winter.

Recent development work done on the Cliff claim, the property of Thompson & Wharton, has brought to light one of the largest ore bodies ever uncovered in the camp. The ledge matter runs from twelve to thirteen feet in width, and assays have been secured ranging from $39.50 to $41.62 in gold per ton.

The O. K. claim is making a record for itself of late. A strike was made on this property a few days ago, and out of one pocket six or seven hundred dollars were pounded in a hand mortar in a few days. A crusher which was ordered some time before the new strike, is expected soon, and when it arrives a force of men will be put on and the property opened up in good shape.

Some favorable looking ore is being taken out of the Homestake mine No. 2. The ledge is well defined and in a good formation. The ore body is about four feet in width, and samples have been secured that assay $30 in silver and $28 in gold.

The first carload of ore ever shipped from the Boundary Creek district was sampled at the Tacoma smelter during the past week. There were 385 sacks in the lot, weighing in all 21,000 pounds. At current quotations the ore carried over $160 in silver, and $100 in gold per ton.

Howard C. Walters reports that the Tacoma smelter is still in active operation, but produces only $3,000 worth of bullion daily, as against double that amount when the slump is silver. "It is," said Mr. Walters, "decidedly creditable to the management that the smelter continues in operation at all, and the miners of the north-west would regard its suspension as little less than the crowning adversity of the year. At present the purchases of ore are limited to actual requirements for mixing with the ore on hand, and to the product of districts that were shipping to Tacoma when the other smelters closed down. The regular weekly report from our superintendent in the Boundary Creek district indicates that the Providence and Skylark claims are doing handsomely, and we will continue shipments as long as the smelters can purchase ore. If silver is further depreciated, or is made a fluctuating article like copper or lead, the silver smelters will be compelled to go out of business entirely as they are obliged to buy large stocks of ore six to twelve months in advance of actual use and will not be able to quote prices and terms of payment that will enable sale of ore necessary to the operation of the mines. This fact many people do not understand, and affords one of the greatest reasons why silver can not be ruthlessly pushed aside, for with suspension of the silver smelters and mines will come such a great diminution of the annual gold product that the white metal must speedily be restored to its legitimate place in the coinage of the world.

Another rich strike of free milling ore has been made on Siwash Creek, in the Yale district. The locality adjoins the New Whatcom company's ground. The find is a decomposed quartz assaying as high as $130 per ton.

The Yale Hydraulic Company made a clean-up after a week's run a few days ago. The exact figures were not given but the result was announced as being of a very satisfactory nature.

New Explosives.—According to experiments by Cronquist (Ingeniors-foreningens forhandlingar, through the Oesterreichische Zeitschrift fur Berg-und Huttenwesen, vol. xxxix., p. 542.) the blows required to explode the following explosives, each about 0.4 gramme in weight, were approximately as follows:—

	Foot.		Pounds.
Nitro-glycerine	2.1	to	5.7
Dynamite	3.5	"	12.8
Gun-cotton, dry	5.7	"	
Gun-cotton with 20 per cent. moisture	16.5	"	
Sebastine	4.9	"	
Romite, common	4.3	"	
Romite, naval	13.7	"	
Powder (fired only)	271.2	"	
Bellite	448.4	"	

According to Lindall, on the other hand, plastic dynamite is much more useful than romite or bellite, which are also very much lighter—as much even as 40 per cent. Comparative experiments between plastic dynamite and bellite which were made near Stockholm, showed advantages in favour of the former, though Cronquist states that bellite shows not the least trace of flame on explosion. A mixture of 20 per cent. of dynamite with 80 per cent. of ammonia powder is also stated to be a very safe explosive as regards freedom from flame.

Nordenstrom observes that explosives, such as romite and bellite, which contain hydro-carbon derivatives, have as yet been comparatively little used in metal-mining. Fifty tons of romite was used at Gellivaara, but details are not available. These explosives are of little value for wet holes, and require much stronger caps than those usually employed. On the other hand, their transport is a matter of very little danger.

According to E. Pellissier, (Revista Minera, Metalurgica y de Ingenieria, vol. xlii., pp. 306-308.) comparative trials have been made in the district of Linars, Spain, of an explosive called nitramite and gelatine dynamite. In hand-boring the nitramite, though somewhat less powerful in its action, showed a saving in the expenditure, and this saving became considerable when compressed-air boring was employed. In this case, too, the work performed in the twenty-four hours was greater in the case of the nitramite than when dynamite was used. The tunnel being driven was advanced in the twenty-four hours 33.39 inches when dynamite was used and 34.97 inches when nitramite was employed, the respective costs being 2s. 11d. and 2s. 6d. per shift. The author observes that the action of the nitramite, though less violent than that of the dynamite, is more shattering. He recommends that in using nitramite, the cartridges should be placed well home in the bore-hole and in intimate contact with each other, but not in any way compressed. The detonator must not on any account be allowed to detach itself during the charging of the hole from the central portion of the cartridge, as this has a different composition. If there is water in the bore-hole, extreme care must be taken that none of it penetrates into the cartridge or detonator. This requires peculiar care if the charge is to be fired after filling the bore-hole with water. The chief experiments in Spain with this explosive have been carried out at the Arrayanes mine, under the direction of P. P. de Uhagon. The rock bored through in the experiments to which reference has been made was granite in the case of the handboring, and vein-stuff with some granite intrusions in the case of the machine-drilling

A commision appointed by the Belgian Government has recently experimented with a new explosive. This is stated to be named "Fortis," and to be from 30 to 40 per cent. more powerful than any other explosive known. A comparatively small charge placed in a 13-foot bore-hole in the face of a quarry dislodged a mass 200 feet in height, breaking it up into pieces mostly of from 50 to 60 lbs. in weight, and hurling some of these for a distance of 350 yards. (Iron Age, vol. xlviii., p. 523

O. Muhlhauser, (Chemiker Zeitung, vol. xvi., p. 163), describes an explosive made from hemp and named nitro-hemp, (nitro-jute. It is produced by treating one part of hemp with fifteen parts of nitro-sulphuric acid at a temperature of 15° C. After washing, this material is a brownish-yellow silky-looking wool, having the composition $C_{12}H_{16}O_5ONO_{25}$. It is insoluble in water, ether, benzine, or alcohol, but is soluble in acetic ether and nitro-benzine, or partially in ether-alcohol. In its explosive action it is almost indentical with gun-cotton.

A new explosive named "Nico" has been tried at the Corporation quarries, Clifton Hill, Melbourne. A 4-foot hole in the toe of a solid piece of rock was charged with 1¼ lb. of cartridges and a little loose powder, the hole being too large for the cartridges. A second hole 6 feet deep was similarly charged with 2½ lbs. of powder, and a third with 21 lbs. Each of these shots gave successful results, as also did a number of others. (Australian Mining Standard, vol. vii., p. 201).

Queens University School of Mines.—The following appointments have been made:—

Professor of Chemistry, W. H. Goodwin, D. Sc.; Professor of Mineralogy, Metallurgy and Assaying, W. Nicol, M. A.; lecture on Geology, Petrology and Ore Deposits, W. G. Miller, B.A.; Lecturer on the Economic Geology of Ontario, and the Discovery and Mining of Ores, W. Hamilton Merritt, M.E., F.G.S.; Lecturer on Engineering, R. Carr Harris, C.E.; Demonstrators of Chemistry and Laboratory Instructors, T. H. Walker, M.A, Dr. Isaac Wood, M. A.; assistant to Professor of Engineering and Instructor in Drawing, Surveying, and Levelling, W. Mason. The laboratory equipment of the school is complete.

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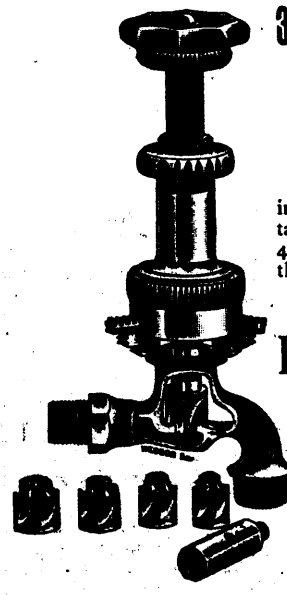

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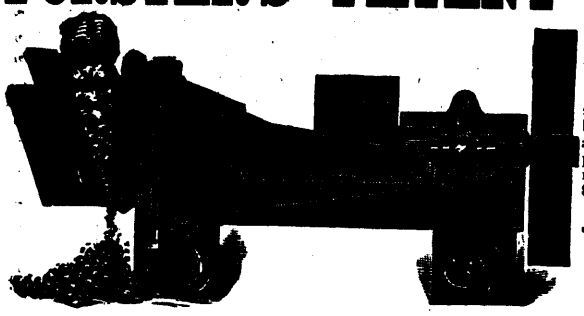

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Licenses are issued to owners of quartz crushing mills who are required to pay Royalty on all the Gold they extract at the rate of two per cent. on smelted Gold valued at $19 an ounce, and on smelted gold valued at $18 an ounce.

Applications for Licenses or Leases are receivable at the office of the Commissioner of Public Works and Mines each week day from 10 a.m. to 4 p.m., except Saturday, when the hours are from 10 to 1. Licenses are issued in the order of application according to priority. If a person discovers Gold in any part of the Province, he may stake out the boundaries of the areas he desires to obtain, and this gives him one week and twenty-four hours for every 15 miles from Halifax in which to make application at the Department for his ground.

MINES OTHER THAN GOLD AND SILVER.

Licenses to search for eighteen months are issued, at a cost of thirty dollars, for minerals other than Gold and Silver, out of which areas can be selected for mining under lease. These leases are for four renewable terms of twenty years each. The cost for the first year is fifty dollars, and an annual rental of thirty dollars secures each lease from liability to forfeiture for non-working.

All rentals are refunded if afterwards the areas are worked and pay royalties. All titles, transfers, etc., of minerals are registered by the Mines Department for a nominal fee, and provision is made for lessees and licensees whereby they can acquire promptly either by arrangement with the owner or by arbitration all land required for their mining works.

The Government as a security for the payment of royalties, makes the royalties first lien on the plant and fixtures of the mine.

The unusually generous conditions under which the Government of Nova Scotia grants its minerals have introduced many outside capitalists, who have always stated that the Mining laws of the Province were the best they had had experience of.

The royalties on the remaining minerals are: Copper, four cents on every unit; Lead, two cents upon every unit; Iron, five cents on every ton; Tin and Precious Stones; five per cent.; Coal, 10 cents on every ton sold.

The Gold district of the Province extends along its entire Atlantic coast, and varies in width from 10 to 40 miles, and embraces an area of over three thousand miles, and is traversed by good roads and accessible at all points by water. Coal is known in the Counties of Cumberland, Colchester, Pictou, and Antigonish, and at numerous points in the Island of Cape Breton. The ores of Iron, Copper, etc., are met at numerous points, and are being rapidly secured by miners and investors.

Copies of the Mining Law and any information can be had on application to

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SOME REMARKABLE RESULTS IN GOLD EXTRACTING.

New York *Sun*, Sept. 12.—"The Crawford Gold extractor, which was recently put into the Richmond Hill at Hillsborough, New Mexico, is giving satisfaction. It has been tested on runs of ores from different mines in the district with uniform good results."

Salt Lake *Times*, Aug. 28.—"Mr. Woodman came in from Deep Creek yesterday, where he has been for a month or six weeks, and he pronounces the Crawford mill a perfect success, saying that since the mill started it has saved 92 per cent. of the assay value of the Gold Hill ores, some of which are very rebellious."

John C. Smith, Supt. of the Ogema Mining and Smelting Co., says: "It gives me great pleasure to add my testimony in favor of the Crawford mill in every way, as to its 'gold saving qualities,' 'practically no loss of mercury,' 'small volume of water required per ton of ore,' great ease of manipulation,' also as to its portability to mines remote from railroads, and 'ease of setting up ready for operation.'"

L. J. Boyd, M.E., Supt. Montagu Mines, after personally supervising a test on arsenical ore says: "The results were simply wonderful. I am personally perfectly satisfied with this system of ore treatment, and should advise its adoption, as the experiments were carried on by my personal superintendence. Similar ore was treated by the Montagu stamp mill showing a difference of 100 per cent. in favor of the Crawford mill."

Fredericksburg, Va., *Free Lance*, Sept. 6.—"L. G. Johnston, of this city, in an interview, said he sent to the M.G.E. Co., N.Y., one ton of very low grade sulphuret ore from the mines of the Powhattan L. & Mining Co., Culpepper Co. He went to New York and personally witnessed the working of the ore. The results of ten different samples of ore, averaging in assay value from $2.13 to $7.35 per ton, showed a saving of 88 per cent. of the value by actual mill run, this without the use of chemicals or fire. These results were so satisfactory that a large sized mill will be placed on the property at once."

W. D. Sutherland, Secretary of the Salisbury Gold Mining Co., of Nova Scotia, after having over 4 tons of ore treated by the Crawford mill, says: "Sample of the tailings taken during the run showed by assay an equivalent to 0.033 oz. to the ton. This evidence of the capability of the Crawford mill to extract all but a trace of the gold which the ore may contain must be considered of importance by all who are interested in the question of improved methods of milling gold from the ore. The test alluded to was made under the supervision of our company through trustworthy agents."

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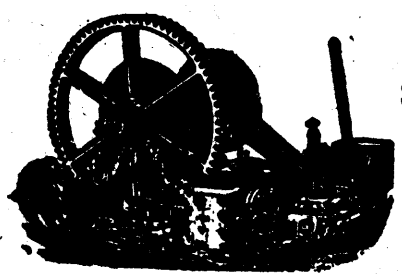

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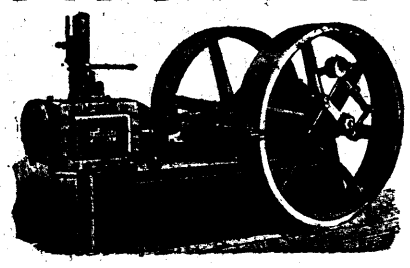

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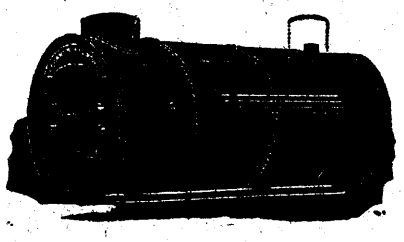

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