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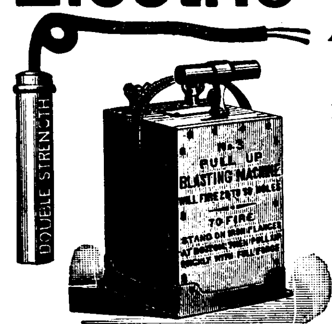

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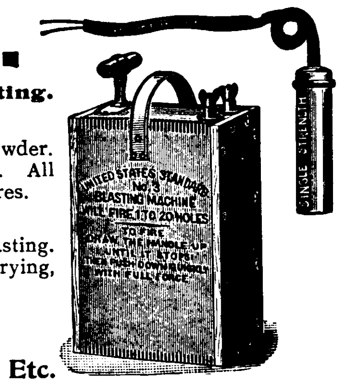

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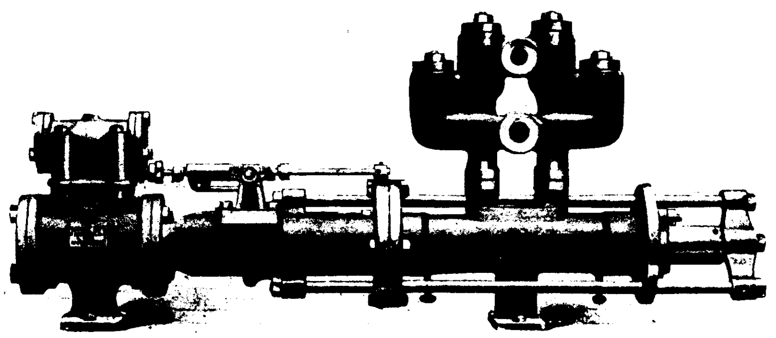

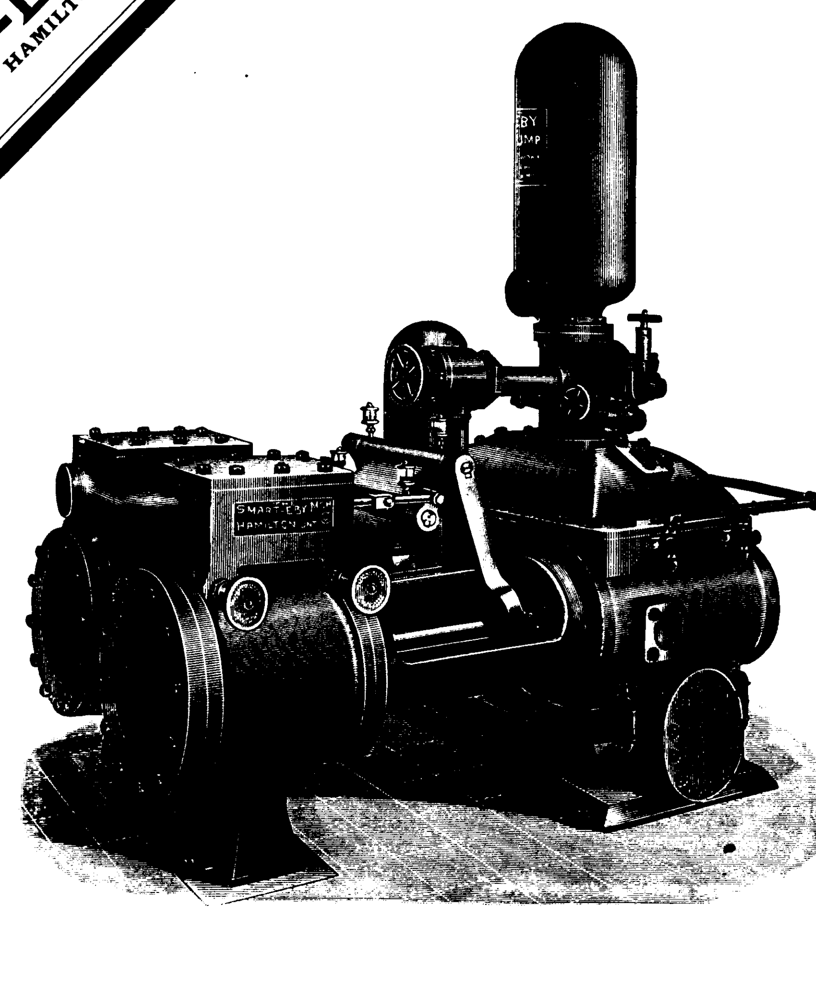

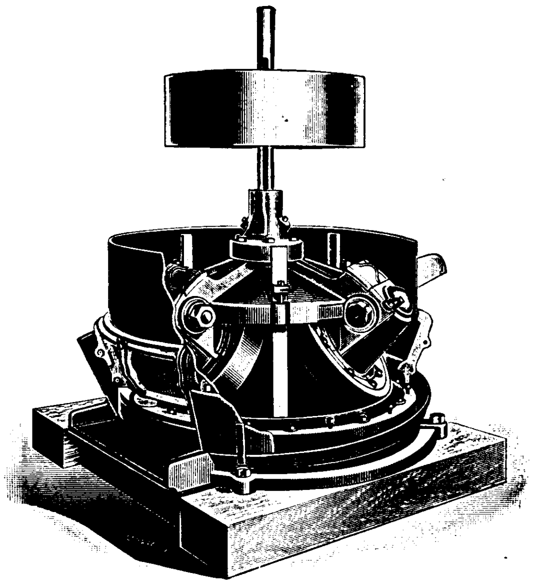

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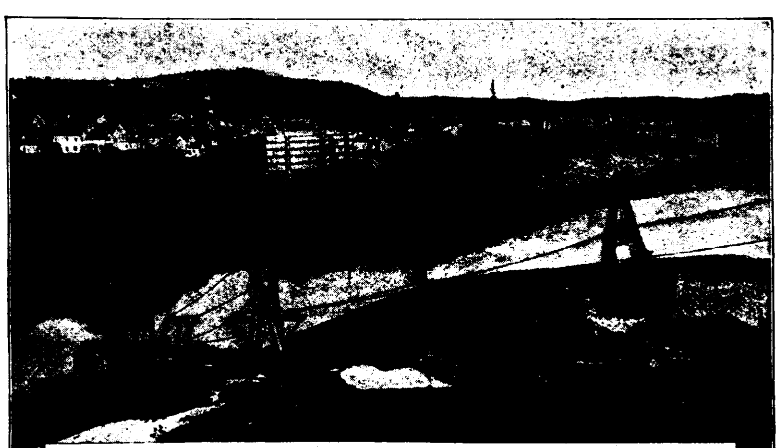

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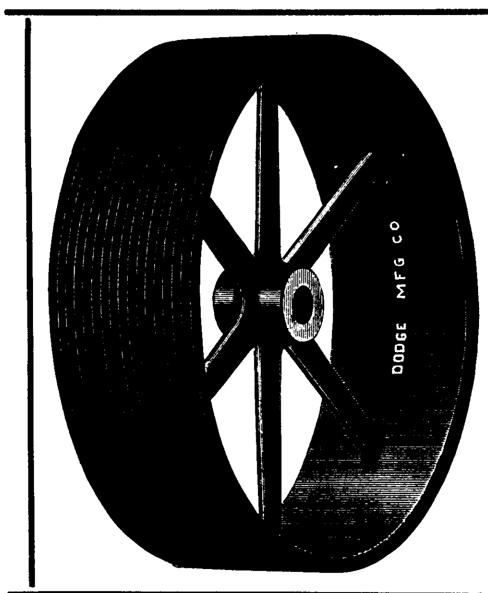

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VOL. XXI., No. 4. | APRIL, 1902. | VOL. XXI., No. 4.

The Future of the Dominion Coal Company.

The sensational advance in this stock from 33, at which it stood a year ago, to the high-water mark of 149 during the present month is probably without precedent in the history of industrials, and the extreme fluctuations which have taken place during that time are only matched by the extreme views taken by those who have tried to explain the cause. That much of the buying has been speculative, and that the public has rushed in and out a dozen times to scalp a few points is notoriously true, but no one acquainted either with the character of the property or with the methods of stock exchange manipulators will for a moment believe that the stock has been carried to the present high price by any such speculation. Other hypotheses have been put forward, any one of which may be true, as for instance that an amalgamation with the Steel Company would be effected on more favorable terms than the 6 per cent. interest originally specified. Or, again, that a still larger financial scheme was on foot through the agency of the Managing Director, which would effect the amalgamation of the two companies on the basis of a stock valuation. The third suggestion can only have been a mere guess, namely, the revival of the rumor of a year ago that a sale of both properties to the United States Steel Company was on the *tapis*.

We are not concerned either to confirm or deny any of these rumors, but for the information of our readers propose to discuss the intrinsic value of the stock on its own merits as a profit earner, our remarks being based upon actual data furnished to us by a competent expert, and our object to prevent a feeling of panic amongst those who may have bought stock at recent prices, should any of the imaginary schemes fail to be realized. Nothing would be more disastrous both to the individual investor and to the industries of the Maritime Provinces than that there should be any serious collapse in the price of Dominion Coal stock, and that this is not necessary, whatever may happen to outside schemes, is well known to those who have a thorough knowledge of the capacity of the concern.

Our conclusions are based upon an estimate as to the future profits of the concern, but we will anticipate the very natural question as to why such profits are expected in view of the fact that the company has been in operation for 9 years without paying any dividend on common stock. This must be explained before one can claim credence for favorable estimates of the future. Briefly then, the past history of this company may be summarized as follows:—

Acquiring in the fall of 1892 all the operating coal mines of the County of Cape Breton, except the Old Sydney Mine, they commenced seriously in 1893 to remodel and equip the mines, which they proposed to operate according to modern ideas. The history of the coal trade in Cape Breton for 30 years preceding this had been that of 6 to 8 months work and 4 to 6 months enforced idleness during the winter, with a very modest profit in favorable years, and no profit at all at other times; and in addition the cost of producing coal was extremely high in consequence of the antiquated methods of machinery employed. This is evidenced by the fact that in the first report issued by the new company they stated that the average cost of coal when the mines were taken over by them was $1.14 a ton; it was, in 1898, reduced to 80 cents. In addition to equipment a larger market was necessary, and especially a winter trade. To secure this Mr. Whitney made a desperate effort to carry free coal in the United States Senate, and it is a matter of history how at the last moment the measure was defeated. This was a source of great disappointment to the promoters, and for the moment seemed almost fatal, since they had expressed the utmost confidence in the passing of the measure, and had spent enormous sums of money in equipping their mines and building railways and piers on the strength of the possibility of the New England market, which consumes 8,000,000 tons of bituminous coal a year, and would undoubtedly have taken from the Dominion Coal Company as much as they could furnish. This then was the first great blow which the company received, disappointing them as to an outlet for a larger tonnage, and rendering useless much of the heavy expenditure which had been incurred. Whilst on this point of expenditure it is only fair to our statement of the case to say that a great mistake was made in placing men without any previous knowledge whatever of mining operations in charge of most of this expenditure. Men, who had distinguished themselves in other professions, such as electrical engineering, civil engineering, and street railway work, were imported to devise and superintend the equipment of coal mines, a policy which undoubtedly cost the company several million dollars, and is represented in Cape Breton to-day by numerous monuments of folly in the shape of heaps of scrap iron, and abandoned machinery and appliances. We do not hesitate to say that if the management had been conducted upon the same intelligent lines which have been adopted during the past year since the concern came under Canadian control, with a capable business man at the head of affairs, a practical mining engineer in full charge of mining operations, and an expert controlling each department, all with a free hand in their own section, the company would have been saved from an enormous expenditure upon useless appliances, and would have developed far greater capacity than has yet been reached. It has long been an open secret that until the advent of the present management there was no executive head; officers in Boston, officers in Montreal and officers in Cape Breton were working at cross purposes, questioning each other's authority, undermining each other's influence, and frittering away one of the finest properties on this continent, until when it was taken over by Mr. Ross and his associates it was practically on the verge of bankruptcy. To illustrate this point we cannot do better than refer to the ridiculous and ill-advised opening of the Emery seam, which was insisted upon two years ago by an official who should have had no influence whatever in the mining department, but whose favorite hobby it had been for at least 7 years to develop this seam. The experts were unanimous in their opinion that the coal could not be profitably worked, and in support of their contention pointed to the fact that nearly $100,000 were spent between 1890 and 1893 in endeavoring to work it near the Reserve mine, and after a thorough proof and a heavy loss it was abandoned. The result of the latter experiment, which has just had so ignominious a conclusion, was the further expenditure of more than $250,000, and the abandonment of the operations after an expensive modern plant had been erected, and every preparation made for doing a large trade. Equally fatuous was the policy of the same official in bringing about the closing of the Victoria mine in 1896; a mine which contained the best quality of coal on the company's areas, and the only quality which would compare with that produced by the Old Sydney mines. True, this coal was costing 20 cents a ton more to mine than the average of the other coals produced by the company, but it easily sold for 25 cents a ton more, and will have to be re-opened if the company wish to compete with the Nova Scotia Steel and Coal Company for domestic trade. A third blunder, worse than either of the foregoing, was committed in 1896, on the advice of an official who had no possible connection with the mining department, in the closing down of the Stirling mine. This mine operated in the Harbour seam, and had been splendidly equipped during the two preceding years at a cost exceeding $200,000; in fact the old plant had been torn out and replaced by the most modern appliances, and a successful system of haulage and coal cutting by machinery established. At the time the mine was closed it was producing coal cheaper than any other mine belonging to the company, all the same it was shut down and dismantled almost before the mortar was dry in the new buildings. The most remarkable feature of the case, however, is that the company continued to operate upon the same seam, an old ill-equipped mine, the International, which has been a source of trouble ever since, has been partially flooded for the last 4 years, and is still working at a much heavier cost than would have been necessary at the Stirling mine. Such gross stupidity can only be explained on the ground of utter ignorance and incompetency, and we have referred to it simply to confirm our statement as to the kind of management which is responsible for the position in which this company found itself in the spring of 1901. Passing from the blunders made in Cape Breton, we come to what has so far proved the most suicidal policy upon which the company has ever embarked. When the measure for wiping out the duty on coal imported into the States was killed, the energetic president began to look around for some other means of establishing a market, and with great energy and skill in the face of tremendous odds succeeded in establishing the New England Gas and Coke Company. It is a secret, but not an open secret in spite of the lucubrations of Mr. Thomas Lawson, what this measure cost, but it must have been something considerable. So far the policy was an enlightened and commendable one, but in the light of recent events it was manifestly the greatest mistake which could have possibly been made, both for the Coal Company and the New England Gas and Coke Company. The former were tied to a contract compelling them to furnish a tonnage of coal which at that time was equal to almost the whole of their output, and which may be stated as a maximum of 1,000,000 tons a year, at a price which left absolutely no margin of profit. There have been numerous contradictions as to what this price actually is, since it is a moveable one, but at the present time it may be stated at $1.50 a ton; it has been as low as $1.05. The only effect of this contract so far has been to deprive the company of the opportunity to sell from 600,000 to 800,000 tons of coal in the open market at prices ranging from $2.50 to $3.50 a ton, and the best authorities have estimated the actual loss, being the difference between cost and selling price, as involving the company in a loss of $250,000 last financial year. The most singular aspect of the matter is that even upon such a low contract the New England Gas and Coke Company have not been able to manufacture their product at a profit, but are at the present moment in liquidation, having lost every cent of the common stock invested in the company, and being dependent upon the good will of the bondholders if the concern is to be reconstructed. In view of these facts it is hard to see at what price the Gas Company could import Dominion coal and manufacture their goods at a profit; it looks as if they would have to beg it. Undoubtedly this was the last straw that broke the camel's back, loaded up the Dominion Coal Company with nearly $2,000,000 of a floating debt, and kept their common stock wavering between 10 and 25. Now all this is changed, we find common stock at 149 with plenty of eager buyers, and everyone connected with the concern jubilant as to the future. How far is this state of mind justifiable? We will endeavor to answer the question, and the first reasonable ground of expectation is based upon the fact that totally inadequate management has been replaced by a well organized and systematic staff, with admittedly one of the strongest and most brilliant of Canadian financiers at the head. Under this new control, in the short space of one year, the capacity of the mines has been increased at least 25 per cent., in spite of the legacy of blunders which they had to shoulder. The directors have for the first time realized the impossibility of doing any considerable trade with the United States so long as their high tariff wall exists, and have boldly gone out over the seas to establish a new market. The result of this enterprise is already known. The coal has been successfully placed in some of the best European markets, and it is now not a question of seeking a market but of producing sufficient coal to supply at remunerative rates. The West Indian and South American markets have not yet been touched, but we are satisfied in the course of a few years it will be demonstrated that there are possibilities in that direction.

We have said nothing hitherto about the great twin enterprise the Dominion Steel Company, because we intend to deal with that in a future article, but it furnishes one of the most important factors in considering the coal company because of the permanent market which it affords for a large tonnage, and it would be unfair not to admit that Mr. Whitney is entitled to the highest praise for his conception and successful launching of this great enterprise; it is the true solution of the difficulty as to a permanent market. Summarizing our conclusions we consider that during the financial year ending February 1903 the profits of the company should be $2,600,000, based upon the sale of

1,000,000 tons to the Steel Company at a profit of 50 cents a ton....................	$ 500,000
1,400,000 tons in the open market at a profit of $1.50 a ton........................	2,100,000
	$2,600,000

This assumes the sale of 600,000 tons to the New England Gas and Coke Company in the event of their continuing to do business,

DR. EUGENE HAANEL, SUPT. OF MINES, OTTAWA

Dr. Haanel will, in every likelihood, be the Director of the new Department of Mines and Geology, at present being organised by the Hon. Clifford Sifton, M. P., Minister of the Interior.

upon which no profit will be made, but it will probably be produced at cost. If, however, the coal should not be shipped to that concern it could be classed with the sales in open market, and would show a further profit of $900,000. These estimates of profit do not include interest upon bonds.

From this it will be seen that the balance of the floating debt which is in the neighborhood of $800,000 could be paid off, and a handsome dividend also paid upon common stock. It also shows that when once the floating debt is got rid of there should be a substantial dividend even upon a consolidated capital account of $20,000,000 which has recently been talked about.

This estimate is based upon the earning power of the coal as an independent going concern. In view of what has been demonstrated during the past year as to the possibilities of coal, we do not believe that the Steel Company, even if disposed, can exercise their option on the basis of 6 per cent. interest. Should it be found necessary to amalgamate upon an interest guarantee, we hold that it should certainly not be less than 10 per cent, and would remind our readers that in the earlier days of the concern there was an issue of perference stock bearing as much as 12½ per cent.

Since the above went to press the following statement has been made public by Mr. James Ross, Managing Director, concerning the amalgamation of both companies:—

"1. The Steel Company agree to pay the fixed charges of the Coal Company, that is, the interest on its 6 per cent. bonds, the dividend on its 8 per cent. preferred stock and the sinking fund of 5c per ton on the entire output to provide for the redemption of the bonds and preferred stock.

"2. A 6 per cent. dividend on the common stock.

"3. An allowance of $25,000.00 a year for the Coal Company's expenses, the latter company having to maintain a staff to look after its property, and for accountancy work, etc, etc.

"4. The Steel Company to pay to the Coal Company $600,000 in cash as a forfeit for the due carrying out of the terms of the lease.

"5. The Steel Company to pay to the Coal Company a royalty of 15c per ton on every ton of coal taken out of the property in excess of 3,500,000 tons in any one year.

"6. The Steel Company to assume and pay all the debts and liabilities of the Coal Company, less the value of certain cash assets, which the Coal Company was to retain. The obligation of the Steel Company in this respect involves an immediate payment of about $2,000,000.00.

"7. The property to be leased did not include all the properties of the Coal Company, certain valuable properties, including shops and the entire mercantile business of the Coal Company, being excepted."

The Directors, in considering what modifications of the terms of the option might be made, so as to make an arrangement that would be entirely satisfactory to both companies, and ensure harmony between them, had to consider the following points:

1st—The Coal Company had earned during the past two or three years $1,530,000 in excess of all its fixed charges, but none of this had been distributed amongst its common stockholders by way of dividend, and it was admitted by all concerned that the stockholders were entitled to this surplus in the event of the option being exercised by the Steel Company.

2nd—The ability of the Steel Company to raise the $600,000 and the other sums required to discharge the debts and obligations of the Coal Company, which, as above mentioned, would amount to about $2,000,000 more.

3rd—The disruption of the business now carried on by the Coal Company, if but part of its properties and assets were taken over, leaving still in the hands of the Coal Company valuable assets, including its mercantile business.

After careful consideration, it was unanimously resolved by both boards that, subject to ratification by the shareholders of each company, an agreement should be entered into embodying the following terms:

(*a*) "The present agreement to be modified so as to make it include all the properties and assets of the Coal Company, including the $1,530,000 surplus earnings above referred to.

(*b*) "The Coal Company to pay off its bonds and preferred stock by the issue of $5,000,000 common stock at 120 to its common shareholders thereby increasing its total capital to $20,000,000.

(*c*) "The Steel Company to be relieved from the obligation to provide the $600,000 forfeit money, and to pay the Coal Company a rental equal to 8 per cent. on its $20,000,000 capital stock."

The New Superintendent of Mines.

At the moment when the Dominion Government has under consideration the reorganization of the Geological and Natural History Survey of Canada and its consolidation with the new Department of Mines and Geology, the portrait of Dr. Haanel, who will, in all likelihood, be the head of this important institution, will, we are sure, be of interest to our readers.

For some time past Dr. Haanel has occupied the position of Superintendent of Mines to the Federal Government at Ottawa, his first work being the designing and equipment of the excellently organized Government Assay Office at Vancouver. This office has a capacity of handling $500,000 per day, and it is equipped and managed so excellently that it is possible to give the value of the dust to the miner within 24 hours of its presentation at the office, and in few cases does the delay extend over 48 hours. As an encouragement to miners to have their gold assayed at this office, the Government has passed a regulation by which miners who personally deliver their gold at the office are refunded one per cent. on the net value of the gold upon which they have paid royalty, so that in the case of such miners the Yukon royalty is reduced to only four per cent. This concession will no doubt act as an incentive to miners to patronize the institution. Up to 1st January last the office treated 465 deposits, representing 57,221 ounces of gold of a value of $939,654.41.

In addition to the work of supervision of the mining territory of the Yukon and North-West Territories controlled by the Federal Government, and the preparation of statistics and other work of his department, Dr. Haanel is busily engaged in designing and laying out plans for the handsome National Museum which will, we hope, before very long, adorn the public buildings of the capital.

Although only a short time with us, Dr. Haanel has created an excellent impression among the mining men with whom he has been brought into contact. He strikes us as a shrewd, broad-minded officer, fully alive to the importance and necessities of our rapidly expanding mining industries. He possesses an excellent technical training for his work, and, we should judge, will make an excellent administrator of the new Department of Mines.

Dr. Eugene Haanel was born in Breslau, the capital of Silesia, Germany, May 24, 1841. His parents were at the time people of wealth, his father being a lawyer of considerable repute, having charge of landed estates in and about the city of Breslau.

The earlier days of his youth were spent in Breslau. He passed his school days there and graduated from the gymnasium in a classical collegiate course in 1858. At the age of 17 an irresistible longing to visit foreign lands led the young man to America and for about a year his adventures as a wanderer through the Southern States were of most romantic kind.

After a year's visit to his parents and his native city he returned to America to live. The War of the Rebellion soon broke out and Dr. Haanel enlisted in the Union Army as an hospital steward. He served in this capacity for three years and was then appointed first lieutenant of the Second Maryland Volunteers, where he served until the end of the war, participating in many of the principal engagements.

Not long after the close of the war Prof. Haanel was elected to the professorship of modern languages in Adrian College, at Adrian, Michigan. He served in this position for one year and then went to Hillsdale College, where he taught the modern languages and philosophy.

In 1867 Professor Haanel was elected professor of natural sciences in Albion College, a Methodist institution, in Albion, Mich. During his work at this institution, which lasted four years, he worked labor-

FOR KING AND EMPIRE.

LIEUTENANT BRUCE CARRUTHERS, KINGSTON, ONT.

A member of The Canadian Mining Institute who greatly distinguished himself last month in action at Hart's River, South Africa.

The following is excerpted from the despatch to the *Standard* describing the gallant stand made by Lieutenant Carruthers and his brave Canadians:—

In the meanwhile, the small band of Canadians and mounted infantry on the other flank found themselves opposed to a force seven times their own number. About 600 Boers advanced upon them, under cover of the belt of trees, and charged down upon the thin line, calling upon them confidently to surrender.

Lieutenant Carruthers, of the Canadians, promptly sprang to his feet, and crying "Back! no surrender!" shot down the foremost man with his revolver, at a distance of 15 paces. The men were not slow in emulating their gallant leader. There was absolutely no cover for them, except the short grass, but lying down in it at full length, they fired steadily and straight, and forced the Boers to bolt back to the screen of trees. The enemy, however, were determined to capture or annihilate the little band. While some of them climbed into the trees, and, from that position of advantage, fired down on to our men, the others extended their line, and quickly brought the defenders under a decimating cross-fire.

But every man of the seventy proved himself a hero. For two hours, until all but 15 of their number had been killed or wounded, they kept the 600 Boers at bay. It was not till then that the enemy ventured to make another rush, and succeeded in capturing the handful of survivors. The Canadians had 21 men out of the 24 killed and wounded, and the mounted infantry lost 30 out of 45. Lieutenant Carruthers was the only officer who was not either slain or seriously hurt. He had several flesh wounds, and his clothes were perforated in many places by bullets, but he stoutly refused to go to hospital. When he was taken prisoner, some of the Boers wanted to shoot him there and then; but they ultimately thought better of it, saying that he was "too brave a man to die in that way."

iously for the department of which he was the head, with the result that it became the largest and one of the finest equipped in the institution. While at Albion he received the degree of Master of Arts from Ohio University.

At the end of his fourth year at Albion, Prof. Haanel's health was so seriously broken down from overwork that he made a second visit to his parents in Breslau. He soon recuperated in his native air and within a year graduated with honor as Doctor of Philosophy from Breslau University. His inaugural dissertation, chosen from only a slightly investigated field and entitled "A Galvanometric Method for the Determination of the Earth's Magnetism and Its Oscillations," gave him at once a high standing among scientific men.

Without loss of time Dr. Haanel returned to America and joined the staff of Victoria University, Cobourg, Ont., where he was for fourteen years the dean of the department of Science and director of Faraday Hall. Many men who were his pupils during these days have since become prominent in Canadian affairs.

Dr. Haanel then went to Syracuse University in 1888, upon the removal of Victoria University to Toronto. He was at the time offered a chair in Toronto University at a much larger salary than he was to receive in Syracuse, but he realized that there were great possibilities in the department of physics in Syracuse University and chose the position there.

When he took charge of the department of physics it was inadequately equipped, but under his supervision and through the generosity of friends of the University, apparatus and equipments have been added so that the department is considered to be superior to that of almost any other institution of the size in the country. Students have been taught the manufacture of apparatus and much of the valuable equipment has been made by their labor.

The regard with which Dr. Haanel was held in Victoria University is illustrated by an incident which occurred soon after his departure from that institution and shows no greater esteem than his students in Syracuse University held for him. The year after his departure from Victoria he returned to Toronto in order to give examinations in some of the science work. Faculty and students met him in a body at the train when he arrived. He was taken to the University in a carriage surrounded by several hundred students acting as an escort.

Reported Nickel Consolidation.

The International Nickel Company, which was organized recently in New Jersey, is the result of the plans to consolidate and control the nickel production of the world, to which reference has been made in our columns heretofore. The plan was originated by Col. Robert M. Thompson, president of the Orford Copper Company, and has been carried through chiefly by his efforts, though he has had recently the aid of Mr. Schwab, of the United States Steel Corporation, and Col. J. R. De La Mar. The purchase of the stock of the Nickel Corporation, Limited, from its London owners was one of the steps toward the present consolidation.

The International Nickel Company will issue $12,000,000 in common stock; $12,000,000 in preferred stock carrying 6 per cent. dividends, non-cumulative, and $10,000,000 in 5 per cent. bonds having 30 years to run. Of the authorized capital stock $9,000,000 common and $9,000,000 preferred will be issued at once to acquire the properties named below. The remaining stock will be reserved for future use.

The officers of the company are announced as follows: President, Ambrose Monnell, formerly assistant to the president of the Carnegie Steel Company; chairman of the board, Col. R. M. Thompson, of the Orford Copper Company; general counsel, Max Pam, of the United States Steel Corporation; treasurer, Stephen H. P. Bell; secretary, Joseph Claudet. The list of directors includes, besides those named above, E. C. Converse, of the United States Steel Corporation; Joseph Wharton, of Philadelphia; Dr. Leslie D. Ward, Archibald W. Maconochie, Col. J. R. De La Mar; Millard Hunsiker, of London.

The properties in which the new company will own a controlling interest—if not the whole—are those of the Canadian Copper Company in Canada and the United States; the Orford Copper Company, with extensive reduction works at Bayonne, N.J.; the Anglo-American Iron Company and the Vermillion Manufacturing Company in Ontario; the American Nickel Works of Joseph Wharton in Camden, N.J.; the Nickel Corporation, Limited, and the Société Miniere Calédonienne in New Caledonia,

The Société Le Nickel, with its extensive properties in New Caledonia and its reduction works in France, is not included in the combination. It is intimated, however, that the International Nickel Company has already a full understanding with the French company. It is believed that a community-of-interest plan has been arranged which will regulate production, prices and a division of the markets.

The nickel companies not in the combine include the Mond Nickel Company, which has good properties in the Sudbury District, Ontario, and refining works in England; the Mond process, however, has not yet proved itself to be as great a success as its projectors expected, and its actual output has not been large. The same may be said of the Lake Superior Power Company, under the direction of Mr. F. H. Clergue, which has properties in the Sudbury District and proposes to refine nickel at the Sault Ste. Marie works. The Nickel-Copper Company of Ontario, which was organized to work mines at Sudbury and to refine the metal by the Frasch process, is doing nothing at present. In Germany the firm of Basse & Selve produces some nickel from Norway and New Caledonia ores and occasionally from Canadian matte, and there are one or two other refineries in Germany. The new International Company and the Société Le Nickel, however, will control by far the greater part of the world's production of nickel. The International Company will also have a considerable output of copper from its Canadian ores. We may add that there are believed to be some valuable nickel areas in the Sudbury District in Ontario which have not yet been taken up and are open to lease or location.

The extended use of nickel in steel making explains the interest in the new company which is evidently taken by the United States Steel Corporation; though there is no official connection between the two companies. Under date of April 14th, the *Cleveland Leader* supplements this information with some particulars concerning the sale of the Canadian Copper Company. It says:—

"Without owning a dollar's worth of the stock, Judge Stevenson Burke of Cleveland remains president of the Canadian Copper Company, which was sold to the syndicate headed by Robert M. Thompson, of New York, over a week ago. The transfers of stock were completed, and the company became the property of Mr. Thompson and his associates week before last.

There has probably never been another instance of such a remarkable confidence in the history of financial transactions. There is probably not another immense company that is left in the hands of a president who has sold every dollar of his interest in it, and it affords one of the most remarkable instances of confidence the business world ever saw. The figure at which the shares of the Cleveland stockholders was bought, $175, shows the value of the company to be over four million dollars, the capitalization having been two and one-half millions.

H. P. McIntosh, secretary treasurer, and general manager of the company, still remains the executive official of the company, although he, like the rest of the larger Cleveland shareholders, has sold his stock. The sale of an immense company like this is usually followed immediately by the election of new directors and officers, who represent the purchasers, but the Thompson syndicate seems satisfied to leave its enormous purchase in the hands of the former owners. No announcements have been made that indicate an immediate election of directors or officers to succeed Judge Burke and the other officers and directors who have sold out their stock in the company, and they continue in control. Nearly all the Clevelanders who had stock in the company have sold out, the price paid for all the stock being about $175, or $75 premium. The stock has never been on the market, and was held altogether as an investment, so that it can only be assumed that the price paid by the Thompson syndicate was a good one, or it would not have been sold.

This syndicate is said to have also bought the great English company that practically controls the nickel business of Great Britain. This leaves the Thompson syndicate and Le Nickel, the great French company, owned by the Rothschilds, in control of the nickel business of the world. The Canadian Copper Company was, despite its name, much less important in the copper business than in the nickel business The ore it took from its Canadian mines bore about equal parts of copper and nickel, but the nickel was of much the greater value. It spent hundreds of thousands of dollars at an experimental works in the Cuyahoga valley in the southeastern part of Cleveland, developing processes for refining the output of its mines, separating the product into pure copper and pure nickel, and the process was just being perfected when the company was sold to the Thompson syndicate."

The Production of Copper in the Boundary District, B.C.

By Dr. Albert R. Ledoux, New York.

While the general public receives its impression of mining as an industry from reports of rich strikes and phenomenal yields, it is probably safe to assert that the industry itself depends upon the low grade mines. As a rule the rich veins are narrow and uncertain, and railroads looking to permanent returns hesitate to build into a region of "one man" fissures or rich pocket deposits, but hesitate less to invest large sums for construction in districts where large ore bodies promise some degree of permanence from their size alone, even if low in assay.

It may be stated in the outset that so far as my observation goes the mines of the Boundary Creek District belong to the latter class. The ores are very low grade, but the ore bodies large, if irregular. Nature has compensated to a great extent for the grade of the copper ore by making it self-fluxing, so that probably nowhere on this continent can smelting be carried on more cheaply, given fair railroad rates and fuel at a reasonable cost.

It is also nothing but simple justice to say that Boundary is today a producing district *because* of the railroads; that it is doubtful if there is a mine within its borders that would pay except at very favorable freight rates and reasonable coke charges. It certainly required considerable courage and considerable faith to build the Columbia and Western Railroad, and no one making the trip from the Columbia River to Phoenix can fail to realise at what expense such excellent railroad facilities were supplied to the various camps. But it is not enough for railroads to build into a district such as this; they must be prepared to handle its product at a minimum cost and to bring in the timber, machinery, supplies, and fuel at the very lowest rates that will pay, if the prosperity of the country is to be established and maintained. There is little or nothing in the way of traffic to be gotten out of the Boundary District, excepting that produced by or relating to the mines.

I ought to say in the outset that my personal observation of the Boundary District has been limited, but from many assays and analyses of its ores; from having handled its entire copper product since it became productive, and from the reports of mining engineers who have carefully examined for me several of the camps other than Phoenix, I feel confident that I know pretty well the characteristics of the Boundary mines and of their ores, and know what may be reasonably expected of some of them, and what has been their record.

Geology.—It is not my purpose to go into the complicated geology of the Boundary District. This has been studied with the usual painstaking accuracy of your Geological Survey, and I understand that the results are soon to be made public.

From such personal observations as I made it is plain that the district is one of great disturbance; that within very small areas almost every variety of later and earlier igneous rock can be found, with the faulting, crushing, folding, and metamorphosis due to these. This is nowhere more apparent than at Phoenix.

I may venture to generalize with the assertion that the ores of Phœnix Camp are almost exclusively altered limestone. On the north side of the ravine which divides the town, the limestone cap is in place, massive and unaltered save by the pressure which has crystallized it, the outcrops of ore being largely at contacts between intrusive eruptive rocks and the body of the limestone. This is notably true of the outcrop at the Brooklyn Mine, where the uplifting of the limestone by the intrusive igneous rock is very marked, and along the vertical crushing zone there has been a second flow of pasty porphory, forming in the most interesting manner a brechia containing sharp, angular pieces of unaltered limestone and of the older porphory. I may say here that in using the term "porphory" I generalise, not having attempted to distinguish the varieties of eruptive rocks, extending vertically or horizontally between the granites and limestones, or filling fissures in the granite itself. These igneous rocks have doubtless received careful classification at the hands of the Survey. In the mines on the north side I am informed that the ore bodies exist in irregular masses of great size in unaltered lime, largely resembling caves which have been refilled with the ore bearing material. The average ore of the best developed mine, showing nearly 500,000 tons in sight, is said to contain 38 per cent. of silica, 16 per cent. of oxide of iron, 15 per cent. of lime, and about 4½ per cent. of sulphur, copper 1.80 per cent, besides gold and silver.

In all of these claims on the north side of the ravine the ore is frequently cut off unexpectedly by vertical dykes or horizontal floors of porphory in a way which would be the despair of those whose duty it is to develop the property, were it not for the great size of the bodies when found On the south side of the gulch of Phoenix I venture to affirm that the mountain was originally divided by a strong dike of fine grained felsite, which crops out boldly in the railroad cut where it crosses the Victoria claim, and is traceable for 4000 feet to the south, crossing the Aetna and disappearing on the War Eagle. This dike has not been cross-fissured by any subsequent geologic action, so far as can be observed by its appearance on the surface and at depths attained at present, or by the result of exploration with the diamond drill which has penetrated it for several hundred feet at various depths and in different directions from the westerly side. It seems to me probable that on both sides of this main dike, which forms a sort of wall, and for a thousand feet or more to the east and to the west, the limestones originally overlying the granite, shattered by innumerable disturbances and cross-fissured by secondary intrusions, have been mineralized and entirely altered by the solutions following up the main igneous dike and spreading, until nowhere that I could observe was the limestone left unaltered, so practically all of the original limestone that was not eroded has been mineralized to greater or less extent. There is everywhere a notable quantity of calcite, a secondary re-deposit of the lime.

To the east of the dike which divided the Phoenix Hill the same general characteristics are noted which I have outlined above, being observed on the Gold Drop and Snow Shoe Claims, and on the Monarch, except that on the Knob Hill, Ironsides, and other westerly claims there is a large, altered, oxidized zone, in which the copper is carried by magnetic iron oxide, while on the easterly side the iron cap is not so extensive.

The Ore.—I have already stated that the ore of the mines on the north side of the gulch of Phoenix is said to contain on an average 38 per cent. of silica, 16 per cent. of oxide of iron, 15 per cent. of lime and 4½ per cent. of sulphur, there being little change between the surface and lower ores so far as the chief constituents are concerned.

This is about the composition of the lower ore from the south side, although many other conditions are distinctly different. The upper ores are largely oxidized and, as stated, consist of massive magnetic iron ore carrying copper sulphide and gold; this surface ore changing at an average depth of perhaps 25 feet to ore more nearly resembling that of the Brooklyn, the iron being largely combined with sulphur, or sesquioxide, rather than in the higher oxidized form. By mixing these surface ores with those from lower levels an ideal mixture is obtained, enabling the furnaces to produce directly a 45 to 50 per cent. copper matte, carrying practically all of the gold and silver which the ore contains.

I have said something about the characteristics of these ore deposits at or near Phoenix, but nothing concerning the quantity of ore which may be depended upon. Of course "available" ore depends on cost of treatment and price of its valuable constituents. With adequate railroad freights and fair charges for coke it is probable that there are reasonably in sight in the Phoenix Camp today several million tons of ore, which with copper at 12½c per pound could be treated successfully. In Deadwood Camp the ore deposits are also enormous, averaging over 130 feet wide, and so situated that surface working can be prosecuted by quarry, a single drill dislodging a train-load of ore in a day. But the problem of mining the lower levels of all these mines without excessive cost of timber or the permanent abandonment of one-half or one-third of the ore, necessarily left in pillars, must be causing serious thought. The tonnage that can be extracted from the mother lode is also up in the high figures, and cheap smelting a welcome fact.

There have been numerous published guesses as to the grade of these Boundary Creek Ores, and this after all is the vital point from which all the others depend. On the north side of the Phoenix ravine the large amount of ore developed is estimated to run about 1.80 per cent. copper, $2.40 per ton in gold, and 25c per ton in silver. The workable ores from the south side of the Phoenix ravine contain on an average copper 1.70 per cent, gold $1.60 and silver 33 cents per ton. The ore from the easterly side of the main dike, dividing the Phoenix Camp, as represented by the Snow Shoe, Gold Drop, etc., probably runs by the carload as shipped about 1.60 per cent of copper, $1.50 in gold and 30 cents in silver. The run of the mines in the Greenwood Camp, as shown by the smelter returns, is probably 1.60 per cent. of copper, $1.80 in gold, and 50 cents in silver.

I may say that I have had unusual opportunities for ascertaining what are the facts. In arriving at these figures I have not been obliged to depend on statements of managers. The entire product of the Granby Consolidated Mining, Smelting and Power Company and of the British Columbia Copper Company passed through the hands of my firm, Ledoux and Company, and from the freight records it is readily ascertainable from how many tons of ore came the matte and blister copper which we have handled. The statements given me of ore mined tally with those of the railroad company representing ore delivered to the smelters, and the statements of the superintendent as to the grade of this ore tally closely with those figured from the copper matte handled by us in New York, checked again by my personal investigations on the spot.

I was accorded every facility in several cases both for ascertaining the ore in sight and the relative assays of the product from different claims. The Granby Company, especially, has kept complete records of all shipments from each claim, not only because this was a proper business policy, but because prior to the recent consolidation of the various interests now included in the Granby Company the Knob Hill, Ironsides, Victoria, and other claims were owned by separate corporations, so that it was necessary to render separate statements of the ore shipped from each claim. It may, therefore, be taken as a safe estimate that the very large amount of ore available in the Boundary District will vary from 25 pounds to 35 pounds of copper per ton of 2000 lbs., with from 25c to 40c of silver per ton, and from $1.50 to $2.50 per ton in gold. It may be stated that there are some mines, like the "B.C." near Eholt, whose ores as shipped contain considerably more copper than the above, but the figures I have given are well within the limits for the average.

Costs.—Next to the quantity and grade of ore, the all-important question is how cheaply can the values from these Boundary ores be extracted and marketed.

I may say that one of the objects of my last visit was to enable me to assure prospective buyers of the product of the smelters that they could safely depend upon the tonnage contracted for, and need not fear a sudden stoppage from lack of ore. There had been various rumors prevalent in New York, such as that only the surface ores were being mined: that these surface ores were richer than those lower down: that when depth was attained costs of mining would prohibit shipments: that the costs of mining were necessarily excessive considering the grade, because the ore was sorted by hand: that only surface ores were self-fluxing, etc., etc.

It is easy to disprove the statement that only surface ores have been treated, because the records at the smelters show from what portion of the working, as well as from what particular claims, shipments were made. For instance, take the Knob Hill Mine as an example. During the year 1901 there were mined:

From the surface	6	per cent.
" " 200 ft. level	57	"
" " 250 ft "	19	"
" " 300 ft. "	18	"
	100	"

Taking the Ironsides and Knob Hill together for the years 1900 and 1901, the figures show that 74 per cent. was from below ground and 26 per cent. from surface ore, varying with the time of year. In the summer time a great deal more ore was taken from surface workings than from beneath; in the winter time surface mining was largely interrupted. The cost of mining these large ore-bodies in the Boundary has varied from $1.66 per ton to $2.10 per ton, the first mentioned figure being the more recent. It is a difficult problem, as I have already hinted, and the one uncertain element in the prosperity of this district, how to handle the very large ore-bodies without the risk of caving and ruining the mine, on the one hand, or the necessary employment of excessive amounts of timbering, or leaving in the mine large blocks of pay ore as a support. The management of the companies have been studying the problem and the Granby Company have commenced ore-handling with steam shovels, and propose to still further decrease the cost of mining by stripping from the surface down to the present level of the railroad track, and by the introduction of the caving system for lower workings.

Smelting Costs.—It has been seen that cost of mining in the district, even with high wages to miners, is very low, the conditions being most favorable. I come now to the all-important statement of these smelting costs.

The Boundary ore being self-fluxing, indeed rather basic in character, allows the admixture of a certain quantity of silicious ores from the Republic Camp or other districts whose ores carry gold and silver, and the sulphur being low permits of smelting without preliminary roasting. With the advent of railways from the south the Boundary smelters can procure more dry silicious ores at profitable rates. It may also be stated at this point that the freedom of the ores from bismuth, arsenic and antimony renders it easy to obtain a ready market for the copper product.

In considering the cost of smelting it is also necessary to take into account the losses in slag and otherwise. I was allowed to sample the slag dumps and to take portions of weekly slag samples which had been preserved in the laboratory. Before the establishment of bessemerizing the slag loss of the Boundary smelters averaged copper 0.4[illegible] per cent, gold 12 cents per ton, and silver 3 cents per ton. With a consumption of about 11 per cent. of coke, and with freight charges as they exist today the cost of smelting at the most favorable location in the Boundary District, after charging against the smelter the costs of marketing the product, must be considerably under $2.00 per ton. Adding the present cost of mining, the total outlay for mining and smelting must be less than $3.66 per ton.

With the introduction of caving and steam shovels at mines, and of bessemerizing at smelters; with further reductions in cost of freight and fuel, sure to come with or without the advent of competing railways, I unhesitatingly affirm that the copper ores of Boundary should be mined, smelted and their contents marketed with profit with copper at 12 cents in New York, and as railway extensions make other ores available that can be purchased cheaply, the profit should increase. But there must always be, as elsewhere, many shipping mines too small to justify their own individual smelters, and mutual co operation and a broad business policy should allow them all to prosper.

Coal Mining in the North-West Territories and Its Probable Future.

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

This vast tract of land with which I will try to deal is too extensive to treat with in detail, but as far as possible I will give a general outline of the coal mining and its value.

The Territories were at one time known as the Indian Territories, but have now been formed into an organized district with a Legislative Assembly. The North-West Territories, however, is the only settled organized district in the Dominion with a Legislative Assembly that has not been granted autonomy.

The area of the three districts which is governed by this Assembly is about 304,340 square miles and comprises the districts of Alberta, Assiniboia, and Saskatchewan. Each of these districts has about an equal area, and are divided from each other by imaginary lines of longitude and latitude.

On the south we have our American cousins, separated from us by the 49th parallel; in the west we can shake hands with our British Columbia neighbors over the summit of the Rocky Mountains until the 54th parallel is reached, then from that point northwards we are divided from them by the 120th meridian of west longitude. On the north we have only a few Indian friends who cross and recross about the 55th parallel at their own sweet will. In the east our Manitoba friends are anxious to extend their boundaries from about the 102nd meridian of west longitude to a point as far west as they can reach, so as to secure a part of the valuable asset in the lignite coal fields of south-eastern Assiniboia.

He would truly be an imaginative writer who could picture the scenery over the 1,000 miles he would require to travel from the eastern to the western boundaries of the Territories. From the immense tract of level prairie, with its waving fields of yellow grain, to the rolling, grassy plains of the foothills, studded with cattle, until the traveller would strike the seemingly impenetrable mural escarpments of palæozoic rocks; and again, should he make a journey from the International boundary northwards, these former scenes would be repeated with many diversities, leaving the rich ranching plains of southern Alberta, crossing stream and lake until he reaches the valuable timber belts of the northern country, with its well stocked limits of wild game.

Geological.—The very important consideration, however, for settlers on these vast plains is the question of fuel, and thanks to a bountiful nature there is an unlimited supply of this necessary article within easy reach of every one, as I think it might be truthfully said that there is no point on this immense area that is more than sixty miles from a coal-bearing belt, either developed or lying dormant.

In the eastern portion of the Territories, as far as the eye can reach, there is not a tree or shrub to be seen, except it may be a few small scrub cottonwood on the banks of a river. The fuel supply here, then, is obtained from the lignite beds of the Laramie series. The seams vary in thickness from 2 to 8 feet, although at some points they have been found to attain a thickness of 18 feet. The coal underlies the level prairie at a depth of not much over 100 feet and the coal seam is usually overlain by soft, soapy sandstones and clays. The exposures along the Souris River are well defined, and the coal easily obtained by an adit level driven in from the river bank at a height of about 30 feet above the water This lignite coal has a great tendency to disintegrate where exposed to the atmosphere on account of the large percentage of hygroscopic and combined moisture. An analysis from an average sample of this section is as follows:—

Moisture	16.92	per cent.
Volatile combustible matter	38.58	"
Fixed carbon	40.72	"
Ash	3.78	"
Total	100.00	"

This coal, however, will stand transportation in box cars and for some time withstand the action of the weather without being hermetically sealed as has often been sarcastically stated. The coal is lamellar in structure, but when freshly broken sometimes shows a conchoidal fracture and much resembles some cannel coals. Journeying further west we come to the coal of the Medicine Hat district, which is also a true lignite, but is an intermediate coal between the Souris lignites and the lignitic coals of the Bow and Belly River near Lethbridge. The coal of this district is very similar to the Souris coal in structure, although containing from 4 to 6 per cent. less moisture, but still has the tendency to split into angular fragments when exposed to the atmosphere. The next important point we arrive at is the Lethbridge coal field, the coals of which are termed lignitic and are much superior in quality to those lying farther east. The coal area in this district forms a low-lying synclinal between Lethbridge and the foothills, but even here we seem to trace in the workings of the Lethbridge Colliery, by faulting, the extreme limit of the waves caused by the tremendous upheaval of the Rocky Mountains The coal, as has been already mentioned, is superior in quality to that farther east, and the closer we approach the foothills this becomes more marked, the coal containing less moisture and more bituminous in character. Whether this alteration has been produced by superincumbent pressure or metamorphism caused by the upheaval of the Rockies is a matter rather difficult of determination. A comparison of four different analyses of coal will admirably show this transition:

	Souris.	Lethbridge.	Blairmore.	Anthracite.
Moisture	16.92	12.08	2.07	0.71
Volatile	38.58	26.87	22.84	10.58
Fixed carbon	40.72	54.93	68.35	82.14
Ash	3.78	6.12	6.74	6.57
	100.00	100.00	100.00	100.00

Approaching the foothills of the Rockies, the coal assuming a more bituminous character has in many cases proved to be of good coking quality, although not equal to that of the Crow's Nest Coal Co. on Elk River, will still make a formidable rival in the smelting market.

The coal seams in the foothills are more numerous than on the plains and occupy a lower horizon in the Cretaceous series, no doubt being of the same contemporaneous age as the Cretaceous coal beds of Vancouver and Queen Charlotte Islands.

The Palæozoic rocks of the mountain ranges, with a general trend from S.E. to N.W., protrude through the Cretaceous strata, and form many detached troughs of coal beds hidden away in the valleys, the coal seams repeating themselves along lines of folding and varying in pitch from 10° to vertical.

Physical Geography.—To gain any idea of the physical features of this western country at the time of deposition of all these coal beds would require more data than we at present have, but some crude scene might be pictured of the general features. With the climate intensely tropical it seems probable that there was a vast swamp at least from the 55th parallel in the north and extending far south into the States and from the western borders of Manitoba to Vancouver Island in the west. This swamp being surrounded by high Silurian and Carboniferous mountains with numerous islands of the same geological age dotted all over it.

The area of these older rocks must have been considerable when we begin to examine the general thickness of the Cretaceous deposits as exposed in the mountains, forming at least a thickness of 3,000 feet, composed chiefly of conglomerates, sandstones, shales and coal. The earth's movements at the time of the Cretaceous era was no doubt extensive, but the general upheavals and subsidence of this part of the continent, from all indications, was more of a wavy movement than the sudden movements which subsequently happened to this area. The sandstones as a whole must have been deposited in shallow waters, and movements frequent, as seldom can one find anything but false bedding exposed. The great movement which subsequently took place, throwing up the great white limestone mountains, has defaced the previous physical configuration and with denudation, actions of the last glacial epoch and other forces of nature have left to us still, however, an immense monument of wealth.

Coal Mines in Operation.—The coal mines in operation over this vast territory are numerous, but few of them as yet have amounted to much more than a prospect or that of supplying the local consumption.

The principal mines are those of the Alberta Railway and Coal Co., at Lethbridge; the H. W. McNeill Co., at Canmore and Anthracite; the Souris Coal Mining Co., at Coalfields, Assa., and the Canadian-American Coal and Coke Co., at Frank, Blairmore District. Outside of these there are over thirty small mines working at Estevan, Medicine Hat, Edmonton, Knee Hill, and Sheep Creek all supplying the local trade.

The Alberta Railway and Coal Co. are now hoisting coal from only one shaft, with screening, loading, and general pit-head arrangements of the most modern type.

The room and pillar method is here adopted for working, being more suitable for flat seams of this kind and more economical. The system, however, has been improved on here on account of the cover and the character of the roof and pavement. Two parallel entries are driven north and south with cross cuts between them every 60 feet for ventilation; from these entries rooms are driven off every 65 feet, with a narrow neck of 15 feet from the main entries then opened out to room width, which is from 20 to 22 feet. When these rooms have been driven a distance of 150 feet they are cut off by another single entry running parallel to the main entry. This constitutes what is termed the four entry system. From this 3rd or 4th parallel entry as the case may be, rooms are driven off at right angles with a narrow neck a distance of about 34 feet apart and continued room width for a distance of 250 feet, which is the limit unless special emergencies arise. These rooms driven 250 feet in the solid, are connected about every 90 feet by cross-cuts and, when the limit has been reached, long wall retreating begins and is carried on till it reaches the 3rd or 4th entry, and part of the pillar is also taken from the lower side of these entries. This 3rd or 4th entry is cut off by a slant from the main entries about every 800 feet, so that all rails may be drawn from the long-wall retreating, and a pillar of at least 130 feet left each side of the main entries, which has been found ample to prevent squeezing until the section is completed and the pillars all drawn from that locality.

The seam is about 5 feet 6 inches thick, and is separated in the middle by a small band of clay varying in thickness from 2 to 6 inches. At this colliery, however, hand mining is practically a thing of the past, as both rooms and entries are cut by the Ingersoll-Sergeant punching machine. This cutting work is carried on double-shifted and the blasting and loading completed by the loader on the day shift, who is not necessarily a thoroughly practical miner, but at this work unskilled labor can earn from $2.50 to $3.00 per day.

The mine development is carried on very systematically and their system of endless rope haulage is equal to any on the continent, the auxiliary horse haulage seldom exceeding 1,000 feet. Their banner hoisting day has been reached this year, a tonnage of no less than 1577 tons being hoisted from one shaft in ten hours.

The ventilation is produced by a Capell fan, which is capable of producing 100,000 cubic feet of air per minute. This company also owns the narrow-gauge railway from Lethbridge to Great Falls, U.S., with a branch line running west tapping the finest ranching and grain country in the Territories, now that it is being watered from the irrigation canal supplied by the waters of the St. Mary's river.

The mine at Canmore, operated by the H. W. McNeill Co., is another steady coal producer, supplying all the steam coal used on the line of the Canadian Pacific Railway between Calgary and Revelstoke. Their system of working is the pillar and stall, which within the past two years has been modified by working across the pitch instead of up the pitch as formerly followed. This modification has been fully discussed in a former paper before the Institute by Mr. O. E. S. Whiteside, and to add anything to it would be presumptuous on my part, but this I must say, that I consider it will certainly reduce the number of accidents, and a less liability to accumulation of gas; also the amount of coal recoverable will be greatly to the advantage of the operators.

The number of seams being worked in this field are four, varying in thickness from 3 to 6 feet. The seams as a whole are clean, shipped direct into the cars and used on the locomotive as run of mine coal. The area of this field is curtailed by the close proximity of the limestone range, and from this cause also considerable faulting and folding is encountered which tends to make economical working a matter of great anxiety to the management.

Ventilation is here produced by two fans capable of producing about 80,000 cubic feet of air per minute, but each having separate districts to ventilate and acting entirely independent of one another.

The H. W. McNeill Co. also operate the mine at Anthracite, which produces about 100 tons per day. The coal here produced is equal in value to the Pennsylvania Anthracite, although just an advanced stage of the Canmore bituminous coal altered by metamorphism. The system of working is similar to that at Canmore, and ample ventilation is supplied by a force fan. The field here is considerably more disturbed as it approaches the west, but a new concession has been obtained in the eastern portion of the field which will ensure a steady output and a supply of this quality of coal in the market for many years to come.

The Souris Coal Mining Co., Ltd., operate four mines in south-eastern Assiniboia and have a shipping capacity of 500 tons per day. The mining is mostly accomplished by punching machines of the Harrison type. The seam is about 8 feet thick of clean coal, and burns to a very fine woody ash. Ventilation at present is produced by a furnace, but it is contemplated in the near future to install a fan.

Consolidation of all the small interests has taken place in this district lately, and will tend to give an impetus to mining in this locality which is impossible where so many small concerns are operating without railway facilities.

The Canadian-American Coal and Coke Co. operate one mine at Frank, which has been opened by two adit levels, and the whole development, for a producer of 500 tons per day, completed in one year. The seam has a thickness of 12 feet and stands nearly vertical with a footwall of hard sandstone and a hanging wall of metamorphosed shale. The system of working is a combination of pillar and stall and long-wall, rooms or long-wall being worked for a distance of 90 feet, and then with a pillar of 40 feet left with a manway in the centre and cross-cuts from them to the rooms. Most of the coal at present is left in, but will no doubt be nearly all recoverable when the pillars are being drawn. Ventilation is produced by a 4-ft. Murphy fan, forcing into the workings and producing 20,000 cubic feet of air per minute. Six bee-hive ovens for coke testing have been built at the mine, and the coal has been proved to produce a strong coherent coke.

The mines in the other districts mentioned are carried on in a systematic manner, and all of them as far as consistent complying with the Coal Mines Ordinance.

Mining Laws.—About ten years ago mining regulations were drawn up by the Legislative Assembly and an inspector appointed to see them carried out, but on account of the great increase in coal mining in the Territories within the past few years, a new Ordinance was passed in 1898 by the Assembly which practically covers all the requirements carried out in other Provinces of the Dominion. A few alterations of course will be made from year to year, and one point which I consider should be carried out by all Provinces regulating coal or metal mines, and that is in the matter of enforcing a supply of all ambulance requisites being kept at the works. With regard to this ambulance work, great progress has been made in recent years by reason of the facilities for training which can now be obtained under the auspices of the various ambulance associations throughout the Old Country. If it was made compulsory that these ambulance requisites had to be kept at the works here, then we would soon have the medical men of this country also take up courses of lectures on the subject, and after a full course the students subjected to a thorough examination to test their fitness for undertaking the preliminary treatment of an injured person until a properly qualified practitioner arrives to take charge of the case. To those successfully passing this examination on ambulance work or first aid to the injured, a certificate of merit or proficiency might be awarded. The appliances required at every colliery or public work includes stretchers, boxes containing splints, bandages, tourniquets, needles, thread, antiseptics, oil paper, sticking plaster and other odds and ends. These requisites should always be kept in a place easy of access, and in the case of a colliery in the weigh-house on the pit-bank.

This matter, if taken up by the management, which is most desirable, would save many a laboring man hours of suffering and earn for the employers eternal gratitude from their employees.

Probable Future.—It might reasonably be asked why the development of this vast field of wealth has been so long delayed, but the answer does not require much enquiry for when a glance at the map is taken. Want of railway facilities to reach a foreign market, the sparseness of population and no industries to make a home market The coal mining of the past in the North-West Territories has been one long struggle for the companies operating to keep their head above water, but the dawn is now approaching and the cloud begins to show its silver lining.

Since the building of the Crow's Nest Pass Railway a magnificent stretch of country has been opened out, and the prospecting which has been carried on in that Pass for the last year has shown to the country a wealth of coal which is daily directing capital towards it.

The long-reaching arm of the Canadian Northern Railway will pass through the northern end of this coal belt, and as the country is settled closer to the foothills numerous additions will be made to our knowledge of this inexhaustible coal field. The coal of the foothills has been proved to be of good coking quality, and the past year marks an era in the history of the North-West which for generations to come will stand out pre-eminently as the golden year of the Territories.

To attempt to estimate the quantity of available coal in the Territories would be to attempt the impossible, but from what we know of the natural exposures and what has been proved, will ensure for us centuries of consumption and a surplus for exportation which will make of the North-West a Province second only as a coal producer to the State of Pennsylvania.

In the districts of Souris, Medicine Hat, Lethbridge, Red Deer, Edmonton, &c., the estimated quantity of coal per square mile is from 5 to 12 million tons and practically inexhaustible as a domestic fuel. When this point is conceded, it possesses no additional meaning when we attempt to estimate the quantity of coal buried in the foothills except for steaming and coking purposes it will be an immense source of wealth to the country. There are many points in the foothills coal area which will bear an immense amount of labor in prospecting and boring. The data thus gained will be of immeasurable value to the country, both scientifically and commercially. Part of this work, especially boring near the foothills, might receive Government aid.

In conclusion, I am sorry to say that the information here given is not as complete or probably as accurate as it might be, but I trust what I have said will be some matter for reflection for a few minds, and probably may be the means of directing additional capital to the development and settlement of this vast area.

Compressed Air.

By W. L. Saunders, New York.

In introducing the subject of compressed air before the members of this Institute, I feel that I am addressing those who are not only interested in the subject, but through the discussion which will follow I hope to gain a good deal of practical information. To me compressed air has been a close study and a pleasant pastime for more than twenty years, and yet every time I attempt to climb up on a pedestal and pose as an expert, I see all around me things that I did not know. Though one of the oldest of the sciences, there is really less known about compressed air than about steam, hydraulics or electricity, and however deeply we may dig into the theories of thermodynamics, we find every now and then a practical mining engineer who shows us by a little experience that the formula which has been guiding us is nothing but a cobweb without substance or strength.

I remember very well my first researches on the subject of compression. After learning what was meant by isothermal compression, it appeared very plain that a serious loss was suffered to take place in the cylinder of an air compressor by attempting to compress without injecting a spray of cold water into the cylinder during the process. All theories and most authorities taught me to advocate the "wet" type of compressor as distinguished from the "dry," and yet it is a fact that at the present time I do not know a single builder who follows the wet process. It must not be inferred, however, that the importance of cooling during compression was over estimated. We have learned to cool by compressing in stages and have abandoned water injection because of its complications of apparatus, the inevitable destruction of wearing parts, and because it is not advisable to bring air and water together while the air is at a high temperature. The reason for this is that the capacity of air to take up moisture is in direct proportion to its temperature, and even with the most efficient system of spray injection it is difficult to start the compressed air on its journey to the mine at a temperature low enough to produce dryness. During the building of the Washington Aqueduct Tunnel a central air compressing plant was located at the foot of a hill. The transmission pipe leading up the hill to the shafts would at times become practically filled with water which would be taken up and sent forward like a piston into the workings. It is interesting here to note that this difficulty was overcome by pumping fresh cold water into the air receivers at the foot of the hill, thus condensing the moisture of compression. Dry stage compression actually gives as a pressure line more nearly the isothermal than was obtained by the injection process. In stage compression there are two or more air cylinders each surrounded by water jackets. Intercoolers are placed between the cylinders, and in this way the air is alternately compressed and cooled until it is discharged into the receiver. By this process the air is maintained in a dry condition, and as it at no time reaches a diabatic, or the heat maximum of temperature, it is not "burned," but is delivered into the mine in a fresh and healthy condition. Too little importance is sometimes given by engineers to the intercooler. The The common or cheap form of intercooler only partially serves the purpose, but the intercooler which is composed of nests of tubes around which the air circulates, splits up the air into thin layers and as cold water passes through the tube these thin layers are rapidly reduced in temperature; so that with cold water, which I judge is not difficult to obtain in Canada, it is quite possible to obtain air temperatures in the intercoolers considerably lower than was the temperature of the air before it entered the compressor. This is an important point as affecting both the actual and the volumetric efficiencies of the air compressor. The theoretically perfect compressor is one which draws in air at a temperature of zero or lower and discharges it compressed at normal or outside temperatures. We must always bear in mind that during compression the temperature of the air at any stage depends upon its initial temperature, and that the higher the initial temperature is the higher will be the temperature throughout the process of compression. This is not a theoretical but a practical question, which concerns those who are engaged in the every day practice of air compression. Engine rooms are usually warm and dirty places from which to draw a supply of air for the compressor Hot air means thin air, and thin air drawn into a compressor means a low volumetric efficiency. The mine owner who pays for an air compressor of a certain size naturally wants to get out of it all the compressed air he can. He should therefore see that the compressor draws air from outside the engine room and from the coldest spot on the property. He should also see that his compressor is provided with a thorough system of cooling, because no matter how cold the air may be, when it goes into the compressor it is sure to warm up by the action of the piston. This warming up process causes the air to expand and to resist the act of compression in degree directly in proportion to the increased temperature—that is, the hotter it is, the harder it is to compress the air and the more power is consumed for a given volume To express this in figures, we find that when air is compressed in a single stage machine from atmospheric pressure and 60° Fahrenheit temperature to 80 pounds gauge pressure, the maximum theoretical loss due to increased resistance through heat is about 33 per cent., when represented in foot pounds of work. As a matter of fact no such loss is ever suffered, because maximum temperatures are never reached even in single stage compressors, cool metallic parts brought in contact with the air absorb some of this heat, so that we may safely say that a well designed water jacketed single stage compressor suffers a loss of 20 per cent. in foot pounds of work when compared with isothermal or perfect compression, and under the conditions of temperature and pressure stated above. We may therefore say that in compressing air to 80 pounds pressure without compounding, it is possible to lose one-third in power though we usually lose one fifth. To illustrate with these figures the importance of compounding, I would state that under the conditions stated a two-stage compound compressor, when properly designed, would suffer a loss of a fraction over 15 per cent., and in a four-stage machine we are able to get this down to near 5 per cent. As some of you may be using air at 100 pounds pressure, you may be interested to know the figures under these conditions. The maximum loss in a one-stage compressor is 38 per cent.: this in a two-stage machine may be brought down to a fraction over 17 per cent., and in four-stages to 8 per cent. Even at 1,000 pounds pressure the heat loss in a four-stage compressor is brought down to 17 per cent. All representing foot-pound of work.

The subject of cooling is not complete without a brief statement about after-cooling. It is easier to get our ideas about intercooling carried out than it is to get any hearing when we talk about after-cooling. Assuming that you agree with me that air should be cooled before it enters a compressor and that this process of cooling should go on *during* compression, I would also like you to agree that even after we have bottled up the air in the receiver something might be gained by inflicting it with a further and final cold bath. This is really the last time that the cooling process should be applied, and from this time on we are to turn square about, reverse our treatment, and begin to warm up. An after-cooler between the compressor and the receiver, or just outside the receiver in the main line, is a good thing because it will serve as a condenser to abstract moisture from the air by bringing its temperature below the dew point. Air at all times contains moisture, the average moisture being about 50 per cent. of what is required to produce saturation, and it is safe to say that during our cooling process in the compressor we are not likely to abstract any of this moisture The only mechanical way as distinguished from the chemical process by which we may get moisture out of air is to lower its temperature. But we must lower it below its initial temperature to produce any results. Notwithstanding the best systems of jacketing, compounding and inter-cooling, the compressed air is usually discharged into the receiver at a temperature about double the initial temperature, and as this air cools on its journey to the mine, it is likely to condense moisture on the interior walls of the pipe In cold weather this freezes and accumulates, sometimes restricting and even stopping the passage of the air. In other cases it condenses its moisture in the ports and passages of the drills and pumps. These troubles can be reduced to a minimum and even overcome entirely by a thorough system of after-cooling, which means nothing more than reducing temperature and abstracting moisture just outside of the engine room.

Before leaving the subject of compression, I would say a word about oil. Air cylinders do not require oil either in quality or quantity like steam cylinders. What is good for the one is bad for the other. A steam cylinder needs an oil of low flashing point, and plenty of it, because the tendency of the wet steam is to wash the oil out of the cylinder. Not so with air, there is no washing tendency and very little oil will last for a long time. This oil should be of the best quality obtainable and of a high flashing point. It should not be a coking oil, that is when evaporated on a piece of hot metal it should not leave a carbon deposit. This is a subject which has been very much neglected, and this neglect is responsible for much waste of money, and worse than this, for explosions which destroy property and threaten lives. The actual amount of oil that should be used in an air cylinder is one-quarter that which should be used in a steam cylinder of the same size. I would call this a maximum, for very much less will often suffice, especially where the oil is of the best quality. Too much oil where there is a coking tendency results in choking the valves and ports. A discharge valve might stick through coking, and when stuck it will admit some of the hot compressed air into the cylinder against the receding piston which on the return stroke is compressed and carried to a temperature beyond the flashing point. Sometimes when discharge valves give trouble, they are cleaned by injecting kerosene; this is a fatal error. Kerosene should never be used in the air cylinder, but instead of this, fill the oil-cup with soap-suds made preferably of soft soap, and feed this into the cylinder; let the compressor work with soap-suds instead of oil for a day each week and no harm is done, care being taken to feed with oil a half hour before stopping, so that the parts may not be subject to rust, which is the only danger from soap-suds.

Compressed air has always been and still is supreme in mining. As a means of transmission and for surface work it must in many cases give place to electricity and hydraulics, but as an underground power its supremacy is admitted. No power is so safe, none so free from objections in mining work. It aids ventilation and cools the heading. If the conduit pipe is large enough, you will suffer no loss by friction and may convey compressed air several miles from the generating station. In recent years compressed air economics in production, transmission and use have opened up a large field in directions other than mining. All of our large railway systems are now provided with pneumatic appliances in the shops and many of them use the system for switching. Machine work of all kinds, such as drilling, chipping, riveting, moulding and hoisting is done by compressed air. The air lift pump, for lifting water, salt water and oil from wells occupies a field of much usefulness. The compressed air locomotive has an established place in and about mines, nine of them being in constant operation in the Anaconda Copper Mines in Montana, and several are now at work for the Cambria Steel Company in Pennsylvania. The use of compressed air in bridge and tunnel work has made possible many of these large undertakings. The Blackwell tunnel under the Thames, in England, is one of the most recent evidences of the utility of compressed air for such work. The stupendous scheme, which has been inaugurated by the Pennsylvania

Railroad, to bring its terminal into the heart of New York City, is made possible only by the use of compressed air.

In conclusion, it may be interesting to call your attention to a column of "Donts," which I found in an engineering paper published in far off New Zealand, and from which we may all, I think, carry home some useful lessons.

"Don't install a compressor just about equal in capacity to your present requirements, for when once you have compressed air available its number of uses becomes legion. Good practice is to provide a compressor at least 50 per cent. greater in capacity than your immediate necessities demand. Duplex compressors are made divisible, permitting the installation and operation of one-half at first and the other half later when the additional capacity is needed.

"Don't accept the theoretical capacity of an air compressor stated in the list of the maker, as the equivalent of the actual volume of air needed for your service. Remembering the difference between theory and practice, allow a small deduction for friction, heat, clearance, etc., being unavoidable losses in air compression, before calculating what your actual delivery in compressed air will be.

"Don't buy an air compressor because it is cheap. It will prove the most expensive proposition of its size that you have ever encountered. If a water pump fails in its work, you will know it at once; if a steam engine is deficient, its shortcomings are self-evident, but if an air compressor is poorly designed or badly constructed, it may continue in the evil of its ways until the scrap-heap claims it for its own, unless, as is more than likely, an absolute breakdown calls attention to its deficiencies, and you learn all too late that the hole it has made in your coal pile, added to the loss of keeping it in repair, would have paid a handsome interest on the additional first cost of a properly designed and properly constructed compressor.

Don't buy a second-hand compressor unless you know it has given satisfaction in work similar to your own, and that its working parts retain their full measure of usefulness without deterioration. An air compressor with valves, pistons, etc., worn out or in bad repair, can waste more good power than anything of its size known.

Don't buy a compressor that your neighbor used for operating oil burners because you intend putting in pneumatic tools. For, even if all compressors look alike to you, experience teaches that oil burners operate under 12 pounds pressure, whilst pneumatic tools require 100 pounds, and the oil burner compressor, with unevenly proportioned cylinders, devoid of water jackets, will equal your service as well as a low pressure boiler for heating will run a high speed engine.

Don't use air brake pumps or direct acting compressors. Statistics show that their steam consumption is about five times that of a crank and fly wheel compressor for the same volume and pressure of air delivered.

Don't install a steam driven compressor if your steam supply is short and plenty of belt power available.

Don't put in a belt driven compressor if you have plenty of steam and are short of belt power.

Don't draw your intake air to the compressor from a hot engine-room, or from any point where dust is abundant. The volume of air delivered by the compressor increases proportionately as the temperature of the intake air is lowered, and dust or grit entering the compressor clogs the valves, cuts the cylinders and generally impairs the efficiency.

Don't use any old thing for an air receiver. Compressed air under 100 pounds pressure will leak a horse-power through a 1-16 in. diameter hole in five minutes, and a well made, strong, and tight air receiver is the second essentially important factor if you would realize to the utmost all the advantages which compressed air provides.

Don't connect your air admission and discharge pipes improperly at the receiver. To secure the best results and eliminate moisture from the compressed air, connect your pipe leading from the compressor at the top of the receiver and lead your air pipe to points of consumption from the bottom of the receiver.

Don't have leaky air pipes. Test your piping when it is installed, and at regular intervals thereafter, allowing the full pressure to remain an adequate length of time, and if the gauge indicates leakage locate and remedy it.

Don't install your piping without properly providing for drainage of condensed moisture at regular intervals in the system. The simplest method is to slightly incline the branches leading from the main line and insert drain cocks just before the hose connection is reached."

On the Use of Wood Gas in the Manufacture of Iron and Steel.

By Dr. James Douglas, New York.

Since suggesting in my paper, which appeared in the *Transactions* of 1899, the utilization of the waste wood of Canadian Lumber Mills for the reduction of iron ores and the making of high grade steel, I have been experimenting on the gasification of wood for gas engine purposes. The object I had in view was to make a fixed gas immediately in the generator, and avoid the complication and waste which result from gathering the volatile products of combustion in any form of condenser. We have obtained this object by using the Loomis-Pettibone Generator and apparatus, but modifying their method of working. The essential feature of the Loomis process is that the air and steam are drawn by an exhauster downward, and therefore the volatile products given off on the surface of the charge, in passing through the incandescent lower layer of fuel, are converted into fixed gases. When the apparatus is used for making water-gas from coal, the operation, as described in the pamphlet of the Loomis-Pettibone Co., is as follows:

"In starting fires in the generators, a layer of coke or coal, about five feet in depth, is put in, and ignited at the top, the exhauster creating a downward draught. When this body of fuel is ignited, coal is frequently charged, raising the fuel-bed to about eight feet above the grates, and there maintained. Bituminous coal is generally used, and is charged at intervals as needed through the feed-door in the top of the generator.

"Air is also admitted through the same doors, and, by means of the exhauster, is drawn down through the fresh charge of coal, and then through the hot fuel-bed beneath. The resultant producer, or generator-gas, is drawn down through the grates and ash-pits of generators 1 and 2, values A and B, up through the vertical boiler 3, valve C, to scrubber and exhauster, valve D being closed, and is delivered into a small gas-holder for supply to the furnaces. When the exhauster has brought the fuel up to incandescence, the charging-doors E and F are closed, valve B lowered, valve C closed, and valve D, leading to the water-gas holder, opened. Steam is then turned on into the ash-pit of generator 2, and, in passing through the incandescent coal, is decomposed, forming water-gas. From generator 2 the gasses pas through the connecting pipe shown near the top of the generators, and down through machine No. 1. The gas passes through valve A into and up through the boiler 3, and thence, after being washed in a scrubber, is conducted into a holder. Water-gas is made for five minutes, when the temperature of the fuel-beds having been considerably reduced, the steam is shut off, valve D closed, valves B and C opened, and the charging-doors E and F opened.

"This process of making water and producer gas is alternated at intervals of about five minutes.

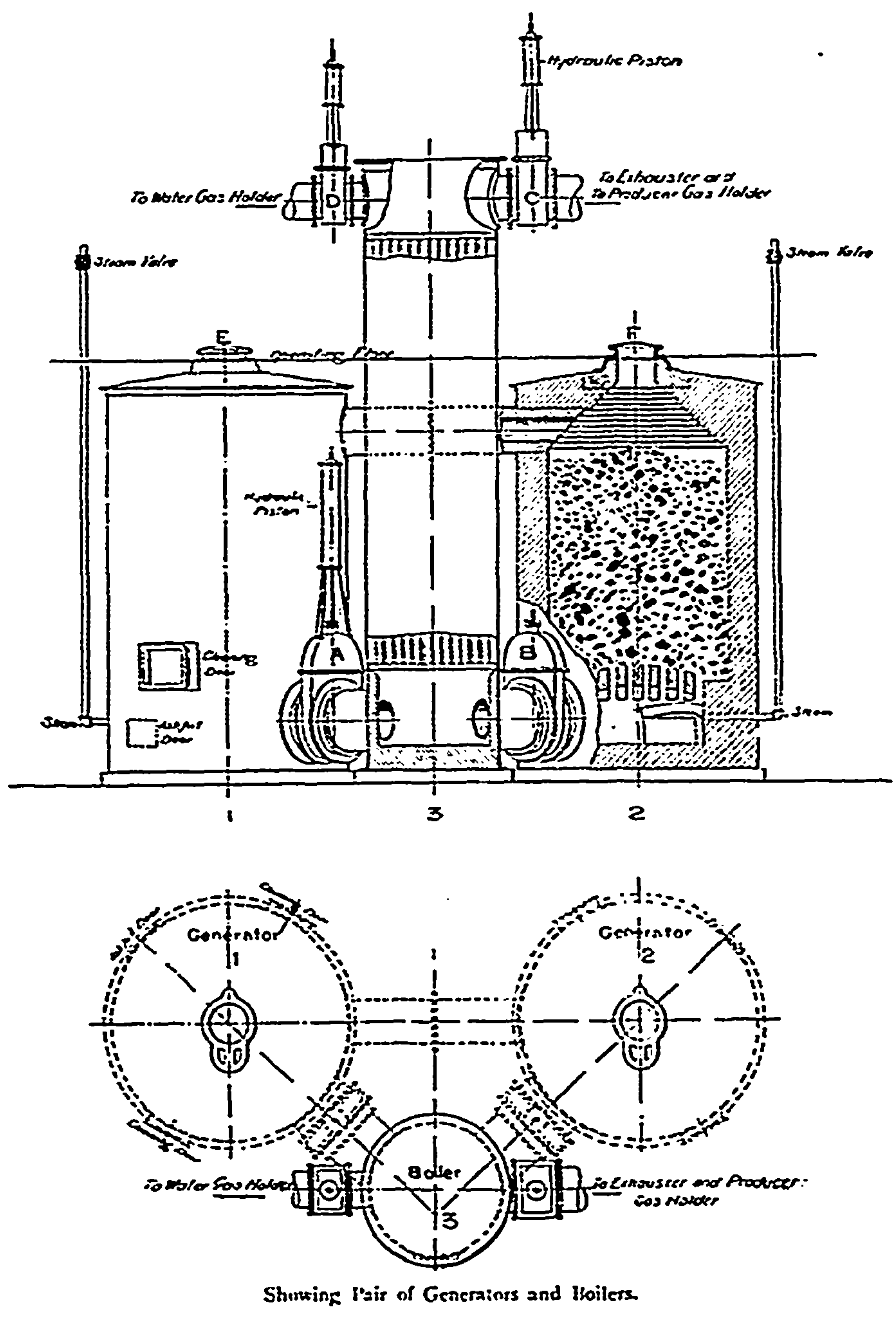
"In making the next run of water-gas, the course of the steam is reversed, *i.e.*, valve A is closed, and the steam is turned into the ash-pit of generater No. 1. Valve B is left open, but the other valves, C and D, and the Charging doors, E and F, are operated the same as in the first case.

"While the fires are being blasted, and during the making of a run of water-gas, the hot gases in passing through the boiler give up a large proportion of their sensible heat, which is converted into steam. This in turn is directed under the fires in the generators for decomposition. Another advantage of the double-generator apparatus is that, as all gas is made to pass through the fire, the tarry matter from the coal is converted into fixed gases that can be conducted any distance through ordinary pipe, and at any temperature or pressure. Again, as the steam is forced through two fires, the percentage of condensable water-vapour is exceedingly small."

The process above described is modified at the Nacozari works with a view of making a uniform gas of calorific power, higher than producer-gas and lower than water-gas out of wood. This is effected by introducing very little steam with the air, and drawing the steam and air almost continuously downward through the incandescent fuel. Every half-hour or so the heat of the burning fuel becomes excessive, the feed port is closed, and steam alone in a larger volume is drawn through the layer of fuel. In two or three minutes the temperature is sufficiently reduced to permit of the door being reopened, and of the mixed air and steam being supplied to the charge The effect of thus drawing the gas, whether water-gas or producer-gas, through a layer of incandescent fuel, is to decompose the tar and all volatile products of combustion so perfectly that little more than a trace escapes to the scrubber, and none reaches the gas-engines, which are situated 400 feet from the gas-holders.

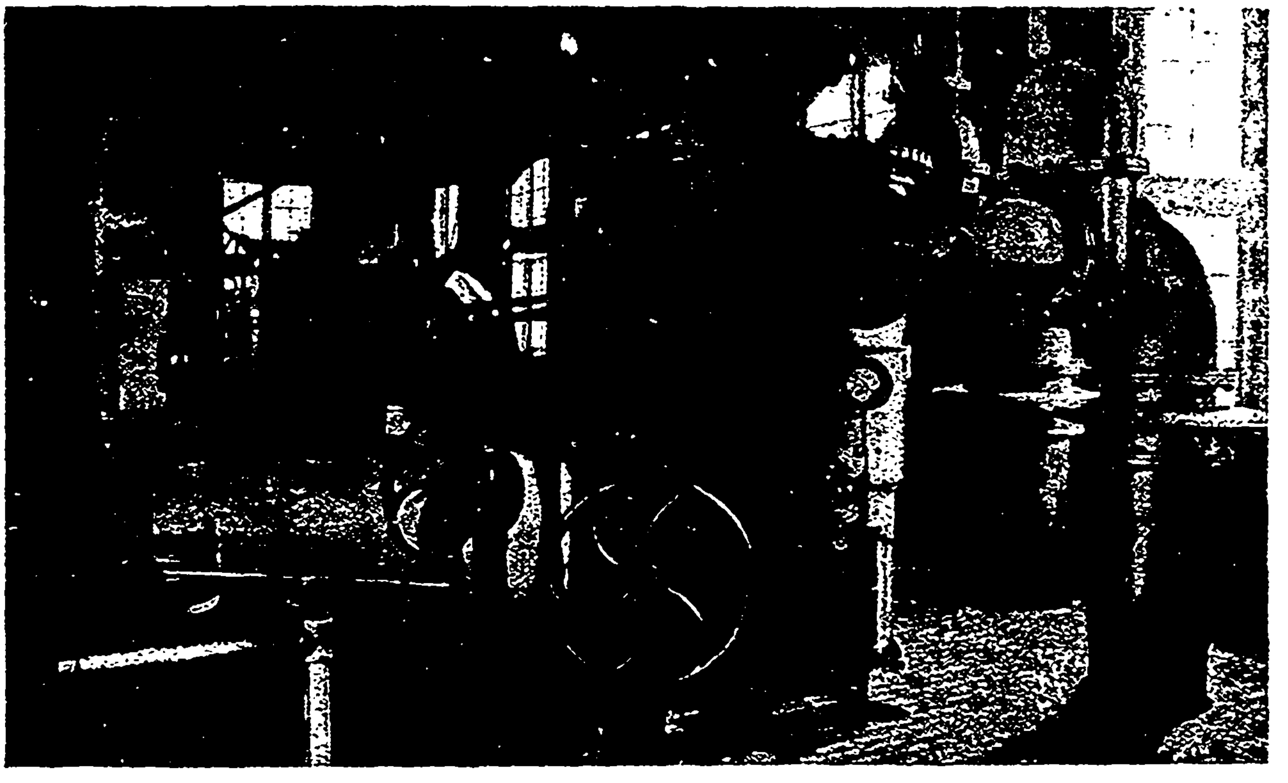
When using wood, a layer of incandescent fuel, coke or charcoal, must be ignited on the grate bars of the generator before the feeding of wood billets commences. The Nacozari generators, having been designed for coal-fuel, are only 6 feet 9 inches internal diameter, and it is found desirable to cut the green wood into lengths of 18 inches, which are fed in the same way as coal through the open port. The feeder, who can see perfectly the surface of the charge, is careful to prevent the formation of cavities, whether the fuel be wood or coal. When using wood, a stack of billets cut into smaller lengths is at hand on the feed-floor for the purpose of correcting irregularities in the surface of the charge. When using wet wood the mixed water and producer-gas is made without the injection of any steam, as the water in the freshly cut wood supplies the necessary steam.

PLATE I.



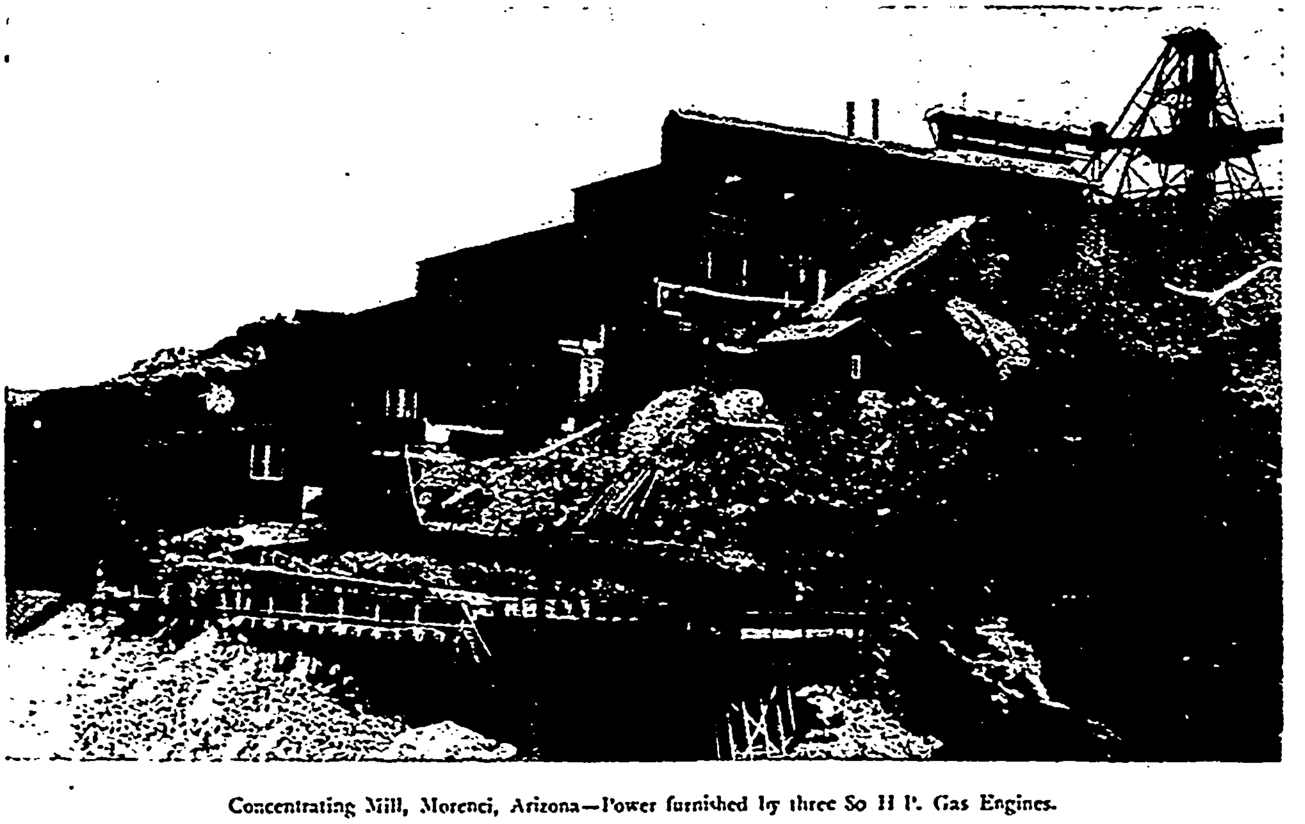
Showing Pair of Generators and Boilers.

PLATE II.



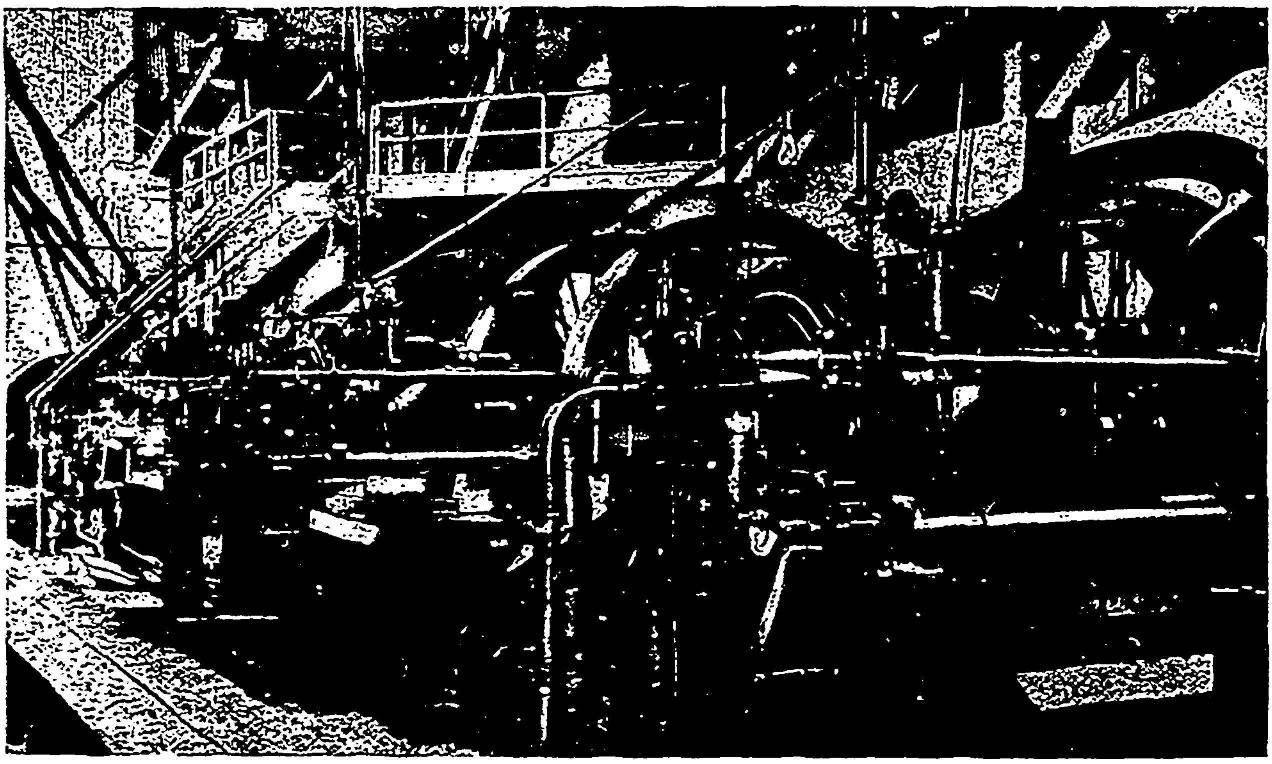
Operating Floor—Winchester Repeating Arms Co.

PLATE III.



Concentrating Mill, Morenci, Arizona—Power furnished by three 80 H P. Gas Engines.

PLATE IV.



The Concentrating Mill is operated by three 80 H.P. Gas Engines, placed in the center of the mill, belted to clutch pulley on countershaft. Two engines are required to drive the mill, one for each side. The third engine is for reserve, thus insuring continuous operation.

PLATE V.

Detroit Copper Mining Company, Morenci, Arizona.—The Gas plant is located between the Smelting and Concentrating Plant, with gas piped three-quarters of a mile from Smelter and one-quarter of a mile to Concentrating Mill. The Main Power Plant at Smelter consists of two 150 H.P. gas engines, each operating a 120 K.W. alternating Electrical Generator running in parallel. Induction motors are used in this department. The Concentrating Mill is operated by three 80 H.P. Gas Engines. There are a number of small gas engines of different makes about the works.

The composition of the mixed gases and their variations from day to day, when made from coal, may be judged of from the following series of analyses taken on consecutive days from the record, two or three minutes being taken to draw off the samples and to make the simultaneous calorimeter readings :—

Gas made from Mixed Anthracite and Soft Coal, Nacozari Gas Plant.

Date			C O	H	CH_4	Cn H_{2n}	CO_2	O	N	B. T. U. at 62° F. and Sea Level
2-27	Mixed Gas	Anthracite	20.80	11.47	2.78	0.10	8.80	0 10	55.95	132.66
3-7	"	"	19.90	13.84	2.30	0.20	8.40	0.00	55.36	134.18
3-12	"	"	20.90	10.40	2.31	0.20	7.30	0.50	58.39	126.4
3-12	"	"	24.40	9.90	1.10	0.10	5.10	0.40	59.00	122.4
3-2	"	Soft Coal	20.30	14.43	2.28	0.20	8.20	0.00	54.59	137.13
3-3	"	"	22.20	11.58	1.74	0.20	7.40	0.20	56.68	128.70
3-4	"	"	18.40	12.42	2.11	0.20	7.80	0.00	59.17	122.82
3-5	"	"	21.60	12.99	2.78	0.20	6.50	0.00	55.93	141.70
3-6	"	"	19.50	13.21	3.01	0.20	7.70	0.00	56.38	136.37

Composition of Wood Gas made by Nacozari Gas Plant, from Eight Consecutive Analyses, is as follows :—

Date			H	C O	CH_4	Cn H_{2n}	CO_2	O	N	B. T. U. at 62° F. and Sea Level
3-14	Mixed Gas	6.05 p.m.	13.50	11.70	2.30	0.60	16.20	0.00	55.20	113.2
3-14	"	9.35 p.m	18.91	11.00	3.10	0.30	17.90	0.00	48.79	131.5
3-15	"	10.25 a.m.	20.61	14.80	1.67	0.30	14.70	0.00	47.92	134.8
3-15	Water Gas	....	51.38	10.30	2.38	0.80	20.20	0.00	14.94	233.97
3-15	Mixed Gas	4.40 p.m.	22.31	11.80	3.10	0.40	17.20	0.20	45.19	146.55
3-16	"	11.35 a.m	22.35	14.00	2.45	0.20	15.20	0.00	45.80	144.00
3-16	"	3.40 p.m.	22.35	12.50	3.06	0.30	16.40	0.10	45.29	146.9
3-19	"	12.15 a.m.	19.28	15.50	2.31	0.20	14.40	0.40	47.91	137.59
Average of Mixed Gas Analyses			19.90 19.28	13.04 15.5	2.57 2.3	0.33 0.20	16.00 14.40	0.10 0.40	48.00 47.91	136.36 137.6

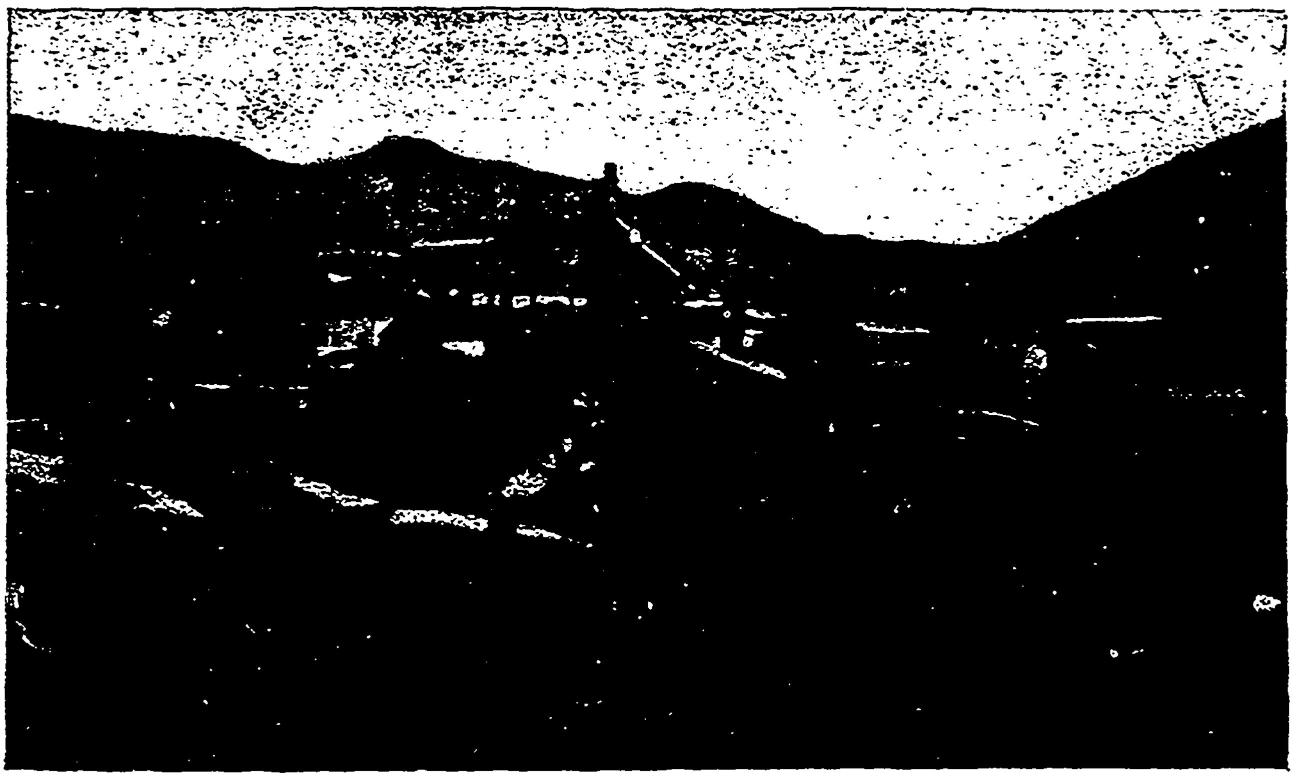
Calorimetric Tests on Wood-Gas from Nacozari Gas Plant.

Date		B. T. U. Actual	B. T. U. at 62° F. and Sea Level	Date		B. T. U. Actual	B. T. U. at 62° F. and Sea Level
3-30	Mixed Gas..	108.8	125.8	4-16	Mixed Gas..	120.8	139.9
4-8	" ..	105.2	122.5	4-16	" ..	118.7	138.1
4-8	" ..	112.34	128.77	4-17	" ..	113.4	129.6
4-8	" ..	110.84	128.14	4-17	" ..	112.0	128.9
4-8	" ..	115.72	134.93	4-17	" ..	112.0	129.5
4-9	" ..	112.4	131.7	4-18	" ..	110.7	128.4
4-9	" ..	111.9	128.1	4-24	" ..	116.5	135.7
4-9	" ..	109.4	126.9	4-30	" ..	115.4	134.2
4-9	" ..	112.2	130.61	4-30	" ..	119.9	140.6
4-10	" ..	113.2	129.1	4-30	" ..	123.9	146.5
4-10	" ..	113.7	130.1	5-8	" ..	104.8	122.4
4-10	" ..	122.9	141.6	5-8	" ..	114.7	136.4
4-11	" ..	108.58	126 86	5-8	" ..	118.3	140.7
4 15	" ..	109.7	128.1	5-9	" ..	115.8	134.8
4-16	" ..	111.8	128 85	5-9	" ..	118.8	139.2

The efficiency of the mixed gases, whether made from wood or coal is substantially the same in the gas-engines. The engines are direct belted to generators, which give continuously, with wood or coal-gas, 48 kilowatts per generator, equal to 70 B.H.P. per engine. The capacity of the engines is reduced, due to the works being at an elevation of 3,500 feet above the level of the sea. A gas as high in hydrogen as the wood-gas would give much trouble from back-firing in the engine. No inconvenience, however, is experienced on that score, which is probably due to the retarding influence of the high percentage of carbonic acid.

I have no doubt whatever that this apparatus and process would be admirably applicable to the conversion of the coarser waste from saw mills; but in using sawdust the grate bars would, as in the Swedish sawdust producer, have to be dispensed with, and in their place probably a deep layer of coke supplied. The combustion of this coke would

PLATE VI.



General view of Concentrating and Smelting Plant of the Moctezuma Copper Co., Nacozari, Sonora, Mexico.
All the power is furnished by Loomis Gas Plant with Gas Engines and Electrical Distribution.

be slow, and therefore it would need to be replaced only every three or four days, when the accumulation of wood ash would necessitate cleaning out one generator and lighting another. It would probably be most advantageous to use a mixture of sawdust and the coarser waste.

The wood used at Nacozari is a green scrub oak, which, however, remains stacked in the yard for six weeks or two months before being burnt. The very green wood does not give a gas of as high calorific composition as wood thus partially dried: and therefore the probability is that sawmill waste would have to be stacked for a time before being gasified. Whether, therefore, the gas be used for steam generation at the mill, or for heating in metallurgical furnaces, or as a source of heat for other purposes, it would seem that the practicability thus afforded of turning the large quantity of waste, which is annually disposed of at considerable loss, into fixed gas, capable of being used at a distance from the mills, should excite some interest among our lumbermen. At Nacozari the quantity of wood-ash, as made, is large enough to warrant us in recovering from them the potash salts, and the same would be true at any mills which might adopt this method of disposing of theie waste.

Mining and Concentration of Corundum in Ontario

By M. F. Fairlie, School of Mining, Kingston.

Although corundum, in a deposit capable of being economically worked, was discovered in Ontario some twenty four years ago, the mineral remained unidentified till the year 1896, when its occurrence in the Township of Carlow, Hastings County, was proven.

During the ensuing two years the corundum-bearing rocks of this district were accurately traced, and conditions of occurrence discovered. The prevailing country rock is gneiss, composed chiefly of hornblende, biotite and felspar, which is cut through by dykes and masses of felspar and mica and in some cases nepheline syenite; these dykes and masses carrying corundum as well as small quantities of magnetite, pyrite, garnet, etc.

The largest deposit of corundum yet discovered in Ontario, and the only deposit which has as yet been economically worked, occurs on the Robillard property, Raglan Township, Renfrew County. In this instance the occurrence is on the southern face of a high hill, at whose base lies a marsh, into which empties a stream running along the western base of the hill. The corundum occurs in a broad dyke of almost pure felspar outcropping at intervals on the face of the hill, which is thickly covered with underbrush. The corundum itself is in the form of hexagonal crystals usually barrel shaped, scattered through the felspar, the crystals varying in size from half an inch to five or six inches in length, and varying widely in color although usually of a brownish and greenish shade. The crystals occur in varying profusion throughout the felspar, being thickly concentrated in one place while a few feet away the felspar will be practically barren; this concentration of the corundum in the felspar apparently follows no definite law. The property was secured by the Canada Corundum Company in 1900, and during the year work was begun in developing the deposit and in constructing an experimental plant for the concentration of the ore and preparation of the raw corundum for market. Since then the process has been gradually improved, and from personal experience in this plant, I shall endeavor to first give a description of the mining of the ore and method of concentration as at present practised, and then discuss the methods in use.

Regarding the mining little need be said, as the operations are exceedingly simple. As yet no sinking or tunnelling has been done either on this or on any other Ontario corundum deposit, a fact which is to be regretted, and the winning of the ore merely consists in stripping the dyke, drilling being done by hand and dynamite being used in blasting. The ore is roughly sorted at the mine and waste rock discarded; the picked ore carrying probably an average of 10 to 15 per cent. corundum, being transported by wagon to the mill, situated three-quarters of a mile away on the creek before mentioned. This method of mining will probably be improved by the installation of a steam breaker plant at the mine and the use of power drills.

The concentrating proposition presented by the ore is the separation of the aluminum oxide with a sp. qr. of about 3.9 from the felspar gangue with sp. qr. of about 2.4 to 2.5 and the elimination of such impurities as magnetite and pyrite as well as mica. Previous to this time the only attempt at concentrating corundum had been made on the North Carolina and Georgia deposits. In the case of the North Carolina deposits the corundum occurred either loose in chlorite and vermiculite scales or enclosed in a gangue of felspar, margarite, etc., or as a constituent of a solid rock. Where the gangue was sufficiently soft it was merely washed in sluice boxes, through which flowed a strong stream of water, carrying away the lighter gangue; where the ore was not adapted to this method it was crushed in breakers and rolls, then stirred in boxes with a strong current of water, thus removing part of the gangue, and was then passed through a machine in which a coarse worm, like a screw conveyor, revolved on a shaft. Most of the gangue was thus cut away by the friction of the corundum grains on each other and was washed out by a current of water. To finally clean the corundum it was placed in a machine called a "muller," a low tub in which two rolls moved round the circumference on the corundum. Iron teeth in front of the rolls kept the ore stirred up and a stream of water carried the light gangue away. The methods used in Georgia were on the same principle, depending on the grinding together of the corundum grains to effect a separation of the gangue and corundum. These methods were not adapted to the Ontario ore owing to the hardness of the gangue and the close connection existing between the felspar and corundum; so that any experience gained in the South was of little value in designing a plant for the treatment of Ontario corundum.

For treatment of the ore at the Ontario mine an old saw mill was remodelled, additions made to it, and concentrating machinery with a capacity of about 25 tons of ore per day was installed. For the operation of crusher and rolls, water power is used, a head of 50 feet being available. The creek is dammed above the mill and the water led through a 14-inch pipe for about 100 yards to a five nozzle water wheel of the Cascade type. The wheel is belted up to shafting and from there power is transmitted to the mill by means of wire cable. The rest of machinery of the plant is run by a 25 h.p. high speed engine.

The ore as it comes from the mine, is dumped into ore bins situated at the crushing floor and from there is fed by hand into a No. 2 Gates Gyratory Crusher, with a rated capacity of 12 tons per hour. This rating is, however, far above its actual accomplishment on account of the tenacity and extreme hardness of the corundum, and also the toughness of the felspar which is finely crystalline and devoid of cleavage lines. In crushing, the corundum and felspar do not part readily, and a clean separation cannot be effected unless crushed to at least 12 mesh.

After crushing to pass through a 1½ inch ring, the ore is elevated to a storage bin and is thence fed to a set of 16 × 24 inch belt-driven Gates rolls, and crushed to ½ inch size. The crushing in these rolls, as well as all subsequent crushing, is done wet. The ore is now elevated to a two-compartment Trommel 1 fitted with 4 mm. and 8 mm. punched steel screens, giving three sizes. (1) The 4 mm product passes to Trommel 2. (2) The 8 mm. product passes to a double-compartment Hartz jig fitted with 7 mm. screens, thus giving both heads and also hutch product; the overflow is run off as tailings, although a considerable amount of corundum is here lost owing to the fact that until more finely crushed, the corundum and felspar do not break cleanly and a large piece of felspar attached to a smaller piece of corundum will escape into the tailings. (3) The oversize from Trommel 1 goes to a double-compartment Hartz jig, whose overflow returns to the rolls. The 4 mm. product from Trommel 1 passes to Trommel 2, which divides it into three sizes. (1) 1.5 mm. product going to a Wilfley concentrating table. (2) 2.5 mm. product going to a double-compartment high speed Gates jig (3) Oversize going to another double-compartment Gates jig with a slightly longer and slower stroke than latter. The overflow from these jigs is run off as tailings. The hutch product and heads from all the jigs go for recrushing to a set of 30 × 6 inch high speed Colorado rolls, and after crushing are elevated to Trommel 3, which divides into three sizes:

(1) 1 mm. product going to Bartlett table.
(2) 1.5 mm. product going to Wilfley table.
(3) Oversize returning to rolls.

On the Bartlett table a fairly clean corundum-magnetite concentrate is got on the two top shelves; the product from third shelf passes to a Wilfley table which also receives the 1½ mm. product from Trommel 3, and on this table also a concentrate of probably 85 per cent. is recovered. The capacity of one of these tables on corundum ore is about 12 tons per day, but of course depends on regularity of feed, and manipulation. The concentrates from the Bartlett and Wilfley tables are placed on a steam drier, heated by exhaust steam from engine and thoroughly dried, then elevated and passed through an electro-magnet. This first passage through the magnet removes practically all the magnetite from sizes coarser than 24 mesh, but the percentage remaining in finer sizes increases directly as mesh increases in fineness.

The dried ore is now ready for sizing, and is elevated and run onto "splitters," long horizontal frames, fitted with screens and given a reciprocating motion by means of an eccentric. These splitters "split" the corundum into the primary sizes, 90 mesh and finer, 80 mesh, 30 mesh, coarser than 30. Each of these sizes, with the exception of 80 mesh, goes to a separate "grader" working on same principle as "splitter," and there the corundum is graded into sizes 12, 14, 16, 20, 24, 30, 36, 46, 54, 60, 70, 80, 90, 100, 120, 150, 174, 200 mesh. Approximately 50 per cent. of the product is in sizes 12 to 24, 45 per cent. is in sizes 30 to 80 mesh, and 5 per cent. in fines.

In order to get a sufficiently clean product for shipment it is necessary that the sizes from 24 up to 200 mesh be "rewashed" to remove the remaining felspar. Each size is washed separately on a Wilfley table used for this purpose alone, and corundum practically perfectly free from felspar is thus secured; whereas, without sizing, such a result was found to be impossible with this ore. After this rewashing the corundum is dried and again run through the magnet to remove any remaining magnetite. It is then sized again as before and put in 200 lb. sacks ready for market. The sizes from 12 to 24 are entirely freed from felspar and magnetite by one operation, so require no rewashing. Of the other impurities in the ore, the mica causes no trouble and is easily removed on the jigs, while the pyrite, which, however, is almost negligible, remains in the finished product.

To discuss the methods of corundum concentration: The crushing machinery, of whatever kind, necessary for corundum ore, should in the first place be of the very best owing to the extreme hardness of the corundum itself; which, in fact, is only exceeded in this respect by the diamond; and to the felspar also, which, although not as hard as a quartz gangue would be, is more tough. Repairs to crushing machinery used on this ore is a very important item of expense, so that an ordinary jaw breaker of the Blake type would be more profitable than a gyratory of the same rated capacity, owing to the ease, rapidity and low cost of repairs of the former compared with the latter.

Regarding the rolls also, the best are necessary. Manganese steel shells are here used on the roughing rolls, the life of a set being limited to about two months, as it is impossible to prevent uneven wear of the shell face and the forming of flanges on the edges. The shells, however, can be turned down in a lathe and again used. For recrushing the jig products high speed rolls are best adapted, as the object is to produce as small a proportion of slimes and fines as possible. The high speed roll does this admirably, as it is possible for the ore, when once crushed fine enough, to drop away from the coarser, thus escaping the further crushing which results where "free crushing" conditions do not prevail. The Colorado high speed rolls used here are especially adapted for this hard work, owing to the side adjustment by which the free roll can be shifted laterally to effect the even wear of the shell face. Centrifugal rolls, driven by a single belt at a speed of 800 revolutions, were tried here for recrushing concentrates, but owing to the rapid wearing out of the shells, and the wearing out of the bearings from the jar caused by the crushing of such hard material, they were found entirely inadequate for the work.

Regarding the trommels it will be noted that all the material from the roughing rolls passes first over a 4 mm. screen; this of course causes excessive wear on such a screen, and a better arrangement would be a a set of short trommels each fitted with one size of screen and placed in a series beginning with the coarsest and ending with the finest, but the method in use is best suited to this mill as the fall required is not so great.

Hydraulic classification is not employed here and as a result slimes, formed by crushing, escape into the tails from the jigs and tables. Owing to the character of the ore, however, by the proper arrangement of the feed to the rolls, the production of fines can be reduced to a minimum. To save the slimes hydraulic classification would have to be resorted to, with subsequent treatment of the overflow in settling boxes and some form of slime table. Although practically all the product passes over jigs before going to the concentrating tables, it will be noted that no final product is obtained and that both concentrates from the jig bed, and also hutch product from all the jigs, go finally to the concentrating tables. This seems to be open to criticism. From experience with both Bartlett and Wilfley tables on corundum ore I think that they will take 1 mm. and 1.5 mm. material direct from the trommels without previous classification or jigging, and give a fair concentrate. This would necessitate another table for a plant of this size and another set of recrushing rolls, but the expense of jigging would be removed, and loss of corundum in jig tailings obviated. As the jigs are at present run it is necessary in order to prevent loss in tailings, to keep the bed on the second compartment very low and, as a result, felspar gets into the hutch. Of course without the use of jigs, so clean a concentrate might not be obtained on the tables; but when this concentrate is sized and rewashed on Wilfley, as is necessary in any case, no trouble should be found in getting a pure corundum product. The increased crushing necessary, where jigs were not used, would result in an increase of corundum fines, but this increase would be unimportant, as the corundum does not readily form fines.

I have already mentioned the necessity for careful sizing of the table concentrates, and then final concentration of each size separately on a Wilfley table, in order to secure pure corundum; this was proved by experience. In experimenting, the "30 to 80" mesh material, as it came from the "splitters," was run together over a Wilfley table, but practically no further concentration took place; however, when this was sized on the "graders" into the intermediate sizes 30, 36, 46, 54, 60, 70, 80 mesh and each size run over the concentrator alone a perfect corundum product was obtained.

A machine which may yet have a very important bearing on the economical concentration of corundum, is the Hooper Pneumatic Concentrator, one of which is in operation at this plant, being used only for rewashing the sized material. As its name implies, no water is used, the concentrating being effected by air blast. This is a great advantage in the work for which it is used here, *i.e.*, reconcentrating the sized product, as it saves the redrying and resizing necessary where the Wilfley is used; and it also gives a magnetite and pyrite concentrate, thus affording an opportunity for removal of the latter impurity. It has also the added advantage of slightly greater speed than is possible on Wilfley, but it has the disadvantage that it cannot treat a finer size of corundum than 100 mesh nor coarser than 24 mesh. A change in design may, however, obviate this difficulty. If this concentrator were used for general work, the crushing would be done dry and the ore carefully sized, as the machine will not work on damp, unsized material.

It might be added that, in the case of corundum occurring in "nepheline" syenite, as is very frequently the case in Ontario, the difficulty in getting a pure product might not be so great, as the corundum breaks very freely from the gangue.

The Old and New Iron Industry Compared.

By JOHN BIRKINBINE, Philadelphia.

The activity prevailing in the iron and steel industry, especially the developments contemplated and in progress in the Dominion of Canada, will probably command attention at the Annual Meetings of the Canadian Mining Institute, and the following is presented as a contribution to such discussion and as a slight recognition of the compliment conferred upon the writer by his election to honorary membership.

The known deposits of iron ore in British Columbia, on the north shores of the Great Lake region, in Central Ontario, in Quebec, New Brunswick, Nova Scotia, Labrador, and in the adjacent islands, including Newfoundland, have invited the prospector and explorer, while facilities offered in the Dominion have suggested the possibility of the ores from some of these being assembled where fuel is cheaply obtainable and markets for the products can be developed. Descriptions of some of these deposits or of works to treat the ores are included in the Institute's transactions and the history of iron manufacture in Canada from the establishment of the St. Maurice forges has been presented by those posted as to details or familiar with local conditions. The development of the iron and steel industry within the United States also forms an equally interesting story, although it covers a lapse of time less than three centuries, and a brief resume of this is offered.

This paper is suggestive rather than historical, hence mere mention will be made of the early effort in the United States where an iron industry was attempted along the Atlantic Coast from 1630 to about 1740, primarily by utilization of bog ores and local brown hematites. The production was not of importance, measured by quantity, and practically all of the plants were either forges, or blast furnaces and forges combined so that the pig metal was cast, and also the wrought material fabricated.

About the middle of the 18th century the distribution of blast furnaces extended over a somewhat greater area and in addition to the brown hematites, magnetic ores were employed, but the ore was either reduced to blooms in Catalan forges or the pig metal was still fabricated in forges after it came from the blast furnace. All of the furnaces and forges up to about 1840, were fed with charcoal and were operated with cold blast.

The control of the iron works was generally directed by the owner, who exercised absolute dominion over a considerable territory. Each plant produced its fuel from wood, cut and carbonized upon property connected with the furnace or adjacent thereto, mined ore from its own or convenient lands, or quarried limestone nearby, making these early iron works self-dependent. In addition to the supply of raw materials, each works maintained its store, smithery, and generally a mill to supply the employees and their families; little money was used, most of the labor being taken out "in trade" at the store or mill. Each aggregation of houses about these iron works, which sheltered the employees and their families as tenants of the owner, was a settlement and independent of others, often reached by long and tedious wagon journeys. The transporting of the material to the furnace or forge and also the product from them was by animal power, first on the backs of mules, or later by large wagons each drawn by a number of animals. These wagons made extended journeys to points of consumption and brought back, with the necessary supplies required for the community, news from the outside world. The owner or "iron master" was practically "monarch of all he surveyed," owning the lands, farm, furnace, forge, mill, store, tenements, not infrequently the church and school house, or at least the ground they occupied, and while slavery prevailed in a portion of the United States, some were also owners of many of the employees. On his arm, feed for his horses and cattle and grain for his mill were raised. If he elected to serve, he was Justice of the Peace and Post-Master—otherwise trusty subordinates were named at his dictation. He was the political, and in some instances, the religious guide for his people, but often the manager did not intrude upon religious duties as upon political privileges, giving to his employees and their families unlimited proxies to represent him at the revival services at which a number "got religion" each year—at least a supply believed to be sufficient until the frogs croaked in the spring, after which it was often accepted as more or less of an incumbrance.

Long credits allowed on the sales of products or claimed on the purchase of materials, made the owner or manager of one of these older plants also a banker, whose fiscal work was mainly confined to short seasons recurring once or twice every year.

As to the blast furnaces, a massive stone stack about 30 feet high and about 30 feet square at the base enclosed the refractory lining whose greatest diameter seldom exceeded 9 feet. This furnace, operated by a water wheel propelling pistons in wooden cylinders or moved ponderous bellows, was kept in operation from 8 to 10 months of each year, producing an average of about 100 tons of pig iron per month, but was then blown out for re-lining. During this season of inactivity the miners and furnace men not needed in repair work were sent into the forest to chop wood for the next season's coaling or aided in stripping the overlay from ore banks. The raw materials for the furnace were produced by hand labor, hauled by wagons to the charging floor on the hillside or bank at the same height as the furnace top, and fed into the tunnel head by barrows, baskets or boxes. The metal produced and the resulting cinder were also handled by manual labor, and the labor item was prominent in the cost of metal produced.

This briefly details conditions prevailing up to about the year 1840.

With the introduction of the hot blast, nearly contemporaneously with the application of mineral fuel in America, and closely following the construction of canals, and later the development of railroads, it became possible to utilize as avenues of transportation the canals and railroads. Some blast furnaces were moved from the immediate vicinity of the ore or fuel supply and the tendency was to locate new plants about business centres. The size of the furnace was increased and improvements in equipment introduced, but up to about 1880, there were a number of cold blast furnaces constructed and operated practically as described above. There are several cold blast charcoal furnaces still active in the United States, whose equipment, however, has been improved and labor saving introduced to a limited extent. These furnaces produce special grades of metal which command prices permitting of following the methods indicated, but the demand for quantity is slight.

With the proportions of the furnaces increased and improved steam machinery to operate them, the product was augmented and from a score of tons per week the output gradually increased to as much as 100 tons per week. About 1850, products from a furnace of 200 tons per week were occasionally reached as more powerful equipment was supplied. The forges being separated from the blast furnaces and rolling mills substituted, more of the product of the furnaces was carried to distant works where it was manipulated and fabricated into commercial forms.

In the next two decades interest in the chemistry of the blast furnace was excited, and about 1876 the technical side of iron smelting received liberal attention, the iron masters of the United States profiting largely from the Centennial Exposition in Philadelphia, where experts in all branches of iron metallurgy came together from various parts of the world and discussed the problems which each had to meet with in his own locality. In the meantime the manufacture of steel by the pneumatic, or what is generally known as the Bessemer process, was advancing and the requirements for metal became greater, so that the product per furnace and the total for the United States was materially increased. The machinery to operate the blast furnace was constantly improved and this improvement extended to the mills where the pig metal was either puddled or converted, requiring a large output, to meet which the capacities of furnaces were augmented.

Up to 1870 the majority of the iron plants had been operated by individuals or partnerships, but incorporated companies entered the field, thus permitting of enlarged development with greater capital and division of responsibility. The fire-brick hot blast stoves were introduced about the time of the Centennial Exposition in Philadelphia, aiding to augment the output and decrease the fuel consumption per ton of iron, while chemical researches demonstrated the increased value of rich ores and the demands of the Bessemer plants made necessary the selection of many ores low in phosphorous.

About the year 1880 a daily output of an individual furnace which reached 100 tons was phenomenal. Since that time general advances in all lines technical, metallurgical and mechanical have been pronounced and a furnace which two decades ago produced 100 tons per day is not now notable if it exceeds 300 tons, although the dimensions of the stack may be the same. Various experiments were made to develop the blast furnace in height, in diameter of bosh and in diameter of crucible, but there has been no greatly augmented height nor has the diameter of bosh of many of the furnaces been extended much more than those of the largest furnaces of twenty years ago, although the record of some individual plants have reached 800 tons in one day, or as much as an up-to-date furnace would produce in a year prior to 1840. In the larger plants which are now in operation, equipped with powerful steam engines, ample boiler capacity, sufficient hot blast stoves, appliances for handling the raw materials and also the product, an average exceeding 500 tons a day is not unusual for a considerable period. A blast furnace plant designed to produce 1,200 tons daily, may at present consist of two or three furnaces, and the question of preference is an open one. It is probable that, all things considered, better results will be obtained from dividing this quantity among three units than among two, that is, having three furnaces each producing about 400 tons per day rather two with a capacity of 600 tons per day. This, however, is not the time to discuss this detail.

A development such as that indicated in the foregoing hurried recital could not have been spasmodic but was gradual and within a half century marked advances have been fairly persistent, although some developments were quite sudden. Conscientious and careful study by engineers, mechanics, chemists and superintendents to obtain a large output and secure the greatest economy of operation has resulted in achieving the record described.

Under the older method detailed, it would be impracticable to assemble the large amounts of raw materials required, or to handle these, and the present product at one of our modern blast furnace plants. The number of men and animals necessary would interfere with each other, and the available space around a furnace plant would be insufficient for the work, if it were done according to the older and more expensive methods.

To obtain the amount of pig iron credited to the United States in 1901 (15,878,354 gross tons) it has been necessary to develop enormous mines, both of ore and coal, to equip them with the best of machinery for winning and handling the material, to build thousands of coke ovens, to construct hundreds of miles of railroads supplied with powerful locomotives and capacious cars in which the materials can be cheaply transported and from which they can be readily discharged; to erect enormous shipping docks where the ore is conveniently and economically handled into vessels and to prepare also extensive docks where the ore can be taken from vessels and transported rapidly and at small cost placed on stock piles or railroad cars.

These features have also resulted in the establishment of an important maritime trade on the Great Lakes, where powerful modern vessels of large capacity have been supplied in great number.

When the raw material reaches the modern blast furnace, it is received and distributed by means of mechanical appliances and bins costing large amounts of money, the tendency being to eliminate, as far as possible, in mining, in handling, in transportation and at the furnace, manual labor, by substituting mechanical appliances. The pack mule first gave place to the wagon and team, the wagon and team were supplanted by canal boats and these by railroad cars carrying five tons of material. Now cars holding 50 tons drawn by ponderous locomotives move the ore which is dug from mines by steam shovels or won by the use of air drills, supplemented by electrical or air motors. It is discharged by gravity from cars with drop bottoms, which either carry the material directly to the consumer or to docks where the material drops into pockets and from these is shot into vessels. Great "grabs" at the terminal docks lift this ore from the holds of vessels and mechanical appliances convey it to stock piles and cars, these latter transporting the ore to the bins or stock piles at the blast furnaces where other mechanical appliances move it or lift it to the furnace top, and much of the ore now used is not touched by hand from its native bed until it enters the throat of the blast furnace. This ore obtained from mines several hundred, and even exceeding 1,000 miles distant from the blast furnaces, is delivered to them at no greater cost than some of the near by ores fed to the older furnaces which were won entirely by manual labor. Similarly the advancements in coal mining have been in the use of compressed air and electricity or continuous rope haulages with cars which convey the fuel to the ovens into which it is automatically dumped. Some ovens are built so as to utilize a portion of the non-condensible gases, the condensible being converted into commercial products, and in addition to obtaining value from these it is possible in by-product ovens to utilize some coals which otherwise would be unfit for coking by reason of their low volatile contents. The metal, after it is smelted in the blast furnace, instead of being tapped as was formerly the case, and handled by manual labor, now runs into ladles carried on trucks which deliver it to mechanical casting machines, or it is charged direct into mixers or converters at the steel plant. It is at these plants that mechanical ingenuity and great economy in labor and material have reached a most commendable result. The converted metal cast into ingots of weights up to 5 tons (and in the construction of ordinance or armor plate of 20 tons or more) passes to hydraulic presses or to blooming mills and in many cases a practically continuous mill permits of the finished product being produced without the metal reaching a temperature below that which can be readily raised by temporary "wash" heats. The finished product from a number of these mills, whether it be rail, bar, shape or plate, is now produced and marketed at prices no greater than the old charcoal furnaces received for pig iron.

The perfection of the mechanical equipment is marvelous. The molten metal brought in ladle cars each holding 15 or 20 tons, is discharged into a tilting mixer with a capacity of 300 tons. This mixer feeds the converters or open hearth furnaces from which ingots are cast and quickly conveyed to soaking pits or gas furnaces. Powerful cranes place the ingots on the feed tables of blooming trains to be rolled and sheared to billets and these pass to other trains so that in a brief interval the finished rail, shape, bar or plate is produced.

It is probable that in a modern mill ten tons of finished product are obtained by the employment of no greater number of workers than were necessary in crudely fabricating one ton a half century ago.

With the increase of quantity and the improvements for handling and using the raw materials, augmented capital became necessary to develop and exploit large mines, to build railroads, to construct vessels with the necessary shipping and receiving docks, to erect furnaces, converting plants and mills of large capacity and equip them with the machinery and appurtenances requisite to produce the quantity of material desired at the lowest practicable cost. As this augmentation became general, private or partnership control was, except in relatively few instances, supplanted by corporate ownership. At present corporate control is so combined as to encourage centralization of interest and management, capital of some of the important iron and steel companies reaching figures scarcely appreciable to the average business man. When the stock of companies is rated by hundreds of millions, and in one case exceeds one thousand million dollars, the figures are hardly understood by most of those engaged in commercial enterprises. This centralization and consolidation is being watched with great interest; that it has merit can be demonstrated from a number of points of view; that there is danger in it is apparent from different aspects. But few combinations have been possible except by associating with successful and good paying enterprises, others which were at least doubtful and whose location, equipment or other causes, handicapped them in the race for pre-eminence. The stronger will have to carry the weak, and there may be times when this burden will be troublesome. A great business can undoubtedly earn great profits, but enormous capital also means proportionate interest charges which must be met.

While we may consider ourselves in an era of consolidation, the entire iron and steel business may not be so classed. The bulk of the iron and steel trade of the United States is undoubtedly controlled by a few corporations, but there are a number of relatively modest enterprises which are, and under proper management, will continue to be successful. Although the prices of products may be generally dictated by the stronger, the relatively weaker will prove important factors not only to the supply of the general public, but will be used to a greater or less extent to supplement deficiencies of the larger enterprises, and even a small producer with a moderate amount of product to dispose of may demoralize a market apparently strongly sustained.

In some of the later developments which have been made or are in contemplation, there is apparent neglect of the essential feature of convenience to a remunerative market. The industries which have been most profitable have developed from smaller ones to great ones. There are but few instances where large plants have become successful unless these have resulted either from an earlier development or of a combination of neighboring interests. Many of the modern plants occupy the sites of ancient industries, are successors of these, or are located in districts in which for a term of years labor has been educated and market facilities secured.

The danger which seems to threaten the iron and steel industry is the enthusiasm with which great projects are launched and for which great promises are made. With no desire to question the propriety of a number of the important projects contemplated or in course of erection, there is, to the careful observer, an apparent neglect in some instances of the question of practically continuous remunerative markets.

The iron and steel industry of the United States is no longer in its infancy, it has grown to maturity and individual plants now produce more metal in a year than the entire United States supplied less than half a century ago. Nor is the industry dependent upon local supplies of raw material; railroads with improved locomotives, large cars, substantial road-beds and bridges and advances in vessel construction both as to power and capacity, the facilities of shipping and receiving docks where these are necessary, the equipment of important mines and the selection and handling of the material mined, all combine to admit of assembling raw materials from long distances or of shipping manufactured products to far away consumers. The mechanical appliances and methods introduced at the blast furnace, the converter, and the mill, make possible enormous outputs at small cost for labor, fuel and administration.

The substitution of mechanical appliances has materially reduced the requirements for skilled labor, while the transportation problem permits of the assembling of the raw materials and distribution of the product.

The modern blast furnace stack, although three times as high, occupies no more ground space than its ancient prototype, and the equipment of 4,000 H. P. boilers, cross compound blowing engines, supplying 1,000 cubic feet per second, at pressures of 20 pounds or more, delivered through 10 or more tuyeres into the blast furnaces at temperatures of 1,200 degrees Fahr. seem strange developments from the weary water wheel forcing from its bellows or tubs a weak blast through a single open tuyere. The 3,000,000 or 4,000,000 gallons of water demanded for steam and cooling purposes by a modern blast furnace would have gone far, under a liberal head, to have been the motive force operating the older furnaces.

The advances in quantity of product, in the control of its character, in the low consumption of fuel, have all been made possible by a study of the chemistry of the blast furnace, which exposes to the student the secrets of the smelting process, and the modern furnace is as much a tribute to the work of the chemist as it is an example of the highest skill of the mechanical engineer. It is not alone to the blast furnace that such credit is due, for the Bessemer steel converter with its startling reactions, the massive open hearth steel furnaces, the handling of large ingots, the rapid passing of these into commercial shapes, equally pay tribute to the genius of the metallurgist and the mechanic.

The Centre Star is on the shipping list again, and the output has been at the rate of four thirty-ton cars daily since operations were resumed. It is regarded as probable that this will be increased at an early date to ten cars daily or thereabouts. The management of the mine is devoting its attention principally to the development of the deep workings, and good progress is being made in the shaft and the horizontal workings at the 700-foot level recently got under way.

The Harris System of Pumping by Compressed Air, as Applied at the Deloro Mine.

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By J. P. KIRKGAARD, Deloro, Ont.

The raising of *water* from mine workings is often a serious problem, and always a heavy cost on mining, even under favourable conditions; this subject, therefore, is a matter deserving of serious consideration.

At the Deloro Mines, Hastings County, Ontario, a shaft was being sunk which had an inflow of water amounting form 400,000 to 500,000 gallons per 24 hours. To deal with this amount of water by the then existant plant of "direct-acting steam pumps" was both slow and costly.

The greater part of this water flowed into the mine through and along the footwall, at the south end of the ore chute, and from thence to the lower workings, where the shaft was to be sunk.

The writer conceived the idea of impounding most of this water, making a permanent pumping station on the third level, and thus practically leaving the lower workings dry. An old shaft at the south end of the ore chute, being admirably situated to suit this purpose, was selected.

The bottom of this old shaft was 47 feet below the second level and full of water, and 35 feet above the third level, which latter had already been driven under and past this shaft.

The work preparatory to the installation of this pumping system was as follows:—

A chamber 30 x 15 x 12 feet was blasted out on the third level immediately under the bottom of the old shaft, and all necessary preparations made for constructing a dam to prevent the water from flowing into the third level. This being done an upraise was made to the bottom of the old shaft, thus unwatering the shaft.

While this work was in progress investigations were made of the several types and varieties of pumping engines. The direct-acting pump was out of the question. Plunger pumps driven by compound-condensing engines seemed the best in this line of pumps, but the situation was such that, should anything happen to the pumps or engine, they would be drowned before repairs could be effected.

The next thing presenting itself as suitable was the "Harris" system of lifting water by direct air pressure.

Not only did this system promise great economy over previous installations, but its construction was such that no machinery was required in the mine, other than two tanks and some pipes connecting them with the machinery on surface; and with this system there could be no drowning, no matter what happened to the surface equipment.

The objections against its adoption were these, viz., its greater first cost compared to other systems, and secondly it was an untried system as applied to a comparatively high lift mining installation. However, against these, its simplicity so appealed to the writer that it was finally adopted.

The two tanks, 4' x 20', were placed in the "sump" or "chamber" on the third level, the pipes connected to surface and the dam built.

The reservoir thus made, (that is the chamber at the bottom of the shaft 30' x 15' x 12', and the shaft itself, being 82 feet below the second level, and 9' x 15' in cross section) altogether gave a storage capacity of 130,000 gallons approximately, thus permitting the engines at surface, if so desired, a period of from 6 to 7 hours rest, without any fear of the water finding its way to the lower workings.

This arrangement has proved very satisfactory and has been a strong factor in reducing the cost of operations, not only in shaft sinking, but also in stoping; these places now being dry, comparatively speaking.

It had also reduced the cost of raising water from 25 to 30% on former cost—part of the economy being in fuel, but mainly in labor and repairs.

Formerly it was necessary to have a pump man constantly attending the pumps; now this service is entirely dispensed with. It will be apparent from what has been said, that this system is only applicable as a "stationary pump," but as such, it is, in the writer's opinion, very satisfactory.

The "Harris" system of air-lift, is composed of two tanks in the mine, which are connected by two air pipes to an automatic switch located in the engine-house at surface, the switch in turn, being connected with an air compressor.

The principle of the system is simplicity itself, although not easy of explanation.

A "cross compound" "steam and air" of the Rand type, class B, compressor is placed at a suitable location at the surface, and two tanks, 4' x 20' each, are placed in the mine—the air compressor and tanks are connected by two air pipes, and between the air compressor and the tanks at a suitable point near the compressor a switch is located.

This switch serves the purposes of changing the inflowing air from one tank to the other at regular intervals; these intervals are termed "cycles."

The duration of the cycle may be varied from 2½ to 6 minutes, to conform to the amount of the water to be raised; these variations are governed through the amount of air forced into the system.

If there is only a limited amount of water to be raised, (and there is no object in maintaining a constant supply) provided that the sump, or reservoir is of sufficient capacity, the engine may be stopped for a time and again started by simply turning steam on the compressor, the switch at once resuming its functions, no attention being required at the tanks in the mine.

As regards the air, the system is "closed" or return pipe system, *i.e.*, the same air is used over and over again, returning to the compressor at the end of each cycle for compression, ranging in pressure from that required to do the work, to that which equals the pressure due to the head of water around and above the tanks.

The greater the head above the tanks the greater the economy.

In this feature is the chief economy. The tanks are so connected that they receive air and water alternately, when one receives air and delivers water, the other receives water and delivers air.

It will thus be seen that the air is not brought up to working pressure from the atmospheric pressure, as would be the case in the ordinary air compression.

Attention should be drawn to the fact that the only moving parts in the mine are the inlet and outlet valves at the tanks.

These valves only move once for each cycle, and as near as can be ascertained by listening to them, they open quickly but close gradually, hence the wear is slight. In this case they have never caused any trouble.

In the particular plant under review 96 pounds air pressure is required to force the water through an 8-inch pipe to the mill tank, a vertical lift of 208 feet. The "lift" is kept running steadily night and day in order to supply the requisite water for mill purposes, also for condensation purposes in the compressor house for the condenser of the air lift, and also another pertaining to a 20-drill compressor.

As before stated, the air is forced into the system at 96 pounds pressure, and after the completion of the cycle it returns through the switch into the low pressure air cylinder at a pressure of 65 pounds, immediately after switching, and gradually decreases in pressure through the cycle to zero, or the pressure of the atmosphere: on reaching this point and the compressor still running and having no other source of supply, (it should be noted that there is a small loss of air through leakage and the working of the switch, as this latter is exhausted into the atmosphere, this loss is made up by a supply of air through a small check valve on a ⅜" pipe, fixed to the low pressure inflow pipe) it follows, therefore, that all the air in the system is extracted, and finally a partial vacuum is created within the tank and pipe line of that side of the system; this vacuum continues to increase until it reaches a point where the atmospheric pressure on the surface of the water overcomes the weight of the inlet valve on the suction pipe connected to the tank, and the water rushes in filling the tank. The vacuum will vary with the height of the water; if below the tank, switching will take place at about 11 inches, if above the tank at 4 to 5 inches or less.

The switch in general appearance resembles a direct acting steam pump, having what corresponds to both steam and water ends. At what would be the steam end, there is a vertical cylinder serving the purpose of the valve, in this works a piston. The space above the piston is directly connected with the air inlet of the compressor, but the space under this piston is open to the atmosphere; it therefore follows that as the low pressure cylinder exhausts the air out of the tank and the pipe connecting it with the switch, creating a vacuum, a vacuum is necessarily thus produced above the little piston; when this point is reached, the atmospheric pressure pushes the piston upwards and this in turn, being suitably connected with a rotary valve on a ¼ inch pipe connected with the high pressure air pipe, opens this valve, admitting the air which acts upon another piston similar to the steam piston in an ordinary pump. This latter piston is directly connected with a plunger, corresponding to the water-end of a pump, but this latter acts as a valve, opening or closing the passages leading to the pipes connecting compressor and tanks with the switch.

The drawings that accompany this brief description give a general view of the arrangement of the "Harris System of Air Lift" as applied to the raising of water at the Deloro Mine.

Fig. 1 is a plan; Fig. 2, a section; Fig. 3, an elevation of the tanks and dam; Fig. 4, an elevation showing the position of the tanks in the mine.

Referring to the drawings, *a* is a cross-compound steam and air Rand drill compressor, type B, steam, 10-16-16, air, 14-8-16; *a'* is a condenser; *b* is the switch located in the engine room; *c c'* are 3" air pipes leading from compressor to switch, and from switch to tanks, in the mine; *d d'* are the tanks, each 4' x 20' with an approximate capacity of 1,800 gallons each; *e e'* are the suction pipes; *f f'* the valves on the delivery pipes; f^2 the 8" delivery pipe; this, as also the air pipes, *c c'* are securely clamped between timbers, at intervals up through the shaft, and from the collar of the shaft are laid together until they reach the compressor building, here the air pipes are connected with the switch, while the water pipe is secured under the eave of the house, running the full length of the building, 75 feet, and from thence up the hill on trestles, until it reaches the mill at the level of the ore floor, a total vertical height of 65 feet, above the collar of the shaft; here the pipe empties into a tank, *g*, 6 feet diameter, by 8 feet deep, this tank is in turn connected with another tank, *g'*, at the opposite corner of the mill, these are the supply tanks for the mill; *h* is an 8" over-flow pipe connected through the bottom of the tank, *g*, and leading back to the circulating tank, *i*, in the compressor building.

This was done to obviate any waste of water, which might otherwise occur if the mill at any time needed less water than the regular supply.

On the delivery pipe, *f'*, at f^2 a 6" branch is fixed, leading to the circulating tank *i*; on this 6" pipe is a valve, f^3, for the purpose of regulating the amount of water needed for the compressor condensers.

For about four to six months in the year all the water raised by the air-lift from the mine is needed at the mill, and during this time the condensers, as also the boilers at the compressor, are supplied by an auxiliary pump located on the river; (*j* is a 20-drill cross-compound steam, single acting air, Rand compressor, furnishing air for all underground work, *j'* the condenser); *l* a battery of three, 100 h.p. each, return tubular boilers.

Fig. 4 shows the position of the tanks in the mine; it will be noticed that these are located at the bottom of a shaft ending on the third level. As already explained, nearly all the water of the mine is confined to this place, the fourth level is almost dry, as is also a winze lately sunk to the fifth level, it is also pointed out that work is being pushed to pass under the bottom of the water shaft, leaving 50 feet of the ore in place.

When this air-lift was put in, it was thought quite probable that the water would break through to the fourth level, it was therefore specified that the lift should be capable of lifting 500,000 U.S. gallons per 24 hours from the fourth level, this would add about 70 feet more to the vertical lift. The makers of the plant have given a guarantee that the plant will perform the above duty, should it be necessary to move the tanks down.*

The writer would like to give more detailed data covering the efficiency of the plant, but owing to the fact that the steam used for the lift is drawn from the same boilers that are supplying the larger compressor, and this latter running constantly, there has been no opportunity to make a test other than a series of "cards" taken at intervals of 15 seconds, throughout the cycles, both from the steam and air cylinders.

These cards are very interesting, showing the variation throughout the whole cycle—there are no two cards alike, but the very fact of this variation makes them of little value—no information of value can be deduced from them.

A table showing these variations is hereto attached.

INDICATOR CARDS, TAKEN JUNE 8TH, 1901.

HARRIS AIR-LIFT CROSS-COMPOUND AIR COMPRESSOR ENGINES.

No. Card.	Time in Cycle.	Gauge reading H P Steam.	Gauge reading L P Steam.	Gauge reading H P Air.	Gauge reading L P Air.	Revolutions per minute.	End of Cylinder.	Card taken by	Remarks.
1	Start switch.	90	25	110	20	124	Both.	Swallow and Donaldson	
2	15 seconds.	90	28	105	110	120	"		
3	30 "	90	30	110	105	140	"		
4	45 "	90	30	95	95	148	"	"	
5	1 minute.	89	30	95	80	120	"	"	
6	1 "	90	31	93	80	144	"	"	
7	1¼ "	89	30	93	60	144	"	"	
8	1¼ "	90	30	92	75	120	"	"	
9	1½ "	90	28	91	55	148	"	"	
10	1½ "	90	28	92	45	144	"	"	
11	1½ "	90	27	90	40	148	"	"	
12	1¾ "	90	26	92	45	128	"	"	
13	1¾ "	91	25	91	42	132	"	"	
14	2 "	89	25	91	40	124	"	"	
15	2¼ "	89	22	91	34	148	"	"	
16	2¼ "	90	23	92	35	124	"	"	
17	2½ "	89	23	90	30	148	"	"	
18	2½ "	91	23	91	35	136	"	"	
19	2½ "	90	22	92	33	140	"	"	
20	2¾ "	89	22	92	30	140	"	"	
21	3 "	90	22	91	32	144	"	"	
22	3¼ "	91	22	91	30	136	"	"	
23	End of Cycle	90	21	92	30	132	"	"	

*This plant has been in operation continuously for over a year, raising from 300,000 gl., the minimum, to 650,000 gl., the maximum, per 24 hours.

COMPOSITE CARDS.

No. Cards.	Time from.	Steam. H P	Steam. L P	Air. H P	Air. L P	Rev.	End of Cylinder.	Remarks.
24	0 to	90	20	110	20	140	Crank	High and low pressure cylinders.
	30 sec.	90	30	90	100	140		
25	1½ min. to	90	28	92	50	131		—
	2 min.	90	23	92	35	131		*Composite Card Explained.*— Pencil kept
26	2½ min. to	90	22	92	30	127		in contact with card
	3 min.	90	22	92	30	127		during the 30 seconds
27	0 to	90	20	110	20	132	Head	
	½ min.	90	30	100	100	132		
28	1½ min. to	90	27	93	50	143		
	2 min.	90	23	92	35	143		
29	2½ min. to	90	22	92	34	134		
	3 min.	90	22	92	30	134		

AIR CYLINDERS.

30	Switch .	90	20	60	20	136
31	½ min.	90	30	100	105	136
32	1 "	90	31	90	82	148
33	1½ "	90	29	93	60	140
34	2 "	90	25	92	40	152
35	2½ "	90	22	92	35	144
36	3 "	90	22	92	32	120
37	3½ "	90	21	92	30	142

Electrolytic Production of Metals, with Special Reference to Copper and Nickel.

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In considering this subject, we enter a field made attractive by the successful experiments of painstaking, original investigators, but hedged about with patents obtained by persons who seek to appropriate the results of these experiments which they had neither the patience nor the wisdom to make. We shall find that electro-metallurgy is based on facts known to generations earlier than our own, and by their age the common property of every scientist of to-day, and that the principles involved are so much matters of general knowledge that they are not the special properties of any man or association, that all are free to use them, and that any process, by whatever name it is known, is protected by patents only to the extent in which it is a combination of these well known principles with some patentable invention.

Electro-metallurgy, or, in other words, the electro deposition of metals from solutions, as at present practised, is not to be confounded with the production of metals by means of heat generated, and the electrolytic action dependent upon the reduction, in an electric furnace. It is more than that, and is naturally divisible into two branches: first, the electrolytic refining of crude metals, and, second, the direct production of metals from solution.

Before entering directly upon the subject under discussion, it may be well to give a few moments to electrolysis in general. By electrolysis we mean those chemical reactions which take place when a suitable electric current passes through a chemical combination, which is technically termed an electrolyte. In producing electrolysis, conductors of two grades or classes are necessary. Conductors of the first class are wires or sheets of conducting material, such as are used in the mechanical arts, their object being simply the conveying of the electric current from a point of higher to a point of lower potential difference. A conductor of the second class is always a chemical combi...ation, existing either in solution or in a state of fusion. In electrolysis, co..ductors of the first class work in pairs. The electric current is not complete when a conductor of the first class enters a conductor of the second class, and to complete the circuit another conductor of the first class must also enter the conductor of the second class, usually at a point opposite that at which the first entered. This pair of conductors of the first class, when in contact with the electrolyte or conductor of the second class are known technically as electrodes, and it is virtually at these points of contact that electrolysis manifests itself. The electrodes are distinguished with relation to the direction of the electric current, as the anode and cathode respectively, the current entering the electrolyte at the anode and leaving it at the cathode. On account of the potential difference produced by the electric current at the electrodes, substantially different masses of the electrolyte (directly proportional to the quantity of current passing) are set in motion. These moving masses, composing the electrolyte, are termed ions, and, for further distinction, those moving toward the anode are called anions; those moving toward the cathode, cathions. At the electrodes proper, in an electrolyte, the ions undergo a chemical change, and this change is known as electrolysis.

The results of this change, according to conditions under which electrolysis takes place, can become of a very complex nature. Under primary conditions the results are comparatively simple. For example, the electrolysis of copper sulphate or sodic chloride solution produces in the first case copper, sulphuric anhydride and oxygen, while, in the second case, sodium (or sodium hydroxide and hydrogen,) and chlorine gas are produced according to the following equation:—

$$Cu\,S\,O_4 \text{ gives } Cu + S\,O_4$$
$$S\,O_4 + H_2O = H_2\,S\,O_4 + O.$$
$$Na\,Cl \text{ gives } Na + Cl$$
$$Na + H_2O = Na\,O\,H + H.$$

A given quantity of the electric current passing through different electrolytes will always set free the same number of valences or transfer them into different combinations. This can most readily be shown by allowing the same current to successively pass through different electrolytes. Results are shown in the following table:—

	Electrolyte	Electrodes	Cathions liberated	Compared to 1 milligram Hydrogen	Atomic Weight	Error
1.	Dilute Sulphuric Acid 1 to 12 $H_2\,S\,O_4$	— Platinum — Platinum	6.002 mg. Hydrogen	1 mg. Hydrogen	Hydrogen 1	
2.	Potassium Silver Cyanide $K\,Ag\,Cu_2$	+ Silver — Platinum	650 mg. Silver	$\frac{650}{6.002}$ = 108.2 mg. Silver	Silver 107.6	+ 0, 6%
3.	Cuprious Chloride $Cu_2\,Cl_2$	+ Copper — Platinum or Carbon	380 mg. Copper	$\frac{380}{6.002}$ = 63.6 mg. Copper	Copper 63.3	+ 0, 4%
4.	Cupric Chloride $Cu\,Cl_2$	+ Copper — Platinum Carbon	Reduction of 190 mg. Copper	$\frac{190}{6.002}$ = 31.8 mg. Copper	Copper 63.3	+ 0, 4%
5.	Copper Sulphate $Cu\,SO_4$	+ Copper — Platinum	190 mg. Copper.	$\frac{100}{6.002}$ = 31.8 mg. Copper	Copper 63.3	0, 4%
6.	Stannic Chloride $Sn.\,Cl_4$	+ Platinum or Tin — Platinum or Carbon	170 mg. Tin.	$\frac{170}{6.002}$ = 28.3 mg. Tin.	Tin 117.8	— 4 %

The figures, representing the quantities of cathions liberated, give when compared to one unit weight of hydrogen, the amount of metal represented by one of their valences, while a single valence represents its atomic weight. In the solutions 2 and 4, the silver and copper atoms monivalent, in 3 and 5 the copper atoms are bivalent, while in 6 the tin atoms are quadrivalent.

From the foregoing it will also be seen that the quantity of cathions or anions liberated are proportional to the strength of the current and the time through which it is acting. According to researches of F. and W. Kohlrausch, 0.3289 mg. copper are liberated from the solution of an oxide salt of copper by one coulomb.

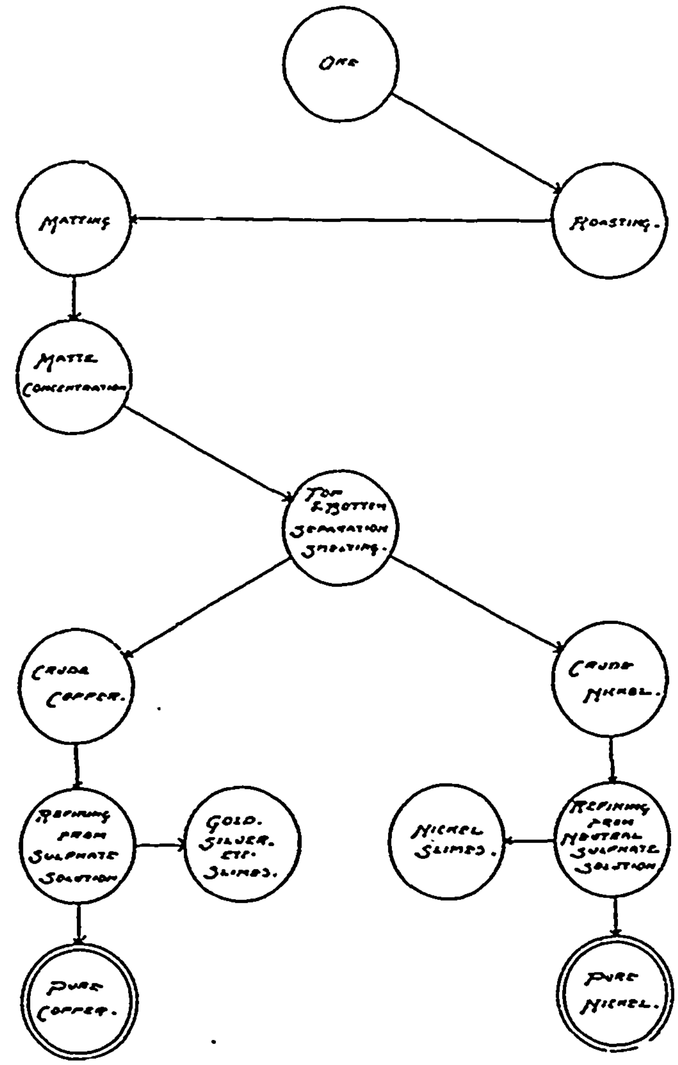
0,6578 mgs. of Copper from cuprous salt.
0,3050 mgs. of Nickel from nickel oxide solution.
0,2394 mgs. of Sodium from salt solution.
0,3682 mgs. of Chlorine from chloride solution.

This list can easily be extended and the values of all elements calculated. The results are known as the electro chemical equivalents. A coulomb being an ampere second, and knowing the potential difference necessary to overcome polarization and bring about dissociation of an electrolyte, the power necessary to deposit a certain quantity of metal from an electrolyte can easily be calculcated. For example, estimating a horse power at 730 watts, or volt amperes, and figuring the potential difference of an electrolyte at one volt, a horse power will contain 730 available amperes. From the above we have the deposition of 0.3289 mg. copper through one coulomb, which, in one hour would be (0.3289 mg. x 3600 seconds) 1.18 grms. copper per hour. 1.18 x 730 equals 861 grms. per hour per horse power, or 20 kilos, about 44 pounds, per horse power day.

As the subject of this paper is electrolytic production of metals, the methods by which matte and crude metal are obtained can only be briefly discussed, For their production various metallurgical operations are resorted to. The ores are subjected to roasting and smelting operations, thereby increasing the metallic values of the products and eliminating some impurities,. When the metal content is sufficiently high they are subjected to what is known as the Bartlett-Thompson separation smelting, by this means producing crude copper and nickel. The crude metals are then electrolytically deposited in general from sulphate or chloride solutions on pure metallic cathodes. (Process by Titus Ulke.)

In the production of copper and nickel, we will first take up the subject of refining. For this purpose a high grade matte, or, better still, crude metal of about 95 per cent. fineness is necessary. The possibility of refining copper by this means was made known by Cruikshanks' researches, dating back to 1800. Of greater importance to refining in general is the process patented by Elkington in February, 1870. This process is the basis of all refining processes in present use, and the inventor claims the recovery of copper, together with the separation of other metals associated therewith. To this end copper ores undergo smelting operations until crude metal is obtained, which is then cast into plates. With the aid of electric current, these are dissolved in a suitable electrolyte and the copper deposited upon other plates. The precious metals contained in the crude metal fall during electrolysis to the bottom of the electrolytic vats. The inventor prefers working ores which contain sufficient silver to effect the good qualities of a pure copper. The impure, or blister copper, is tapped from the melting furnace into cast iron molds, about 600 mm. long, 200 mm. wide, and 25 mm. thick. In one end of such a plate a large and heavy T shaped headpiece of copper is cast into the same. The object of the T shaped headpiece is to provide means for the suspension of the plate and at the same time secure electrical contact. These plates are then suspended, together with the cathode plate, in earthenware vessels arranged in terrace form. This terracing to facilitate the circulation of the electrolyte, which is a solution of copper sulphate, containing a small amount of free sulphuric acid. The vessels, or electrolytic baths, are connected with each other by lead pipes. The solution from the lowest vessel flows into a sump, from which it is pumped to the vessel at the head of the system, and is again allowed to circulate through the system. The variations of this process and the manner in which the refining of metals is now carried on, are wholly mechanical, and in no way is the original process changed or new principles introduced, although there are innumerable improvement patents in existence. The pioneers in the work of developing the electrolytic refining of copper are Siemens and Halske, of Berlin, through whose efforts the success of the process has been largely secured.

It may here be noted that the method described in the treatment of copper is applicable to the production of other metals: gold, silver, lead, zinc, nickel, etc. The Wallace Farmer patents, a description of which will be given later, have special application to this extension of



A scheme for the Production of Copper and Nickel (according to information received by writer) as proposed by Mr. Titus Ulke, for the working of Canadian Pyrrhotite Nickel Ores at the Sault Ste. Marie, Canada. From the above diagram it will be noticed the process is a refining process and uses crude metal as anode material, necessitating roasting and smelting operations together with separation smelting to the stage of obtaining a crude metal of about 90 to 95% metal contents.

the process of all metals, especially to nickel. In fact, the production of fine nickel from crude nickel anodes, using an electrolyte of nickel ammonium sulphate, is at present being carried out on the lines indicated for copper production, and the success attending refining has led to much experimental work on lines tending toward direct production of metals from ores or furnace products. This brings us to the second phase of electrolysis; namely, the direct production of the metal.

Many experiments were made to solve this problem by using mattes or furnace products directly as anode material in a suitable electrolyte identically as in copper refining. It must be born in mind that, in copper or metal refining it is very necessary for economic working to have a pure anode material. Even then the electrolyte will become so fouled by the accumulation of impurities that it becomes necessary to regenerate it. The question may naturally be asked here, if impurities accumulate with comparatively pure anode material, what will be the ratio of this accumulation, and what will be the effect in using an anode material containing from 10 to 95 per cent of impurities? Upon the answer to this question hinges the direct economic production of metal through electrolysis. A number of processes tend to answer this question, and we will speak of them in the order of their priority or date. First of these is the Marchese Process, (D.R.P. No. 22429 May 2nd, 1882.) This process was given a thorough trial by the Societa Anomima Italiana of Genoa. This company built a 125 horse-power plant for a practical test, and after spending large sums of money came to the conclusion that the same was a failure. The method of working was as follows :—

1st. The smelting of copper-bearing ores to matte of about 30 per cent copper and 40 per cent. iron was accomplished by well-known methods.

2nd. This matte was cast in plates (800 x 800 x 30 mm.) by means of iron frames or molds, a strip of copper being at the same time cast into the matte to serve as connection. Later this strip of copper was supplemented by a copper wire gauze extending through the whole form. This was done in order to prevent a too rapid disintegration of the anode plate, and also to equalise the distribution of the electric current throughout the whole mass composing the anode.

3rd. The cathodes, thin copper plates (700 x 700 by 0.3 mm.) were suspended by copper strips from wooden rails extending over the bath.

4th. The electrical connection between the anodes and cathodes of a single bath and twelve baths were known as a multiple series. All the cathodes of one bath were connected to one conductor, while all the anodes were connected with the positive conductor. The connection of the first to the second bath, and of the second to the third, and so on throughout the series, were made between the cathodes of the preceding bath and the anodes of the following bath.

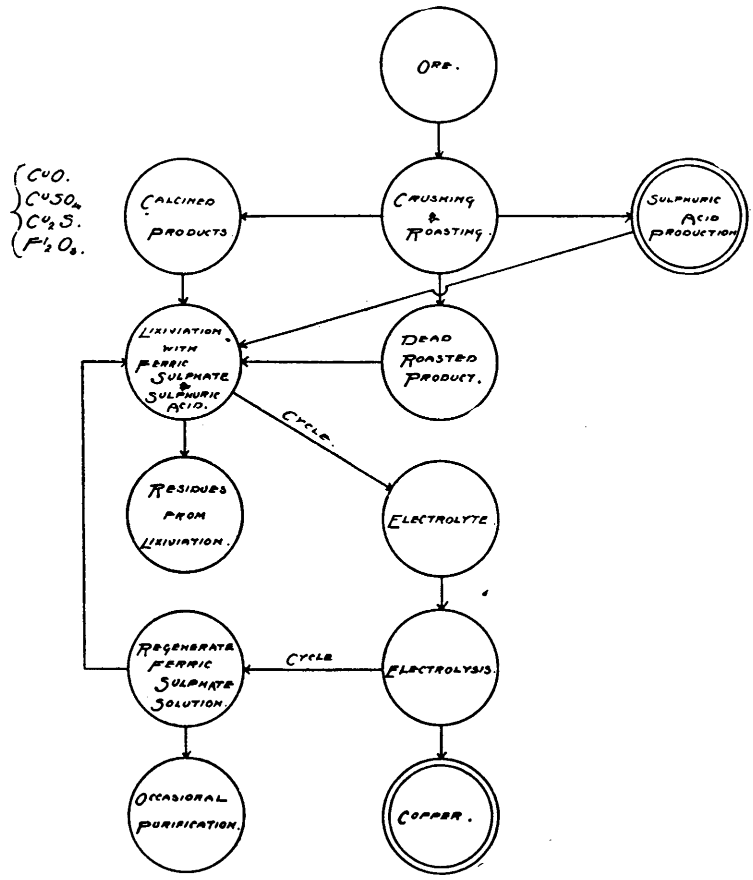
5th. The baths were lead lined wooden vats (2000 x 900 x 1000 mm. deep). Twelve of these vats set in terrace form were connected to one machine.

6th. The electrolyte was composed of a solution of copper and iron sulphate, which was obtained by roasting ore and leaching the roasted product with dilute sulphuric acid. The circulation of the electrolyte through the series of baths was accomplished by means of lead pipes connecting the individual baths, the overflow from each entering at the bottom of the succeeding bath. (The diagram giving outline of process is appended).

This process proved a failure from a financial standpoint and was speedily abandoned. The prominent reasons for this failure were the uneven disintegration of the anodes, polarization arising from the encrusting of the anodes with impurities and consequently a very high rise in voltage, and further an accumulation of impurities in the electrolyte.

Nothwithstanding the failure of the Marchese Process, certain experiments carried on in connection therewith developed valuable and interesting facts. The action of the electric currents upon iron salts, during electrolysis, was found to result in the production of ferric sulphate from ferrous sulphate. This fact was made the basis of a patent issued to Body in 1886. Although Body's process and apparatus were not limited to copper alone, but were made the issue or the extraction and recovery by electrolysis of metals in general. This process is in reality the forerunner of what are at present the two principal processes for the recovery of metals from their solution; namely, that of Siemens and Halske, and that of Hoepfner.

Body's electrolytic vat consists of a square box made of Portland cement and covered with an acid and waterproof paint. Parallel to the four sides and some distance therefrom, are four tile plates so



Outline scheme for the Electrolytic Production of Copper. Siemens & Halske (Ferric Sulphate) Process.

joined as to form a second box. The bottom of the outside box is composed of a carbon plate and is connected as an anode to the terminal of an electrical generator. The four tile plates composing the inner box are half the height of the outer box. Within the gap formed by the inner box and the bottom of the outer box, is stretched a felt cloth or some form of a diaphragm. In the space between the two vessels the copper cathodes are suspended. The electrolyte, composed of a solution of a ferric salt in salt or sodium chloride, enters the bottom of the inner vessel. Upon the carbon plate is placed raw ore. The solvent action of the electrolyte, together with the action of the electric current, dissolves the soluble part of the ore. The electrolyte, after filling the inner vessel, overflows into the outer, and here the copper, which it has taken up, is deposited. The electrolyte is drawn off at the bottom of the outer vessel.

According to Body's specifications, as the electrolyte flows through a bath, the following reactions take place:

1st. The metals contained in the ore are brought into solution by the reduction of a ferric sulphate or chloride solution to ferrous sulphate or ferrous chloride.

2nd. The dissolved metals are deposited upon the cathode.

3rd. The nascent chlorine generated at the anode reconverts the ferrous salts into ferric salts, and the excess of chlorine dissolves more metal from the ore lying in contact with, or existing as part of the anode.

Body's process was improved by Siemens and Halske. The improvement consisted in having the reactions between ferric salts and the metal in the ores take place outside of the electrolytic vats, and independent of the electrolysis. Figuratively speaking, they stored up the work at the anodes in the electrolytic baths for immediate use outside of the baths. In their patent specifications they claim the following method of procedure :

Sulphide ores (copper bearing pyrites, etc.) are roasted at a low temperature in such a manner that the iron contained therein is mostly oxydized, while a part of the copper should be present as copper sulphate, another part as oxide, but by far the greater part as sulphide. The roasted ore is then leached with the solution flowing from the electrolytic decomposition vats. When this solution had dissolved as much copper as is possible and all the iron salts have been converted back again into the ferrous condition, the same is then returned to the electrolytic vats for copper extraction and reconversion of the ferrous salts to ferric salts. The solution is then returned to be used for further extractive purposes. This cycle continues until the solution becomes so fouled with impurities that it becomes necessary to purify the same. The chemical processes involved in leaching and electrolysis are represented in the following equations:

1.—$H_2SO_4 + 2\ CuSO_4 + 4\ FeSO_4 = 2\ Cu + 2\ Fe_2(SO_4)_3 + H_2SO_4$.

2.—$x\ H_2SO_4 + Cu_2S + 2\ Fe_2(SO_4)_3 = 2\ CuSO_4 + 4\ FeSO_4 + S + x\ H_2SO_4$.

3.—$CuO + H_2SO_4 = CuSO_4 + H_2O$.

4.—$3\ CuO + Fe_2(SO_4)_3 = 3\ CuSO_4 + Fe_2O_3$.

5.—$CuO + 2\ FeSO_4 + H_2O = CuSO_4 + (Fe_2O_3 + SO_3) + H_2$.

If we compare reactions 1 and 2, we will immediately see that, provided all the copper in the ore exists as copper sulphide (Cu_2S), the solution after lixiviation contains exactly as much copper sulphate, iron sulphate, and sulphuric acid (reaction No. 2) as the solution before electrolysis has taken place (reaction No. 1). In other words, the electrolyte is completely regenerated, and can be used as such.

From reactions 3, 4, and 5 it will be seen that if the ore contains copper oxide, the solution will contain more copper, less iron, and less sulphuric acid.

It is hardly necessary to state that copper matte may be used instead of roasted ore. In this case, more iron will be brought into solution, and it becomes a difficult technical proposition to obtain solutions of the identical chemical composition. It may here be noted that in the electrolysis of the above solution, provided a good and rapid circulation exists, hardly any polarization is found to take place, and the potential difference of a bath remains constant at about 0.7 volts for the same current density, as when refining with matte or soluble anodes requiring about 1.5 volts for the decomposition of the anodes and the deposition of copper.

The electrolytic bath used by Siemens and Halske consisted of a shallow wooden vat, containing a false bottom. Upon this bottom is placed the anode, which is in turn connected with the terminal of the dynamo through an insulated cable. The anode is composed of gas retort or artificial carbon, either in plates, rods, or broken pieces. If the broken pieces are used, they receive a bedding composed of perforated lead plates. On, and covering the anode is placed a diaphragm or filter composed of felt or some other suitable substance. The space over the filter or diaphragm, known as the cathode chamber, contains the cathode in the form of a revolving cylinder, being a cylinder of wood covered with a thin sheet of pure metallic copper, which in turn, through brushes and the like, is connected to the other machine terminal. The cathode cylinder can be revolved slowly by means of suitable gearing or power transmission. The copper containing electrolyte flows into the cathode chambers in such quantities that the cathode cylinders are at all times covered by it. By rotation of these cathodes, the cathode solution is kept in constant motion or circulation. The electrolyte passes through the filter or diaphragm and fills the anode chamber, whence it is drawn off from this space formed through the false bottom. The inflow is kept constant with the outflow, thereby securing perfect circulation. The electric current enters the bath through the anodes and leaves it through the cathodes. At the cathodes the electrolyte gives up about two-thirds of its copper contents, while at the anode an equivalent quantity of sulphuric acid ($SO_3 + O$) is liberated. The electrolyte, partially freed from its copper, flows through the filter into the anode chamber, where the ferrous sulphate, formed in the leaching of the ore, is reconverted in ferric sulphate by the sulphurous anhydride liberated at the anode. The ferric sulphate solution, on account of its higher specific gravity, sinks to the bottom of the vat and is there withdrawn, to be again used for leaching purposes. The potential difference of a bath is claimed to be 0.7 volts at 16 amperes per square meter of cathode surface. Within the last four or five years, extensive mechanical improvements have been made in conjunction with this process.

With the above process it is possible to bring into solution copper and nickel bearing materials on identically the same line as copper

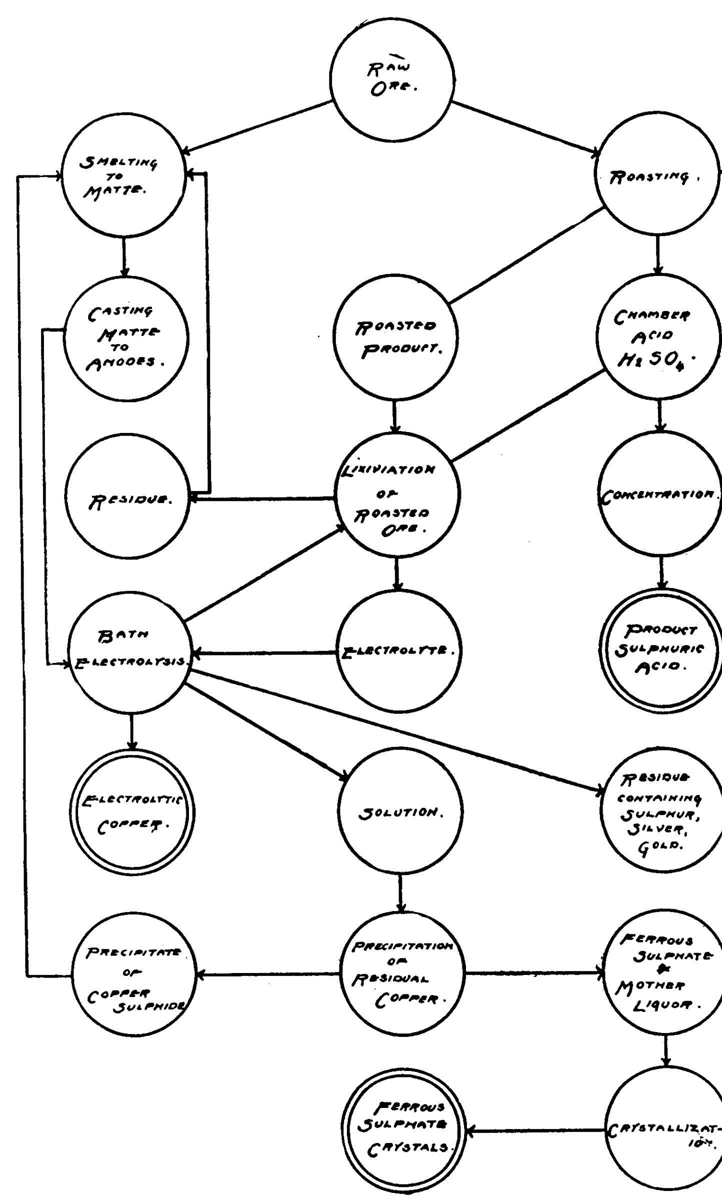


Diagram of the Marchese Process.

alone, enabling to produce copper and nickel from ores and furnace products (mattes, etc), containing both. Since copper is deposited at a different potential difference from that required to deposit nickel, it becomes possible to separate the copper from the nickel contained in the electrolyte, producing thereby a solution of nickel, iron sulphate, from which nickel can be separated either as a salt by displacement, or produced electrically in the metallic condition. It has been found that copper chloride acts similarly to ferric sulphate or chloride, in many chemical reactions—it undergoing oxidation and reduction, and a change of valence very similar to that observed in iron salts. This property of copper salts was introduced as an improvement over the Siemens and Halske process, and we have in this the fundamental principal of the Hoepfner electrolytic process. As in the Siemens and Halske process, we have the extraction of ores or metal bearing products with cupric chloride. The cupric chloride reduces to culprous chloride the same as ferric sulphate or chloride to the ferrous condition. While the cupric chloride is being reduced, an equivalent amount of metal from the product to be leached is dissolved. The process as carried out in practice is as follows: Ore, mattes, or other furnace products, are pulverized. This finely-ground product is treated with a hot solution of chloride, associated with salt, or saline chloride solution. The cupric chloride solution should contain from 60 to 75 grms. of copper per liter. The leaching is performed either in suitably constructed revolving drums or cylinders, or by means of a jet of superheated steam acting upon the pulverized ore product and leaching solution in specially constructed vessels. (This improvement was devised and introduced by the writer while in Europe in 1896.) By this means the cupric chloride solution is converted into cuprous chloride, dissolving an equivalent amount of copper from the material to be leached. If the cupric chloride solution contains 60 grams copper per liter before leaching, after leaching it will contain theoretically 120 grams of copper per liter. This ratio is very nearly attained in practice. If the ores or mattes contain silver, gold, nickel, cobalt, etc., the same will go, in equivalent amounts into solution, producing a complex chloride solution. This solution, after arriving at normal temperature, is ready for electrolysis. By submitting this solution to electrolysis, using copper electrodes, it is possible to drive all the silver, gold, and precious metals out of solution. (Improvement devised and introduced by the writer in 1895). According to Dr. Hoepfner, to establish between electrolysis and lixiviation of ores a process constituting a true cycle, it is necessary to have the original lixiviating liquid produced by electrolysis and the original electrolyte reproduced by chemical process.

For the successful carrying out of this scheme the arrangement of the baths, the chemical composition and the circulation of the electrolyte become of the highest importance. In carrying out his process (D.R.P. 53782, March 1888) he employs baths or a system of baths divided by diaphragms into two compartments. One compartment contains anodes which cannot be dissolved by electrolysis or nascent chlorine and the other compartment cathodes of pure sheet copper.

A solution of a halogen salt and cuprous chloride circulates by itself past the anodes and a similar solution flows past the cathodes. At the cathode metallic copper separates, and at the rate of 2.36 grms. for each ampere hour, or twice as much as is deposited by unit current when a solution of an oxide salt is used, viz., copper sulphate.

At the anodes free chlorine would be produced if no cuprous chloride were present at this point, and a voltage of 1.8 volts would be necessary at the poles of the bath.

The chlorine, however, combines in the nascent state at once with the cuprous chloride which should be present to form cupric chloride. By this means a depolarization is produced which experience has shown amounts to about one volt. The electrolysis therefore practically proceeds with a potential difference of only 0.8 volts per bath.

Cuprous chloride ($Cu_2\ Cl_2$) develops in its formation 65.75 calories. Now as 45 calories of heat thus developed correspond to one volt of electromotive dissociating power, $65.75 \div 45 = 1.46$ volts is that electromotive force in volts which is necessary for decomposing cuprous chloride into 2 copper and 2 chlorine atoms. $Cu_2\ Cl_2 = 2\ Cu + 2\ Cl$.

In order to overcome this resistance in practice the tension must increase to about 1.8 volts, as with 1.46 volts the dissociating and combining power only just balance each other, so that a quantitative decomposition cannot as yet take place. When, however, chlorine in a nascent state oxidizes cuprous chloride to cupric chloride the following reaction occurs:—$Cu_2\ Cl_2 + Cl_2 = 2\ Cu\ Cl_2$. As cupric chloride ($Cu\ Cl_2$) represents 125.4 calories, $125.42 - 65.75$ or 59.67 calories become free and help the work of the depositing current. Theoretically, therefore, according to Hoepfner, electrolysis commences when applying only $65.75 - 59.67 = 6.08$ calories, or 0.13 volts.

The liquor at the cathodes, while successively flowing past a number of cathodes, gradually loses all its copper and leaves the electrolytic

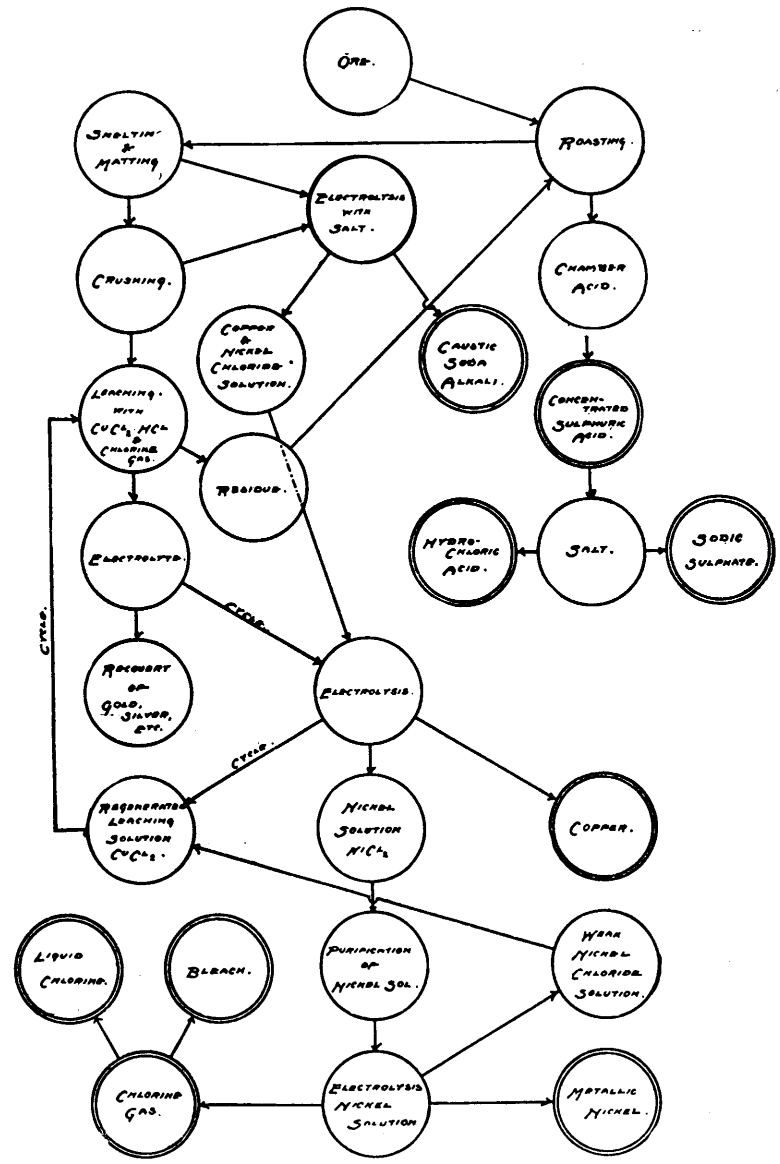


Diagram for working Chloride Solutions viz. Hoepfner Process, together with additions and improvements introduced by writer, viz.: Production of caustic (Salt Electrolysis) Liquid Chlorine, utilization of sulphur for Sulphuric Acid, Salt Cake and Muriatic Acid; also Nascent Chlorine for leaching purposes.

bath to be later on brought back into the process for completing the cycle. The liquor at the anode retains its full copper contents, but in the state of cupric chloride instead of cuprous chloride. At the electrodes the following reactions take place:—$Cu_2\ Cl_2$ gives 2 Cu at cathode, while by electrolytic displacement the chlorine travels to the anode and combines with the cuprous chloride to form cupric chloride ($Cu_2\ Cl_2 + {}_2Cl = 2\ Cu\ Cl_2$).

The solution of the cupric chloride coming from the anodes is then employed for extracting copper, etc., from ores, mattes, and the like. In copper ores containing sulphide of copper the following reaction takes place:—($Cu\ Cl_2 + Cu\ S = S + Cu_2\ Cl_2$.) (${}_2Cu\ Cl_2 + Cu_2\ S = S + 2\ Cu_2\ Cl_2$.) This shows that the cuprous chloride formed has taken up as much copper as had previously been precipitated by electrolysis as metallic copper. As compared with the quantity of copper the concentration of the liquor is now twice as great as originally; in order, therefore, to establish the original concentration the cathode liquor which has been electrolytically deprived of its copper and flowing from the cathode cells is added thereto. It will be seen that the above constitutes a continuous process forming a complete cycle. The cycle is distorted by the gradual dissolution of iron, arsenic, antimony and the like impurities contained in the ores or mattes which become dissolved in place of copper. This defect, however, is overcome by the removal of such impurities, more especially the iron, by the purely chemical method through the use of oxide of copper before conveying the cathode liquor to the baths.

Simultaneously with the iron, arsenic, antimony and bismuth disappear. The advantages of this process according to Hoepfner are: 1st. Twice as much copper is produced from chloride solution as from sulphate with the same expenditure of energy. 2nd. The halogen salts of alkalies and earth alkaline metals (especially calcic chloride) possess such a dissolving capacity for cuprous chloride that in case of solutions free from iron, concentrations can be effected which cannot even be remotely obtained with sulphate solutions. From this it follows that the slighter volume of liquid used in the Hoepfner process enables a smaller plant to produce the same quantity of copper as a much larger plant using sulphate solutions.

An acid solution of cupric chloride in calcium chloride is a very powerful solvent of many metals. If the solution contains free chlorine, gold, silver and allied metals are readily brought into solution, and through proper means can be readily recovered from such solutions independently. In properly constructed divided baths, having a perfect circulation of the anode and the cathode portions of the electrolyte, the writer has obtained from cuprous chloride solutions a quantity of copper comparing very favorably with the best electrolytic copper produced from sulphate solution. The voltage necessary did not exceed one volt per bath. Therefore one horse-power day, at the rate of 700 volt amperes to the horse power, produces 39.6 kilos. or 87 pounds of pure copper to the horse-power. This is double what can be obtained from sulphate solutions.

Cohen cites a very interesting experiment in the electrolysis of cuprous chloride without diaphragms. He noticed that in the electrolysis of chloride solutions at a low current density the solution of cupric chloride, regenerated at the anode, sinks to the bottom of the vessel containing it, on account of its increase in specific gravity, and there forms a definite rising stratum. If the copper cathode be of sufficient length to reach this stratum copper will be dissolved from the same. By employing a very deep bath this difficulty is overcome. His method was as follows:—A deep vessel, having a sump in the bottom thereof, a long carbon anode extending into the sump, a siphon removing the solution from the sump, a short copper cathode reaching about half-way down the bath and an inflow to supply perfectly reduced cuprous chloride solution. Cohen claims that with this apparatus a current density of 20 amperes per square meter cathode surface, and a potential difference of one-half volt per bath, he has obtained copper equal in all respects to the best copper produced by any known process. According to Cohen's claim, it would be possible figuring 700, instead of 730, volt amperes to the horse-power, to produce 79.2 kilos, equivalent to about 174 pounds of pure copper to the horse-power day. Theoretically the above is possible, but the writer thinks that practically it would be very difficult to attain any such results.

If copper nickel ores or mattes are used in the Hoepfner process after removing the copper, a solution coming from the cathode compartments of the bath will be obtained containing all the nickel, cobalt, etc., in the original electrolyte. This solution upon purification by the removal of iron, cobalt, etc., electrolyzed in proper baths, will yield nickel and free chlorine gas. The chlorine gas coming from the nickel electrolysis is in the Hoepfner process reabsorbed by a cuprous chloride solution to be further used in extracting more metal from ores and mattes, or it may be condensed into liquid, or absorbed by lime to produce bleach. The electrolysis of nickel chloride reverts back to a simple chloride solution ($NiCl_2 = Ni + Cl_2$), and for every 59 equivalents of nickel deposited there will be 71 equivalents of chlorine gas set free. The electrolysis of a nickel chloride solution is a simple and elegant technical proposition. Practically about six kilos or thirteen pounds of nickel are produced by one horse-power day. This yield is accompanied by the liberation of about 15 pounds of chlorine gas, yielding 45 pounds of 35 per cent. bleach. Sulphate and chloride solutions are of such a nature that one can almost say that what is possible with the sulphate solution is also possible with the chloride solution. It is in fact just as easy to refine from a chloride solution as from a sulphate. It is therefore possible to produce copper and nickel or any other metal from a chloride solution at the same time using a soluble anode. The electrolysis of a salt or sodium chloride solution in the presence of a soluble copper and nickel anode producing thereby a solution of copper and nickel chlorides and alkali (caustic soda), was introdnced by the writer as a part of the chloride process for producing metals (1898), that is solutions of metallic chlorides from copper, nickel ores, mattes, etc.

The electrolysis of a salt solution having as an ultimate object the production of caustic together with metallic chloride was made the basis of a patent issued to Faure, Eng. Patent No. 1742, in 1872, and again Trickett & Noad, Eng. Patent No. 7754, 1888. (For further particulars see *Electrolytic Alkali Industry*, George Lunge, Vol. 3.)

Little was known regarding the production of electrolytic nickel prior to 1840. At that time an English patent was granted claiming the recovery of nickel from the solution of the double cyanides. This patent had little value. But of greater importance are the researches of Böttger, who established the conditions upon which the production of pure nickel from nickel ammonium sulphates or chlorides depend. This suggestion toward the production of pure nickel was made the object of a patent by Andree, Nov. 1st, 1877. According to Andree, nickel ores or mattes or nickel-cobalt-copper combinations, either as sulphides or arsenides are connected with the positive terminal of an electric generator and suspended as anodes in dilute sulphuric acid. Upon the cathodes only pure copper would be deposited, while the nickel going into solution remained in solution as long as the electrolyte remains acid. Towards the end of the operation, carbon anodes replace the matte anodes and all the copper is forced out of solution, leaving an electrolyte of nickel sulphate with iron sulphate. To electrolyze this solution the same is displaced or made alkaline with ammonia, the precipitated iron separated by filtration and the resulting nickel ammonium sulphate solution electrolyzed producing thereby pure nickel. About ten years later, in April, 1888, Farmer applied for a patent upon an apparatus having for its object the production of sheet metal and the refining of crude nickel. Farmer uses a revolving drum placed in a vat containing an electrolyte of nickel ammonium sulphate, chloride or nitrate. The anode of the bath is composed of a semi-cylinder of impure nickel placed below the drum with its curvature in the direction of the drum or cathode. The cylindrical cathode revolves, thereby agitating the electrolyte while at the same time the nickel is deposited by means of the electric current passing through the same. It is difficult to electrolytically separate from crude nickel the metals which contaminate it. A patent was issued to Basse & Selve in 1891 having for its object the separation of nickel from iron, cobalt, zinc, etc. To accomplish this a neutral or weak acid solution, containing nickel, cobalt, iron, zinc, etc., is treated with a sufficient quantity of an organic substance to prevent the precipitation of nickel, iron, etc., through alkalies. Concentrated caustic is added to slight excess, and the resulting solution electrolyzed. At a current density of 0.3 to 1.0 amperes per square decimeter of cathode service, iron, cobalt and zinc separate at the cathode, the nickel remaining in solution or partly separates as hydroxide. If the current density is large and the solution strongly alkaline, nickel will also separate as hydroxide at the cathode. In order to obtain the nickel from the purified solution the solution is treated with carbonic acid or ammonium carbonate to convert all free alkalies into alkali carbonates. The solution is then again submitted to electrolysis. The organic compounds used for the above purpose are tartaric, citric, acetic acids, glycerine, dextrose, etc. The writer has obtained very good results in this direction by the use of creosote sulphonic acids, made by treating phenoles, obtained from coal tar with sulphuric acid.

The much patented double decomposition arising when a solution of sodium chloride is electrolyzed in the presence of soluble anodes, carrying metals capable of forming chlorides, has again been made the basis of a patent granted to Frasch in 1901. The Frasch process was supposed to be an improvement on the Hoepfner process and was expected to supercede it and completely revolutionize all methods involved in the electrolytic production of metals. Much was claimed for the process by the inventor, but little has been realized, as the result of its work at Hamilton, Ontario, show. Sufficient critical comment upon the Frasch process has appeared within the past year to make further details regarding it unnecessary here. It is the writer's opinion that the patent for the Frasch process was granted as the result of the exertion of a shrewd patent solicitor rather than the public recognition of an invention containing new and original ideas on the subject of electro-metallurgy.

Hoepfner's process, or rather the legitimate electrolysis of chloride solutions, is a commercial success, as is evident from the fact that, 1st, the Papenburg Works in Europe continue to operate the same; 2nd, the Canadian Copper Co. are daily producing a ton or more of metal from chloride solutions, and, 3rd, zinc production from zinc chloride, which is technically a much more difficult problem than nickel from nickel chloride, is successfully carried on at present at the Brunner-Mond works in England. It stands to reason, therefore, that the failure of the Frasch process, judging from results at Hamilton, must be explained in other ways than in the technical difficulties surrounding the electrolytic decomposition of a chloride solution.

In the production of metals by the Hoepfner or by the Siemens & Halske process the question of diaphragms is an important one. The reactions occurring at the cathodes are always of a reducing nature, while those at the anodes are always of an oxydizing nature. The result is that the electrolyte surrounding the anodes is of a different chemical nature from that surrounding the cathodes and it becomes necessary, therefore, to keep the electrolytes separated by a substance having the property of allowing the individual ions to pass, but at the same time preventing the anode and cathode solutions from mechanically mixing. In the earlier experiments felt, cotton cloth, jute, parchment paper, etc., etc., were largely used. Hoepfner uses nitrated cotton-ducking to advantage. In recent times porous tiling and the like (porous cup material as used in two liquid or primary elements) has come extensively into use. The writer is informed that the Canadian Copper Company is using this substance at the present time in the construction of its baths. The Pukall porous cups and diaphragms manufactured by the Royal Berlin Porcelain Company of Europe, are coming into extensive use. Asbestos cloth, mineral wool, spun glass, sand, cements, etc., etc., in almost every conceivable form and combination, have been patented for the above purpose. Although there are innumerable patents, good, bad and indifferent, affecting the manufacture and use of diaphragms, very few of them give satisfactory results.

From what has been said it will be seen that the electrolytical production of nickel and copper as at present carried on reverts back to two fundamental methods, namely: 1st. The production from sulphate solutions; and, 2nd: The production from chloride solution, and any variations of method claiming to introduce new and original ideas or novelties are more of a mechanical than a chemical nature. It was the intention of the writer to furnish a list of patents on this subject, but the number is legion, and it was thought better not to cumber this paper with information which can be had from the Patent Office. In fact, the chemical and mechanical part of electrolysis has been so many times patented that doubt is thrown upon the merit and validity of each and every patent of this nature now upon the market. The question continually arises: Which of these patents are good, and to whom should the producers of metals pay royalties? So uncertain is the answer to these questions that resort is more and more made to the courts, and pending their decision capital is tied up and production stopped, and a new element added to the uncertainties of metallurgical and mining operations which should be as positive in operation as they are scientific in method.

Appended are outline schemes showing the more prominent features of the different processes in use.

MR. E. V. CORLESS, B Sc, McGILL

Who was awarded the President's gold medal for the best Students' paper presented to the Transactions of The Canadian Mining Institute during 1901.

BELL'S ASBESTOS.

The directors beg to submit to the shareholders the report and audited accounts for the year ended 31st December, 1901.

The result of the year's operations is a net profit of	£ 16,824.16.6
To which has to be added the amount brought forward	1,913.14.2
Leaving for appropriation	£ 18,738.10.8

The directors recommend:—

1. The payment on the 7th April, of a dividend at the rate of 6 per cent. per annum, free of income tax.

2. To place to reserve fund £9,000.

3. To carry forward £2,538 10s. 8d.

The trade of the company in raw and manufactured asbestos and machinery, and the result of the working of the company's mines in Canada, showed considerable improvement during the year.

Asbestos in Vermont.—In a report to the Directors of the Geological Survey of the United States, Mr. J. F. Kemp has something to say of the occurrence of asbestos in the State of Vermont, which will, we are sure, be of interest to those of our readers who are interested in the production of the mineral in Canada. He says:—

The asbestos occurs in two distinct and contrasted varieties. In one case it forms veins which ramify in every direction through the serpentine. The asbestos fibres are perpendicular or at a high angle to the walls, and vary from a maximum length, as at present exposed, of ¾ of an inch, down to not more than 1-16 of an inch. The variety is similar in all respects to the Canadian product but it is met only in the prospects owned by Mr. Tucker at Tucker's Mill and near Lowell. The second variety of asbestos is what, for lack of a better name, I will call "slip-fiber" because it occurs upon the slickensided surfaces that are common to this exposure of serpentine, just as to all others the world over. These fibres form layers of varying thickness, seldom more than ¼ of an inch, but as they run parallel to the slickensided surfaces they may themselves be of various lengths, from a fraction of an inch up to 3 or 4 inches. The fibre is coarser than that of the veins, and will not furnish so good a grade. At the same time it occurs in larger quantity. This is the variety of fibre which will be produced by the New England and the National companies. It also appears in a minor degree in the other openings

The developments of the New England company are the most advanced. Foundations have been laid for a mill of an estimated daily capacity of 400 tons. An engine-house has already been erected and equipped, and a superintendent's house is nearly completed, in addition to boarding houses for the men. The mill is admirably located, so that from the cliff of asbestos rock, which rises to the north of it and is much higher, the crude material will be run into it on tram cars and will pass by gravity through the concentrating process. The mill will, in the natural order of things, be productive in 1902. At the National company only a small open cut has been made, in order to expose the deposit. The writer was unable to learn whether the installation of the mill, etc., is immediately contemplated or not. In the town of Lowell the enterprises have as yet only reached the stage of open cuts. In the openings thus far made near Lowell the quantity is apparently not so great as at Tucker's Mill, although the general quality appears to be much the same.

There is little doubt that the region will become commercially productive, and that very considerable amounts of asbestos will be contributed by it to the markets.

Canada's Great Nickel Deposits.—Dr. A. E. Barlow in a short summary of his investigations in the Sudbury District last year for the Geological Survey concludes: It is now confidently believed that the nickel and copper deposits of Sudbury are the most important of their kind known in the world. The inauguration of the extensive and well equipped works of the Mond Nickel Company at the Victoria mines, and the extension of the works of the Canadian Copper Company, will rapidly place Sudbury in the foreground of the nickel-producing areas of the world.

Graphite Mining in Canada.—It is understood that the property owned by the Walker Mining Company, Township of Buckingham, Que. has been sold to a strong American Syndicate and that on the completion of certain negotiations with the old mortgagees, work will be prosecuted on an extensive scale. During the past year considerable progress was made in this industry and the outlook for a larger production of this valuable mineral in Canada is more hopeful. Work was prosecuted at the deposit at Calumet and some selected mineral was shipped. The North American Graphite Company worked during most part of the year and shipped a number of car loads of the finished product of its mill. It is hoped that the investigations and experiments during past years, made by this company, have resulted in such improvements in the methods and machinery for the treatment of the rock that the difficulties encountered in the past will no longer debar the development of the extensive deposits of graphite-bearing rock of the vicinity. In Ontario, the Ontario Graphite Company has been taking steps to extend its operations by erecting a mill for the treatment of the ore.

Copper Production in New Brunswick.—In his report to the Geological Survey just issued, Prof. L. W. Bailey makes reference to the important copper mining operations now being carried on by the Intercolonial Copper Company at Dorchester, a subject by the way, on which we will have something further to say in a handsomely illustrated article in next month's Review. Professor Bailey says:—The conditions of the occurrence of ore at this point have been given in earlier reports. The ore is of low grade, not averaging over 3½ per cent. of copper, but is widely disseminated through the mass of the rock, from which, it is thought, that by the employment of new and improved processes it can be profitably extracted. For this purpose a large and expensive plant has been introduced, but at the time of our visit it had not yet been brought into operation. It is proposed to crush the entire rock, consisting of grey conglomerate and sandstone, more or less mixed with coaly matter and containing the ore, mainly chalcocite, in veins and scattered nodules, and, after roasting and treatment with acids, to separate the copper by electrical action. As copper ores of a like character and with similar associations are known to occur elsewhere in the province, as on the Nepinquit river, near Bathurst, the results of the operations at Dorchester will be awaited with interest.

CORRESPONDENCE.

The Lead Question.

Sir—I find from the Unrevised Statements of the Imports and Exports of the Dominion of Canada, that for the year ending June 30th, 1901, the imports of lead in all forms into Canada amounted to 11,394 tons, and for the half year ending December 31st, 1901, to 9,131½ tons.

The extremely low price prevailing in the latter period stimulated importation, and the figures quoted are probably the largest ever shown for any half year period.

Taken together, the quantity of 20,000 tons for 1½ years, indicates an average consumption of Lead in Canada of about 13,000 tons per annum, which agrees with the estimate generally made by those interested in the production of the article.

The United States appears to afford a market for about 280,000 tons of lead. Allowing our population to be one-fourteenth of their's, we should use in Canada about 20,000 tons per annum.

That we do not is due to two causes:—

1. That lead is largely used used in roofing, and in plumbing in large and costly buildings, such as are found only in great cities, and of great cities we have proportionately fewer than they.

2. Thrifty, enterprising, and well-to-do people, use lead paints largely for the preservation of their buildings and for decorative purposes. Those less wealthy, and less advanced in aesthetic culture, are content with whitewashes and ochres, or to allow their structures to stand four square to all the winds of heaven in native wooden nakedness.

As we have now emerged from the pioneer stage of Canadian experience, we may expect to see our comparative deficiencies in this respect immediately supplied.

Not only, from this time on, will our houses and barns of new erection be painted before occupation, but accumulated arrearages will be made good. All the old houses, and barns, and mills, and fences in the country will also be painted, so that the consumption of lead in Canada in the immediate future may be expected to reach not only a per capita ratio equal to that of the United States, but a higher figure, let us assume, 20,000 tons per annum.

In some appreciative remarks in regard to the lead mining situation in Kootenay, B.C., printed in your February number, you state, and quite rightly, that the crux of the question is that of a market, but you speak somewhat hopelessly of the value of our own home market.

It is a fact that the present ruling prices for lead in the London market are very unfavourable. In July, 1900, lead was worth in London £18 per long ton. In November 1901, it was down to £10 5s. Lately it has advanced to £11 7s. 6d, equal to $2.45 per 100 pounds.

At this rate the B.C. miner receives $1.46 per 100 lbs (being the London price, less $1.00 per 100 lbs. retained for refining and transportation to London) or for ore carrying 50 per cent. lead the miner receives $1.46 per 100 lbs. for 900 lbs., equal $13.14 per ton of ore, whereas freight and smelting charges are $15.00 per ton, leaving a balance of $1.86 to be paid out of the silver contents of the ore, together with cost of mining, conveyance from mine to railway, and all other charges.

The present price of silver (53 cents per oz.) is almost as low as has ever been known, and the situation is that only mines exceptionally high grade in silver can work.

The production of lead in B.C. in 1900 amounted to 31,000 tons, and the production in 1901 to 28,000 tons, but that it was maintained for the latter year at so high a figure was due entirely to the impetus given by the high prices of the year before.

The great lead producing mines of B.C. are now closed, and must remain so until prices rise, or the very distasteful alternative is resorted to of a lower rate of wages to miners.

The production of lead in 1902 will certainly not amount to 20,000 tons, and may not exceed 10,000 tons, so that had we the opportunity of supplying in full the Canadian market we would have for this year no exportable surplus.

Lead mined and smelted in Canada and refined abroad is now readmitted into Canada by payment of duty only upon the cost of refining.

There being as yet no refinery in operation in Canada, our smelters avail themselves of this privilege to the extent of supplying fully the Canadian demand for lead in the form of pig.

Of the total consumption of lead products in Canada, however, one half consists of "corroded" lead, the material which, when ground and mixed with oil, becomes lead paint.

By a maladroit arrangement of the Canadian tariff it occurs that the foreigner who is impeded by a 15 per cent. rate of duty (or if an Englishman by a rate of 10 per cent.) from shipping his pig lead into Canada, can by subjecting it to a further and important process of manufacture, get it admitted as raw white lead, at a 5 per cent. rate (or if an Englishman at 3⅓ per cent).

Against the competition of concerns in the United States and the Old Country, already engaged in the corrosion of lead on a large scale, with facilities already provided, and ample capital already invested, it is almost useless to expect the establishment of the business of lead corrosion in Canada, with a tariff fence so low as this.

I do not wish, for a moment, to use your paper as a medim through which to obtain circulation for a contribution to the current discussion upon the trade policy of the Government.

This particular item of the tariff was fixed as at present at a time when there was no lead prodnction in sight in Canada, and now that conditions have changed, it necessarily awaits a convenient opportunity for readjustment.

In the meantime it amounts to the offer of a premium for the manufacture abroad of an important article, the raw material for which is a drug in our own market.

I am aware that a proposition to increase this rate of duty will meet the objection that an increased price to consumers of paint will be involved, but there is no evidence that this would follow.

The duty upon mixed paint is now 25 per cent., and this I fancy fixes the price of paint mixed at home.

While our miners in B.C. receive for lead $1.46 per 100 lbs, their neighbours in the Coeur DeAlenes camp get from the Lead Trust of the United States $3.50 per 100 lbs., and yet the price of white lead in oil is practically the same (about $5.50 per 100 lbs) on both sides of the line.

I do not claim that while the present excessively low price of lead continues, that there is any very happy solution for the difficulties of the lead mining camps. But the opportunity to supply in full our own market would save the industry from extinction.

Even with last years' production of 28,000 tons, the sale at home of one-half, at London price without the deduction of freight to London, will greatly facilitate the disposition of the other half. And this could, I think, be accomplished if lead were given in the tariff the same treatment accorded similar lines of goods.

Bounty upon Refining.—In the Session of 1901, the sum of $100,000.00 per annum was appropriated by Parliament to be paid out during five years beginning July 1st, 1902, at a rate of $5.00 per ton of refined lead for the first year, with a decrease of $1 00 for each year.

Under the stimulus of this offer, a refinery in connection with the works of the Canadian Smelting Co., at Trail, is in an advanced stage of construction, and the Marysville Smelting Co. have also announced their intention of establishing one in connection with a smelter which they have under way at the Sullivan line in East Kootenay. At the time that this bounty was offered, the price of lead was about £14, and a production of about 30,000 tons per annum was being maintained.

The price of silver was at the same time 65c per oz., and an advance to 75c. was freely predicted. When a few months later lead fell to £10, and silver to 53 cents, the production fell off 50 per cent. or more, and is now proceeding, as I have said, at a rate of from 10,000 to 20,000 tons.

At the beginning of 1902 the B.C. smelters and railways met the necessities of their customers by a cut of $4.00 per ton of ore in freight and treatment charges.

It is possible that the present charge ($15 per ton upon average ore) would admit of further reduction, if it were possible for the smelters to market the lead bullion without loss.

The deduction of $1.00 per 100 lbs. from London price does not, however, come near meeting the actual cost of refining a ton of bullion, paying freight from B C. to London, and meeting the inevitable charges for commission, interest, etc., involved in the transaction.

The total of these charges is nearer $1.75 per 100 lbs. than $1.00, so that the whole of the earnings of the smelter for the treatment of ore would be lost in the cost of marketing, if the whole of the lead production was actually shipped to London.

That the business is continued at all under present conditions is due to the fact that a portion of the output is marketed in Canada, and another small portion in China and Japan, at prices slightly better than London and with a great saving in freight.

A readjustment of the terms upon which the bounty of last year was offered, maintaining the limit of expenditure as now at $100,000 per annum, but allowing it to be paid at a higher rate per ton in case the total production falls below the amount at which the whole appropriation could be earned at present rates, would afford sensible relief to a badly harassed industry, and would be but justice to those who in good faith are investing their money in lead refineries.

It is promised by the smelting companies that in order to promote the establishment of works in Canada for the corrosion of lead, a price will be made upon lead pig, such as will enable such an industry to meet outside competition, even under the unfair existing tariff conditions.

One thing is certain, that to the ore shipper the irreducible minimum of price has been reached, and that the benefit of every concession that can be obtained by the smelter or the refiner must be transferred to the producer under penalty of a total cessation of ore supply.

G. O. BUCHANAN.

Kaslo, B.C., 15th April, 1902.

SIR—I beg to call your attention to the present condition of the lead smelting industry in British Columbia.

Two years ago the Trail smelter settled with the lead mines on the basis of New York quotations for lead, less the duty of 1½c. per lb. on lead contents. In making fresh contracts, however, the manager of this smelter represented that it would be more satisfactory to the mine owners to settle on the basis of London quotations for lead, which would yield them quite as much. Accordingly new contracts were made on the basis of these quotations, less $16 to $18 per ton freight on the lead to London. At the beginning of the present year, however, the rate of freight was raised to $20 per ton, besides an increase in smelting charge, and shortly after lead in London dropped about 40 per cent below New York quotations. The result has been that the lead mines have been receiving about 1½c per lb. net instead of 2½c. per lb., which they would have received for the lead on the basis of the New York quotations, less duty.

The Trail smelter may claim that they are obliged to ship their lead to London, but *if they had closed down* altogether the lead could have been shipped to the United States so that it would yield 2½c. per lb. In other words, the C.P.R., instead of fostering the lead industry, as they promised to do, have been causing it a serious injury by keeping their smelter in operation. The actual difference to mines carrying 50 per cent. of lead amounts to between $10 and $12 per ton.

This explanation may be rather involved, but it is correct, and I think it would be well for you to have a paper on the subject by some of the British Columbia engineers, who are thoroughly familiar with the subject.

This of course brings up the question of refining of lead in this country, which is the most important matter now before our present Government. The refining of copper should be dealt with at the same time.

I daresay that these matters are before you, but I take the liberty of drawing your attention to them.

Yours truly,

CLARENCE J. McCUAIG.

Montreal, 2nd April, 1902.

SIR—In 1899 all of the lead ores of the Kootenay were purchased exclusively by American smelters, which at that time had not been formed into a trust. The basis of the purchase of these ores was to allow the mines 90 per cent. of the lead at the New York quotation for lead, less the duty of 1½c, per pound on 100 per cent of the lead contents, allowing the mines 95 per cent. of the silver and deducting $20 per ton for freight and treatment charges.

The smelters first purchasing ores in the Kootenay country paid the 1½c. per pound on 100 per cent. of the lead contents and sold the resulting lead in the United States; this being possible on account of the very high price of United States lead as compared to the London figure. During 1899, and especially the latter part of 1899, it was found in the smelters' interests to take advantage of the bonding privilege accorded by the United States government, smelt the ore in bond and export 90 per cent of the lead imported in it. In other words, these smelters were purchasing foreign ores, British Columbia ores, on the basis of prices paid for metals in New York and selling in the London market. There being no fixed relations between the price of lead in London and that in New York, it was self-evident that there was no more sense in basing the price of British Columbia ores on the United States prices for lead than there would be in basing such prices on quotations for lead in Russia.

In the fall of 1899 it was decided by all the American and Canadian smelters that instead of purchasing ores on the basis of the New York price it would be advisable to change to the prices in the market where the metals were sold, namely, London.

In December, 1899, the price of London lead was about £16 17s. 6d., which, with a deduction of $14 from the London price was equivalent to about $58.92 per short ton. At the same time the New York price was $4.45 per 100 pounds, or $89.00 per short ton, and with a duty of 1½c. deducted on 100 per cent. of the contents, the net amount paid per ton for British Columbia ore was $55.66. In other words, the amount which was agreed the smelters would allow the British Columbia mines in December, 1899, amounted to $3.26 per ton of lead better on the London basis than it was on the New York basis. This on a ton of 50 per cent. lead ore (assuming payment for 90 per cent. of lead contents) amounted to $1.46 per ton of ore.

It would be impossible for any smelter manager or mine owner to prophesy for any length or period of time as to what the relative prices in London and New York would be for the next two years, but the statements which I enclose for your perusal show that during the year 1900 the mines of British Columbia (assuming their ore to contain 50 per cent. lead) received on an average of $6.09 more per ton of ore shipped than they would have received had they remained on the old basis in which they were allowed the New York price less the American duty.

In the year 1901, it will be noticed that on account of the very low price of London lead, the mines would have received more for their lead had they been paid on the New York basis. It must be taken into consideration, however, that the freight and treatment charges in 1901 were reduced $1.00 per ton as compared with 1900. Leaving out the question, however, of this reduction, the mines of the Kootenay country are shown by this statement to have gained on account of this change to the London basis $230,000, or an average of $2.22 per ton of ore, assuming freight and treatment charges to have been constant, which, as explained above, they were not, for in fact contracts were made in favor of the miner to the extent of $1 00 per ton during the year 1901. Please keep in mind the fact that in December, 1899, when the change was made, that it figured in favor of the miner to the extent of $1.46 per ton of ore, while the average for 1900 and 1901 shows that the mines have netted $2.22 per ton more than they would had they been left on the New York basis.

I give you the above figures assuming that there might have been a grain of truth in Mr. McCuaig's statement that the Trail smelter was responsible for the change. But this statement upon Mr. McQuaig's part is untrue, as the American smelters have continued to purchase ores in British Columbia to almost the same extent as they did previous to the starting of operations at Trail, and the basis used in the purchase of these ores was exactly the same by the smelters in the United States as that adopted by those in Canada.

Certainly the Trail smelter is not responsible for the formation of a gigantic trust in the United States, which is the real cause of the withdrawal of certain of the American smelters from purchasing British Columbia ores in 1901. In the first place the Trail smelter is not sufficiently powerful to keep the American Smelting and Refining Company out of this market, and had the Trust wished to purchase ores at the ruling prices in the country, they would have proceeded to have done, just as the Everett smelter and the Selby Company have been doing.

As a matter of fact, the management of one of the largest lead producers opened up a correspondence during the fall of 1900 with the management of the American Smelting and Refining Company, and asked them to kindly quote a treatment charge on their output for the year 1901, stating that he would arrange freight rates to whatever smelting point they might wish to take his ore. The management of the Trust was at first evasive, but finally replied to the effect that they were not in the market for British Columbia lead ores, shewing that neither the Trail smelter nor freight rates made by Canadian roads had anything whatsoever to do with their absolute withdrawal from the market. The real causes for their withdrawal were two :—

1st—There was no profit to be made in British Columbia lead ores at the ruling prices of the country.

2nd—They had more lead in the United States than they could possibly take care of, there being a shortage of dry ores and a tremendous over-production of lead ores. To prove that this is the cause I will only state that in the Coeur d'Alene country the Trust paid certain lead mines as high as $18,000 per month to keep them closed; in other cases they paid $10,000 and $12,000 per month to mines to get them to reduce their output one-third.

As a further proof of the above statement it would be well to refer to a copy of the report made by Mr. S. S. Fowler, Consulting Engineer of the Whitewater Mines, Ltd., taken from the *B.C. Review*, of London, of December 14th, 1901, in which the Chairman states in part as follows :—

"At the end of last year your directors had hope that the mine had entered upon a dividend-paying basis, with every prospect of its continuance. It was, therefore, with considerable consternation that we were met with the decision of the *American Smelter people to cease taking lead ores from British Columbia, except upon exorbitant terms.* We thought, however, that this condition of things would be of short duration, and continued full operations at the mine and mill until March last, when the mill was shut down, and work confined to development only. In April all hands were discharged, except the small force necessary for keeping the workings in good order, and it was not until July last that we succeeded in making terms with a local smelter for the treatment of our ore, which terms Mr. Fowler describes *as more favourable than those we had been having from the American smelter.* Operations were continued with one shift until August, since when full operations have been resumed. I think, also, that we may look forward to some considerable improvement in the smelting position—in the first place, owing to the liberal action of the Dominion Government in granting a subsidy upon lead locally refined, and, secondly, from the competition of local smelters with those of the United States, which is likely to follow. In fact, we understand that a local refinery will before long be established at Nelson, which place is no great distance from our mine. Our difficulty has been that there was practically no demand for the ore, such as the Whitewater mine produced, in Canada itself. Almost all the ore from our part of British Columbia has had to go to the United States, and *we have had to take what terms the American smelters would give us.* We hope, however, that the outcome of the establishment of the local smelter and refinery I have referred to will be to promote competition and to offer a ready market for our productions."

As still one more additional proof of the looseness of Mr. McCuaig's statements I wish to state that a special correspondence was opened between the Great Northern Railway and the American Smelter Trust, by which the Great Northern Railway endeavoured to get the American Smelter Trust to come into the British Columbia market. The result of this correspondence was that the American Smelter Trust said they would advise them further in case they decided to purchase British Columbia ores. This ended the correspondence, and nothing more was heard from the Smelter Trust.

At the beginning of the year 1901 British Columbia was turning out in the neighbourhood of 300 tons of lead ore daily, which was far in excess of the tonnage that could be handled by the smelters located at San Francisco, Everett, Trail, and Nelson. For this reason the Canadian Pacific Railway Company undertook to and did market a large amount of ore in Germany and other European countries; they would have been glad had the American Smelting and Refining Company taken this tonnage, but the correspondence above referred to between the management of one of the large properties and the Smelter Trust was certainly conclusive so far as convincing the railway companies that the Trust would not purchase any ore in British Columbia at any price.

Mr. McCuaig states that the actual difference to mines carrying 50 per cent. lead amounts to between $10 and $12 per ton. He is not very explicit as to exactly what he means; under any interpretation his statement is not correct. Assuming for a minute that there was some truth in it, no American smelter could possibly purchase British Columbia ores at New York prices, less the duty, when New York prices are at their present figure and London prices are £10 10s., as such a procedure would mean a tremendous financial loss to any such company. There is, in other words, more lead being produced in the United States than they can possibly take care of. They must of necessity, therefore, export lead originating from Mexico and British Columbia under the bonding privilege, or else export lead originating in the United States for which they had paid $80 per ton, and sell it in London, where they would receive 46s. per ton.

In conclusion, I wish to state that the Trail smelter was simply one of a number of smelters which decided for business reasons that it would be well to change the method of purchasing British Columbia ores so that the metal quotations used would be those of the country in which they would sell their product.

Second: That a change made from the New York to the London basis has resulted in round numbers in an advantage of $230,000, or approximately $2.22 per ton of ore, to the mines during the years 1900 and 1901.

Third: That the American Smelting and Refining Company withdrew from the British Columbia market because they were not willing to purchase British Columbia lead ores at the ruling prices in the country. and furthermore, because they had more domestic lead ores than they could handle, as shown by their paying lead mines with which they had contracts to keep closed.

Fourth: Every effort was made by the Railway Companies and the mine owners to induce the Smelter Trust to continue purchasing ore in British Columbia and that all such attempts proved futile.

Fifth: The entrance into the British Columbia fields by local smelters certainly had the tendency of giving the miners a better price for their lead ores, and had it not been for these smelters the bulk of the mines of the country would have have had absolutely no market to which they could have shipped their product during the year 1901.

To show the feeling of the mine owners of British Columbia, I enclose for your information copy of a resolution which was unanimously passed at Nelson, June 28, 1901.

Yours, etc.,

LEAD MINER.

Nelson, 21st April, 1902.

P.S.—Please keep in mind that the freight and treatment charges in 1899 were $20; in 1900, $20; in 1901, $19; and in 1902 it has been proposed to make charges $15, reducing the zinc limit, however, from 10% to 8%.

NOVA SCOTIA STEEL AND COAL.

Your Directors submit herewith the first Annual Report and General Statement of assets and liabilities, and abstract of Profit and Loss Account for the year ended December 31st, 1901.

The company was organized June 28th, 1901, to take over as a going concern as from the 1st January, 1901, the business, assets and liabilities of the Nova Scotia Steel Company, Limited. The reports and statements now submitted therefore include the business for the calendar year 1901.

The capital of the company consists of:—

50,000 shares of Common Stock	$100 00 each
20,000 shares of 8% Accumulative Preferred Stock.	100 00 each

of which 30,900 shares of Common Stock and 10,300 shares of Preferred Stock were issued in payment of the property, business and assets of the said, The Nova Scotia Steel Company, Limited.

An issue of 30 year 6 per cent. gold bonds of the company was made, and the bonds of the Nova Scotia Steel Company, Limited, amounting to $1,500,000.00, were redeemed at par.

The company mined and disposed of over 350,000 tons of iron ore; 238,000 tons of coal; and 26,000 tons of limestone and dolomite. Upwards of 52,000 tons of pig iron and steel ingots were produced.

The prospects for the year 1902 are favorable. Large quantities of coal and ore will be required to meet the sales already made and the requirements of the company for the year.

A coal washing plant and the first block of coke ovens at Sydney Mines are completed; excellent coke has been made and shipped to the blast furnace at Ferrona.

The erection of a new coal shipping pier at North Sydney is progressing favorably, and it is expected that it will be ready to be used during the present shipping season.

In order to increase the output of coal, new slopes, on the Sydney Mines coal areas, are now being opened up. As the work progresses, the output will gradually increase, and it is believed that by the end of 1903, the development work will be completed and the new mines producing to their full capacity.

Contracts have been entered into for the blowing engines, and a large portion of the material required for the construction of a new 200 ton blast furnace, for which the capital is now provided. The site has been selected at Sydney Mines, and the work will be prosecuted as rapidly as possible.

All the products of the company now being sold at thirty days, net cash, the loss in the collection of accounts should be very small, and every effort will be made by the management to maintain the business on this basis.

The profits for the year ended December 31st, 1901 amount to		$508,936 79
To which add balance at credit of Profit and Loss Account of the Nova Scotia Steel Company, Limited, December 31st, 1900		242,030 24
		$750,967 03
Which your Directors recommend be distributed as follows:—		
Interest on Bonds	$ 93,237 84	
Dividend paid on Preferred Shares to July 1st, 1901	41,200 00	
Dividend on Preferred Shares to January 1st, 1902	41,200 00	
Reserve Funds for depreciation, plant, renewals, etc.	100,000 00	
Dividends on Common Shares at 4% payable April 15th, 1902	123,600 00	
Balance at credit of Profit and Loss Account carried forward	351,729 19	
		$750,967 03

The Directors have decided that so long as the earnings justify, dividends on the preferred shares should be payable quarterly, and on the common shares half yearly.

All of what is respectfully submitted.

PROVINCE OF NOVA SCOTIA.

Leases for Mines of Gold, Silver, Coal, Iron, Copper, Lead, Tin

—AND—

PRECIOUS STONES.

TITLES GIVEN DIRECT FROM THE CROWN, ROYALTIES AND RENTALS MODERATE.

GOLD AND SILVER.

Under the provisions of Chap. 1, Acts of 1892, of Mines and Minerals, Licenses are issued for prospecting Gold and Silver for a term of twelve months. Mines of Gold and Silver are laid off in areas of 150 by 250 feet, any number of which up to one hundred can be included in one License, provided that the length of the block does not exceed twice its width. The cost is 50 cents per area. Leases of any number of areas are granted for a term of 40 years at $2.00 per area. These leases are forfeitable if not worked, but advantage can be taken of a recent Act by which on payment of 50 cents annually for each area contained in the lease it becomes non forfeitable if the labor be not performed.

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 acquired 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 sta'ed 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

THE HON. C. E. CHURCH,
Commissioner Public Works and Mines,
HALIFAX, NOVA SCOTIA.

DOMINION OF CANADA

SYNOPSIS OF REGULATIONS

For Disposal of Minerals on Dominion Lands in Manitoba, the North-West Territories, and the Yukon Territory.

COAL.

Coal lands may be purchased at $10.00 per acre for soft coal, and $20.00 for anthracite. Not more than 320 acres can be acquired by one individual or company. Royalty at such rate as may from time to time be specified by Order in Council shall be collected on the gross output.

QUARTZ.

Persons of eighteen years and over and joint stock companies holding Free Miner's Certificates may obtain entry for a mining location.

A Free Miner's Certificate is granted for one or more years, not exceeding five, upon payment in advance of $10.00 per annum for an individual, and from $50.00 to $100.00 per annum for a company, according to capital.

A Free Miner having discovered mineral in place may locate a claim 1500 x 1500 feet by marking out the same with two legal posts, bearing location notices, one at each end on the line of the lode or vein.

The claim shall be recorded within fifteen days if located within ten miles of a Mining Recorder's Office, one additional day allowed for every additional ten miles or fraction. The fee for recording a claim is $5.00.

At least $100.00 must be expended on the claim each year or paid to the Mining Recorder in lieu thereof. When $500.00 has been expended or paid the locator may, upon having a survey made and upon complying with other requirements, purchase the land at $1.00 an acre.

Permission may be granted by the Minister of the Interior to locate claims containing iron and mica, also copper in the Yukon Territory, of an area not exceeding 160 acres.

The patent for a mining location shall provide for the payment of royalty on the sales not exceeding five per cent.

PLACER MINING, MANITOBA AND THE N.W.T., EXCEPTING THE YUKON TERRITORY.

Placer mining claims generally are 100 feet square; entry fee $5.00 renewable yearly. On the North Saskatchewan River claims are either bar or bench, the former being 100 feet long and extending between high and low water mark. The latter includes bar diggings but extends back to the base of the hill or bank, but not exceeding 1,000 feet. Where steam power is used, claims 200 feet wide may be obtained.

DREDGING IN THE RIVERS OF MANITOBA AND THE N.W.T., EXCEPTING THE YUKON TERRITORY.

A Free Miner may obtain only two leases of five miles each for a term of twenty years, renewable in the discretion of the Minister of the Interior.

The lessee's right is confined to the submerged bed or bars of the river below low water mark, and subject to the rights of all persons who have, or who may receive entries for bar diggings or bench claims, except on the Saskatchewan River, where the lessee may dredge to high water mark on each alternate leasehold.

The lessee shall have a dredge in operation within one season from the date of the lease for each five miles, but where a person or company has obtained more than one lease one dredge for each fifteen miles or fraction is sufficient. Rental $10.00 per annum for each mile of river leased. Royalty at the rate of two and a half per cent., collected on the output after it exceeds $10,000.00.

DREDGING IN THE YUKON TERRITORY.

Six leases of five miles each may be granted to a free miner for a term of twenty years, also renewable.

The lessee's right is confined to the submerged bed in the river below low water mark, that boundary to be fixed by its position on the 1st day of August in the year of the date of the lease.

The lessee shall have one dredge in operation within two years from the date of the lease, and one dredge for each five miles within six years from such date. Rental, $100.00 per mile for first year, and $10.00 per mile for each subsequent year. Royalty ten per cent. on the output in excess of $15,000.00.

PLACER MINING IN THE YUKON TERRITORY.

Creek, Gulch, River and Hill Claims shall not exceed 250 feet in length, measured on the base line or general direction of the creek or gulch, the width being from 1,000 to 2,000 feet. All other Placer Claims shall be 250 feet square.

Claims are marked by two legal posts, one at each end bearing notices. Entry must be obtained within ten days if the claim is within ten miles of Mining Recorder's office. One extra day allowed for each additional ten miles or fraction.

The person or company staking a claim, and each person in his or its employment, except house servants, must hold a Free Miner's Certificate.

The discoverer of a new mine is entitled to a claim 1,000 feet in length, and if the party consists of two, 1,500 feet altogether, on the output of which no royalty shall be charged, the rest of the party ordinary claims only.

Entry fee $15.00. Royalty at the rate of five per cent charged on the gross output of the claim, with the exception of an annual exemption of $5,000 00.

No Free Miner shall receive a grant of more than one mining claim on each separate river, creek or gulch, but the same miner may hold any number of claims by purchase, and Free Miners, not exceeding ten in number, may work their claims in partnership, by filing notice and paying fee of $2.00. A claim may be abandoned and another obtained on the same creek, gulch or river, by giving notice and paying a fee.

Work must be done on a claim each year to the value of at least $200.00, or in lieu of work payment may be made to the Mining Recorder each year for the first three years of $200.00 and after that $400.00 for each year.

A certificate that work has been done or fee paid must be obtained each year; if not, the claim shall be deemed to be abandoned, and open to occupation and entry by a Free Miner.

The boundaries of a claim may be defined absolutely by having a survey made, and publishing notices in the *Yukon Official Gazette*.

HYDRAULIC MINING, YUKON TERRITORY.

Locations suitable for hydraulic mining, having a frontage of from one to five miles, and a depth of one mile or more, may be leased for twenty years, provided the ground has been prospected by the applicant or his agent; is found to be unsuitable for placer mining; and does not include within its boundaries any mining claims already granted. A rental of $150.00 for each mile of frontage, and a royalty of five per cent. on the gross output, less an annual exemption of $25,000.00 are charged. Operations must be commenced within one year from the date of the lease, and not less than $5,000 must be expended annually. The lease excludes all base metals, quartz and coal, and provides for the withdrawal of unoperated land for agricultural or building purposes.

PETROLEUM.

All unappropriated Dominion Lands shall, after the first of July, 1901, be open to prospecting for petroleum. Should the prospector discover oil in paying quantities he may acquire 640 acres of available land, including and surrounding his discovery at the rate of $1.00 an acre, subject to royalty at such rate as may be specified by Order in Council.

JAMES A. SMART,

Deputy of the Minister of the Interior.

OTTAWA, 9th Dec., 1901.