THE ROMANCE OF
NICKEL

Published by

THE INTERNATIONAL NICKEL COMPANY
OF CANADA, LIMITED

1st printing	*1945*	*10,000*
2nd printing	*1947*	*10,000*
3rd printing	*1948*	*20,000*
4th printing	*1949*	*10,000*
5th printing	*1950*	*10,000*
Revised edition	*1952*	*10,000*
2nd printing revised edition	*1953*	*10,000*
3rd printing revised edition	*1954*	*10,000*

FOREWORD

Scientists estimate that there is about twice as much nickel in the earth's crust as there is copper, zinc and lead combined. In the past, nickel has been mined in a great many countries, and today is being mined in quantity in Canada, Celebes, Cuba, New Caledonia, Norway and Russia, and in smaller amounts in several other countries. Occurrences in South and Central America, Africa and the Philippine Islands are being explored in the search for other commercial deposits.

What has given Canada its premier place in nickel production has been the long continuing search for new ore, for better methods of getting that ore out of the earth, and for better and more economical methods of smelting and refining it.

Hand in hand with that search has gone the development of new uses and markets that have made possible the plowing back of many millions of dollars to build still better mines and plants, and so keep this Canadian industry in the forefront of world production of nickel.

PART ONE

NICKEL DOWN THROUGH THE AGES . . . . *Page 1*

PART TWO

HOW NICKEL IS PRODUCED . . . . *Page 29*

PART THREE

COPPER REFINING . . . . *Page 47*

PART FOUR

WHAT NICKEL IS USED FOR . . . . *Page 51*

PART FIVE

WHAT NICKEL MEANS TO CANADA . . . . *Page 63*

PART ONE · NICKEL

DOWN THROUGH THE AGES

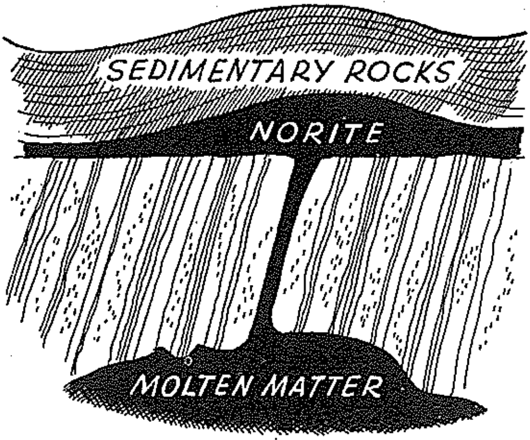
In the Beginning

In that bleak belt of rocky country which lies to the north of the city of Sudbury, some of the world's richest mineral deposits have been discovered during the past sixty years. How did they get there? It was during one of those periods, ages ago, when the earth's outer crust twisted and buckled and was shaken by volcanic disturbances, and mountains were formed.

During that period, a mass of molten rock deep down inside the earth came under terrific pressure, and was forced towards the earth's surface where there happened to be a line of weakness in the earth's crust. As this molten rock was pushed upwards, it came in contact with the under side of thick layers of sedimentary rocks and spread out, forming a large, oval-shaped mass that gradually began to cool and harden into solid crystalline rock known as norite.

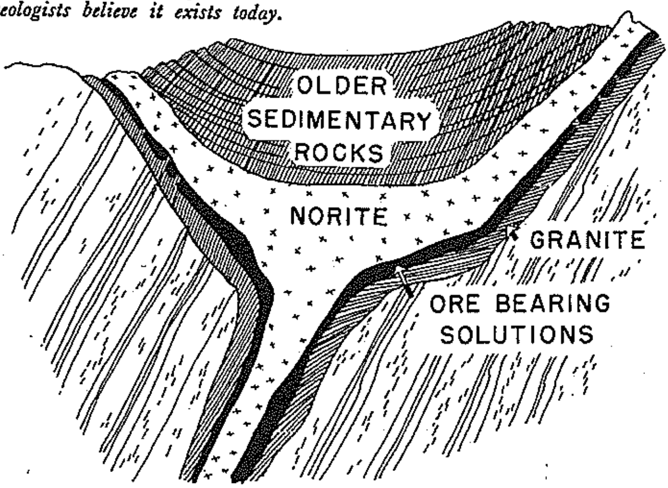
The pressure inside the earth continued. The earth's crust twisted and folded again. A second mass of molten rock, this time of a granite type, was pushed towards the earth's surface. It forced its way into the cracks and crushed areas of the rocks, particularly along the margins of the norite. There it formed irregular masses and dikes and began to cool and harden into granite. Some time during this period the norite mass was caught in the gigantic vise of a major fold in the earth's crust and was folded and bellied downward, and the overlying sediments were forced downward into the centre of the bowl.

While great earth forces continued to twist and bend the rocks, a third mass of hot material was forced towards the earth's surface. Apparently it was composed of hot



Molten matter, forced up through the earth's crust, came in contact with the under side of layers of overlying sedimentary rocks and spread out.

Cross section of Sudbury Basin as geologists believe it exists today.



chemical solutions and gases under enormous pressures. These were forced into the cracks and crushed areas along the margins of the norite and the granite masses, and into clefts in the nearby rocks.

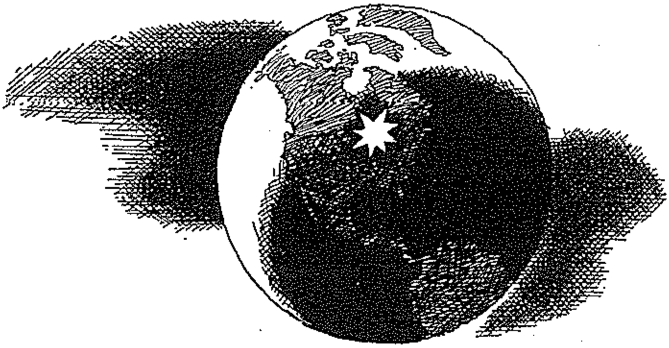
These solutions carried the copper and nickel and other important elements which were deposited in the crevices and in the nearby rocks. Thus the ore bodies containing these metals came into being under a deep cover of volcanic and sedimentary rocks.

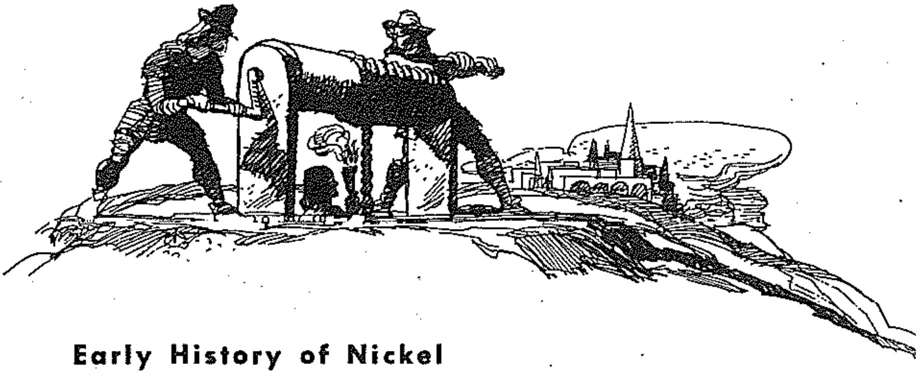
As the ages passed and the great disturbances of that particular period subsided, nature went to work to tear down that which she had so laboriously and fantastically fashioned. Great volumes of rock material were gradually worn away by the rain, wind and ice, and as these rocks disappeared the norite, granite and the ore bodies came to light. The great oval-shaped outcrop of norite, with the sediments within and the ore bodies at the outer margins and along the zones where the rocks had previously been cracked and crushed, has been named the Sudbury Basin.

The surface, as man sees it today, is just that part which happens to be exposed at this time by the erosional processes. Study of this surface makes one wonder what might have existed above and been carried away, and what now exists below.

Thus have geologists after years of study of this surface and the mines in this locality constructed the theory regarding the formation of the great ore bodies of nickel, copper and other metals.

Can it be that Divine Providence, in the beginning of things, pointed a finger at this spot on the spinning globe and said, "Here must rich stores of nickel be hidden away, so that, as the great plan is unfolded down through the ages, this metal may be brought to light to play a deciding part in the affairs of men that are to be."?





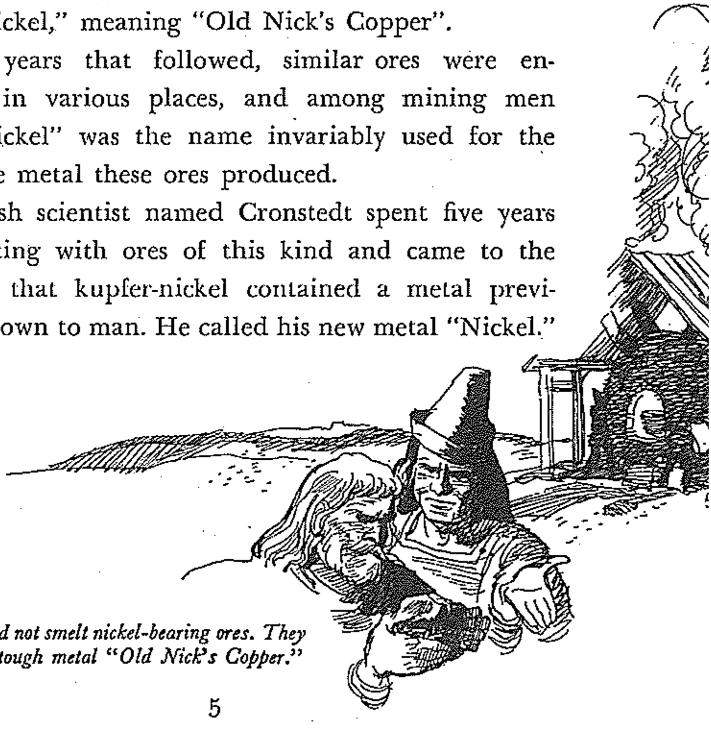
Early History of Nickel

Although used in natural alloys even in ancient times, nickel was unknown as an element until 1751, when its discovery came about in the following way:

Miners in Saxony, several years before, had attempted to smelt some newly-discovered ores which had the appearance of copper ore. But the metal they obtained was not copper—it was a white metal so hard that it could not be hammered into useful articles, and so was useless to them. Believing Old Nick had cast a spell over their ores, the superstitious miners called the metal "Kupfer-Nickel," meaning "Old Nick's Copper".

In the years that followed, similar ores were encountered in various places, and among mining men "Kupfer-Nickel" was the name invariably used for the hard, white metal these ores produced.

A Swedish scientist named Cronstedt spent five years experimenting with ores of this kind and came to the conclusion that kupfer-nickel contained a metal previously unknown to man. He called his new metal "Nickel."

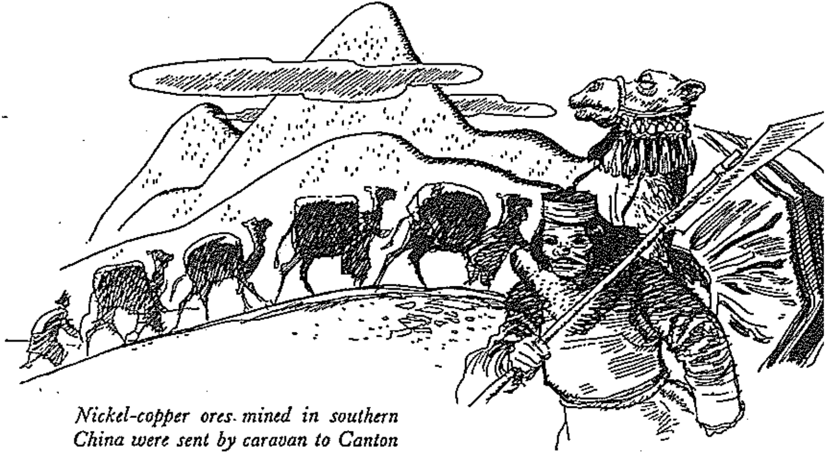


Early miners could not smelt nickel-bearing ores. They called the hard, tough metal "Old Nick's Copper."

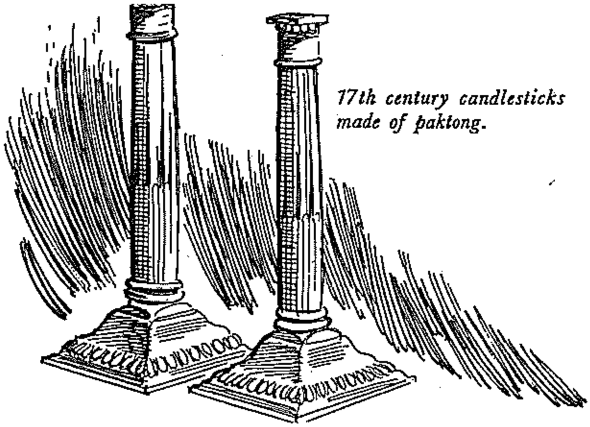
But the influence of this unknown metal had been felt even back in the dawn of history. It is believed that ancient oriental peoples learned at an early date to make useful implements out of meteorites. The tradition that the swords of the great warriors of old in China, Persia and Northern Europe were "Heaven-sent" seems to indicate that they were made from meteorites which fell from the heavens. The unusual keenness of their blades was probably due to the toughening effect of nickel in the iron—nickel and iron frequently occur together in metallic meteorites.

Beautiful boxes and candlesticks made of a white metal called "paktong" made in China since ancient days by adding zinc to what we now know to have been nickel-copper ores, were brought to Europe by the East India Company in the seventeenth century.

Five years after Cronstedt discovered nickel, another Swedish scientist, von Engestrom found that "paktong"



Nickel-copper ores mined in southern China were sent by caravan to Canton where zinc was added. The resulting metal, called "paktong" or white copper, was used for making candlesticks and boxes which were brought to England by the East India Company in the 17th and 18th centuries.



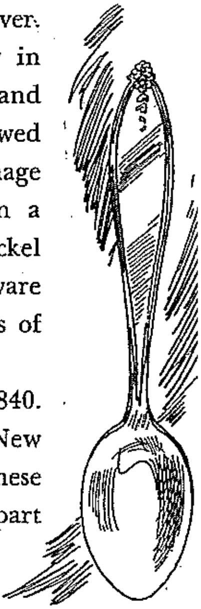
17th century candlesticks made of paktong.

contained copper, nickel and zinc. Soon similar alloys were being produced in Europe and were known as German silver and later as nickel silver.

When electro-plating was introduced in England in 1844, articles made of German silver and plated with silver became popular in place of the more expensive Sheffield plate. Silver plated articles today are still shaped from nickel-silver, then electro-plated with silver.

Belgium introduced coins of a nickel-copper alloy in 1860. Switzerland issued pure nickel coins in 1881, and in the years to come one country after another followed suit. In 1939, over one hundred countries had coinage containing nickel. Nickel plating was developed on a commercial basis about 1870. And for many years nickel plating, coinage and nickel silver for silver-plated ware remained the three chief uses for the small quantities of nickel being produced in the world.

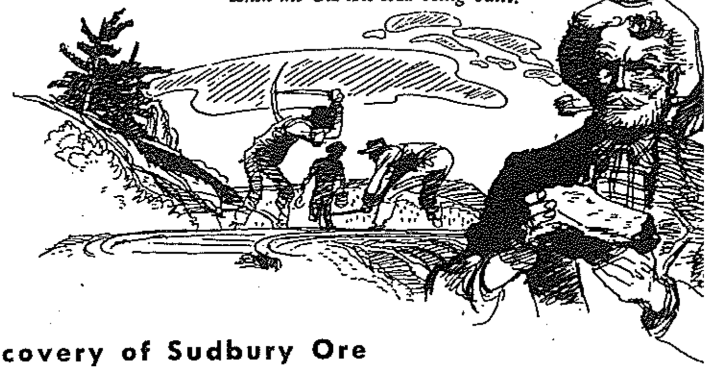
Nickel deposits were developed in Norway after 1840. Then nickel mines were opened up in the island of New Caledonia in the South Seas about 1877, and these remained the chief source of supply till the latter part of the nineteenth century.



Silver-plated ware is stamped from nickel silver (about 18% nickel alloyed with copper and zinc), then silver plated.

The first pure nickel coin ever issued was a 20-centime piece issued in Switzerland in 1881.

The Sudbury ore was discovered when the C.P.R. was being built.

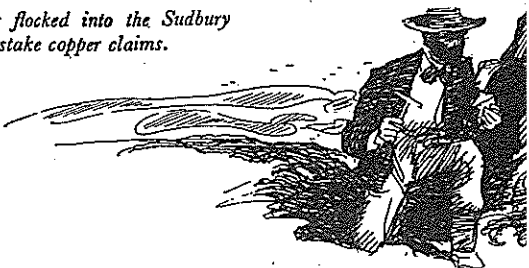


Discovery of Sudbury Ore

Meanwhile the hand of destiny was drawing closer to the great store of nickel locked in the rocks on the other side of the world. Columbus discovered America in 1492. French coureurs de bois pushed their way up the Great Lakes. Colonists settled in Eastern Canada, in British Columbia and a few scattered districts on the Prairies. There was talk of Confederation. So that Canada might stretch from sea to sea, Sir John A. Macdonald's government promised to build a transcontinental railway to bring British Columbia into Confederation. As this railway was being blasted through the rocky wilderness north of Georgian Bay, workmen uncovered a corner of a great ore body deposited there ages before.

Soon prospectors flocked into the Sudbury district to stake what looked like rich copper claims, for at that time no one dreamed that this deposit contained nickel. But to develop a mine in Canada's pre-Cambrian rocks requires years of effort and large sums of money. It was not easy to raise money to develop a copper mine. Moreover there was no copper refinery in Canada.

Prospectors flocked into the Sudbury district to stake copper claims.

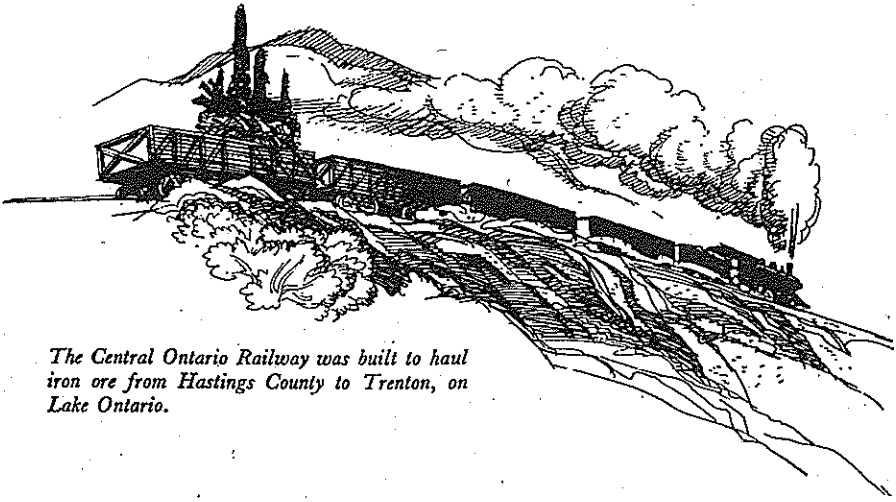


Beginning of the Canadian Nickel Industry

That was the way matters stood when Samuel J. Ritchie came on the scene. Ritchie, a man of great driving force and persuasive power, had been trying to develop iron ore deposits in Hastings County, Ontario, and had built a railroad from there to the port of Trenton on Lake Ontario. Eventually he found that these iron ores could not be developed profitably, and the railroad's chief source of revenue disappeared.

The newly discovered Sudbury ores seemed to Ritchie to be a good way to provide a new source of revenue for his railroad. With ore reported to run more than seven per cent copper, he would extend the line to Sudbury, or hook it up with the C.P.R. Yes, this little mining camp away back in the wilderness would one day be a great thriving industrial centre.

So it wasn't long before Ritchie had purchased the most promising claims in the Sudbury district, and organized the Canadian Copper Company to develop them.



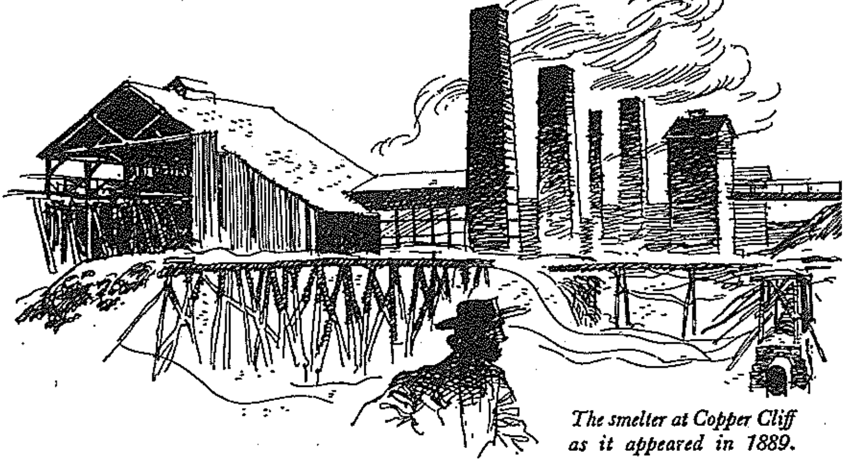
The Central Ontario Railway was built to haul iron ore from Hastings County to Trenton, on Lake Ontario.

R. M. Thompson, when still a young man, had become manager of the Orford Copper and Nickel Company, a company organized in Quebec to operate mines near the village of Orford in that province. Finding it difficult to sell the matte (or partially refined metal), at a profit in Swansea, Wales, where the nearest suitable smelting facilities were then available, the company built its own smelter at Bayonne, New Jersey, where there was a promising market for copper in the heart of the growing industrial region of the United States.

Soon copper ores began coming in for refining from new mines in the east and in the west. Ritchie, too, up in Sudbury, looked around for a refinery to handle his ore. He made an agreement with Thompson to ship one hundred thousand tons of copper ore to the Orford smelter.

Mining Begins at Sudbury

So in 1886 mining operations were begun near Sudbury. At that time no one had the slightest conception of the important part these mines were to play in the life of Canada and in its export trade throughout the world.



The smelter at Copper Cliff as it appeared in 1889.

Sir John A. Macdonald and party visited the Sudbury mines in 1886.

But even at that early period, Sir John A. Macdonald, premier of Canada, accompanied by Lady Macdonald, Sir Charles Tupper, and Canada's two great railroad pioneers, George Stephens (later Lord Mountstephen) and Sir William Van Horne, paid a visit to the little mining settlement. These were men who foresaw that Canada's future greatness lay in the development of her railroads, her mineral wealth, her timber and her agriculture. They were ready to encourage anyone who would invest money in the development of Canada's natural resources.

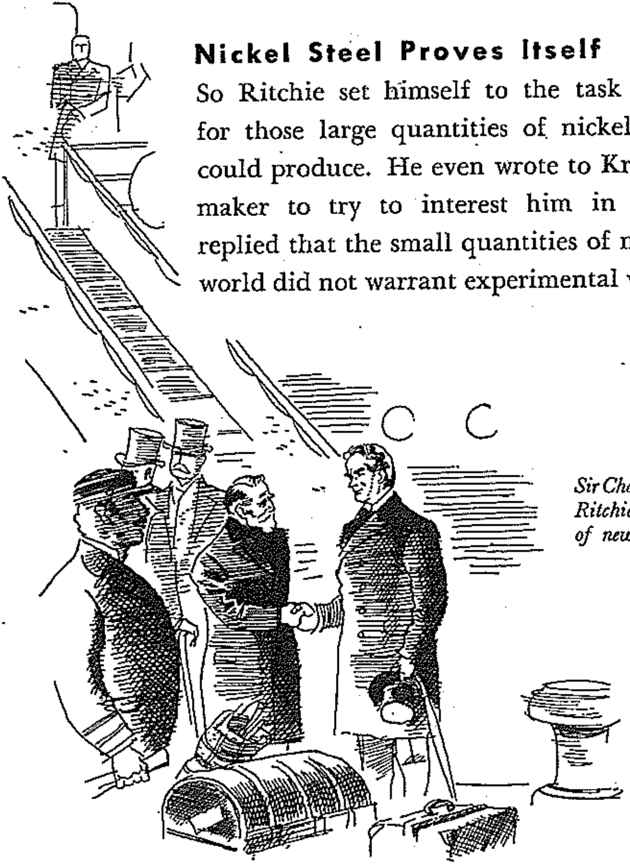
Nickel Makes Trouble Again

When the first batch of metal from the Sudbury ore poured from the furnace down in the New Jersey refinery, Thompson knew he was in for trouble. You couldn't sell that kind of metal to copper customers. He had an analysis made. It contained nickel . . . and nickel was still the trouble maker among metals as it had been to the miners of Saxony more than a century before. Ritchie with his mines at Sudbury seemed likely to be ruined.

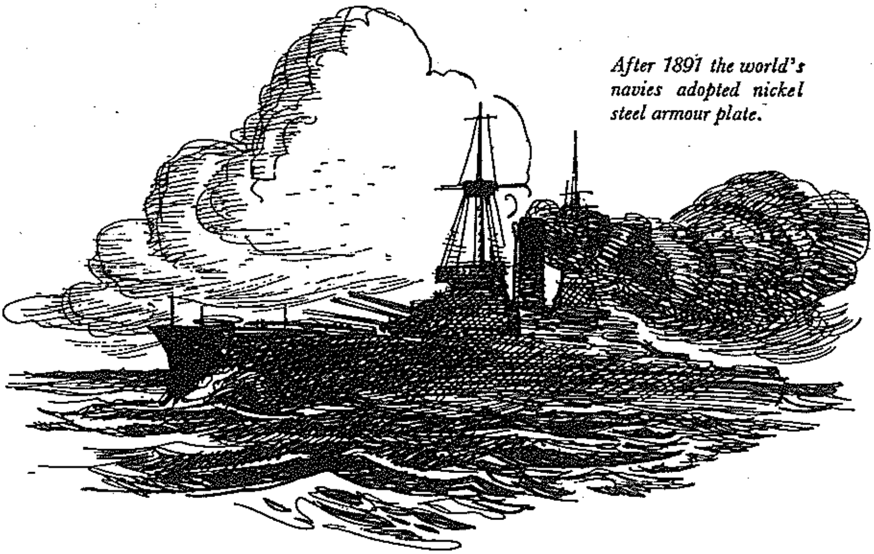
In the face of this disheartening news, most men would have thrown up their hands in despair. Thompson set himself resolutely to the task of solving the nickel-copper separation problem. Ritchie refused to be downcast. Nickel, he discovered, was selling at a dollar a pound, almost ten times the current price of copper. But world production was only a thousand tons a year. His mines could produce twice that much. He must find new uses for nickel besides plating, coinage and nickel silver.

Nickel Steel Proves Itself

So Ritchie set himself to the task of finding new uses for those large quantities of nickel he knew his mines could produce. He even wrote to Krupp the German gun maker to try to interest him in nickel steel. Krupp replied that the small quantities of nickel available in the world did not warrant experimental work in this direction.



Sir Charles Tupper accompanied Samuel Ritchie to Europe in 1890 in search of new markets for Canadian Nickel.

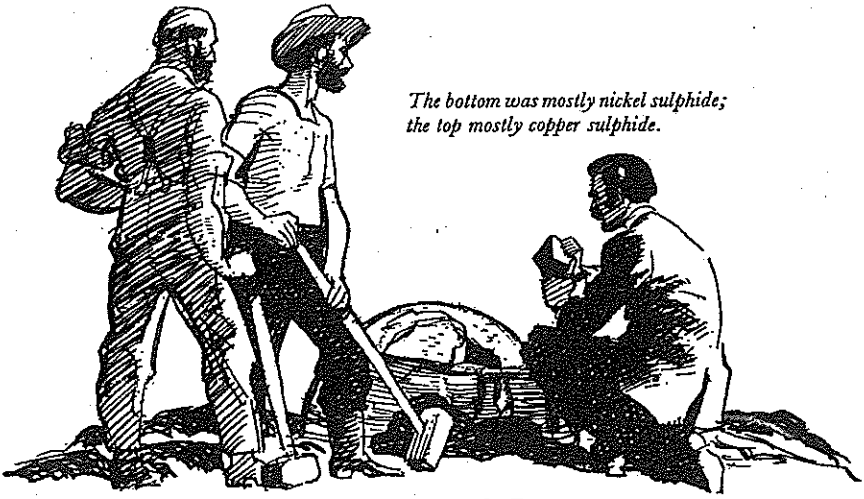


After 1891 the world's navies adopted nickel steel armour plate.

But experimental work had been going on in France and England. The Canadian government had faith in the future of the nickel mines, and Sir Charles Tupper accompanied Ritchie to Europe to try to interest European industrialists in Canadian Nickel.

In 1889 James Riley in Glasgow issued a report of experiments he had conducted with nickel steel. Ritchie brought this report to the attention of the United States navy and a series of tests was arranged. When eight-inch armour-piercing shells were fired at short range at two pieces of armour plate, the nickel steel plate proved definitely superior to the plain steel plate.

Now the great navies of the world began to take a keen interest in nickel steel. The United States navy asked Thompson to supply a large tonnage of nickel which he at that time had no way of producing. Inside of a few months he did succeed in making a red oxide of iron and nickel. While this was acceptable to the navy, the refining costs were equal to or greater than the price he was being paid.



The bottom was mostly nickel sulphide; the top mostly copper sulphide.

Discovery of the Orford Process

So Thompson began experimental work to try to discover a better and more economical method of nickel-copper separation than the wet processes then in use. Finally someone suggested trying sodium sulphate, since he had seen this material used in copper refining in Scotland.

Accordingly, some sodium sulphate was added to the partially refined nickel-copper ore in the furnace. When the molten material was poured into pots, allowed to cool, and dumped out on the floor, it was found that something unusual had happened. There was a distinct difference between the top and bottom parts of the cones of metal, and these could be broken clean apart with a sledge hammer. The bottom was a bright sulphide which proved to be mostly nickel sulphide. The top was mostly copper sulphide. And that was the beginning of the Orford Process of nickel-copper separation—a process that served so well for many years.

Loading nickel matte (partially refined ore) in 1890 for shipment to refineries in the United States and Great Britain.

Threat of European Control

Meanwhile the very existence of the Canadian Nickel industry was threatened from another direction. Mines had been opened up at great expense. A smelter was built at Copper Cliff near Sudbury in 1887. A large new market seemed to be opening up for nickel. But now, with success almost within its grasp, Ritchie's company found itself almost at the end of its financial resources.

The other companies which had carried on mining and smelting operations in the Sudbury district had all folded up. The Canadian Copper Company alone remained.

Now too, the makers of armament were looking for new sources of nickel for the world's navies. Krupps of Germany, who Ritchie had tried to interest in nickel years before, and the Rothschilds of France, were both trying to get control of the Canadian Nickel deposits. It was a big temptation now to sell out at a profit.

Ritchie put the matter squarely to his associates. They felt the same way about it as he did. They weren't going to sell out to outside interests if they could help it. Sir John A. Macdonald and Sir Charles Tupper also used their influence to keep control of the nickel interests on this side of the ocean.

Finally, by pledging their personal fortunes, Ritchie and his business partners were able to borrow about $250,000 from the banks to put the Canadian Nickel industry on its feet.

Further Growth

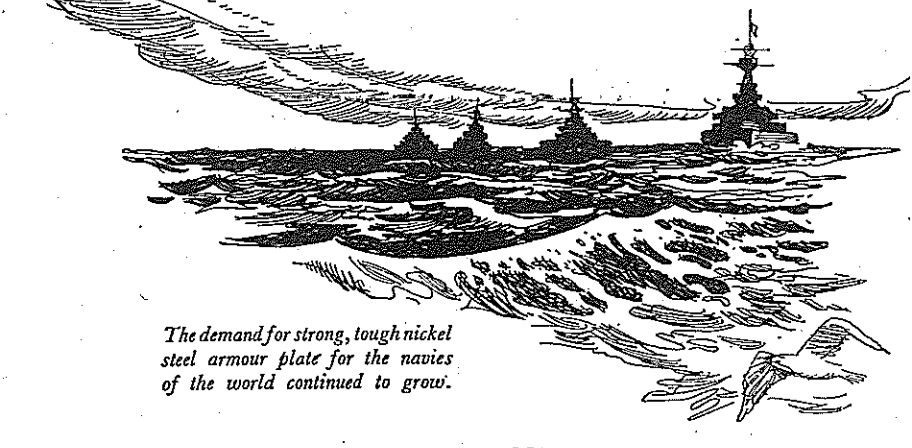
From now on production from the Canadian mines increased steadily. In 1887 the whole world had produced only about two thousand tons of nickel, most of which came from New Caledonia. By 1902 Canadian production alone was more than five thousand tons.

It was at this time that the Canadian Copper Company at Copper Cliff and the Orford Copper Company in New Jersey, which had become dependent on one another, united as The International Nickel Company.

Operations were steadily expanded as the demand for nickel . . . largely for armaments . . . continued to grow. By 1914 Canadian production had reached about 23,750 tons a year, while New Caledonia was producing about a third as much.

World War I.

As the war of 1914-18 progressed, the demand became urgent for stronger, tougher nickel steels for artillery and



The demand for strong, tough nickel steel armour plate for the navies of the world continued to grow.

Nickel steel was urgently needed for battleships, artillery and scores of wartime uses.

battleships and scores of wartime uses. The Canadian nickel mines and plants pushed their production to new peaks and nickel ingots were rushed to the steel mills and munition plants in Canada, England and France. Thus did Canadian nickel strengthen the sinews of the Allied Nations in the first world war.

In 1916 the building of a great new electrolytic refinery was begun at Port Colborne, Ontario, and with its completion in 1918, facilities for producing nickel from ore to finished product in Canada were available.

Starting All Over Again

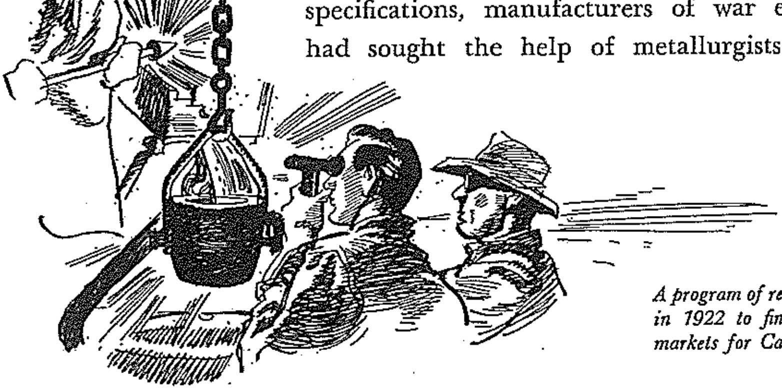
When the war ended, the market created for Canadian nickel in armaments and munitions was largely wiped out. With ninety per cent of its markets gone, the nickel industry was confronted with the same problem as had faced Ritchie in 1889. Operations were completely suspended for twelve months during 1921-22 for lack of demand. The nickel industry had to start practically at the bottom and develop new uses and markets for nickel. There were no established paths to follow. Few people had experience with the use of

The Canadian nickel plants were closed for twelve months during 1921-22 for lack of markets.

nickel by itself or as an alloying element. After laboratory experiments had indicated mechanical or chemical advantages of the use of nickel under certain conditions, it was necessary to find fields where these conditions existed, and urge prospective customers to try the new material. In most cases, nickel was replacing other well established materials which could be obtained at lower first cost. Nickel and nickel alloys had to compete with all commercially used metals and with innumerable alloys, as well as painted and coated materials of various kinds. The prospective customer usually had to be convinced of the economic advantage of replacing his present material with a more expensive metal.

As it turned out later, there were three favourable factors during this post-war period:

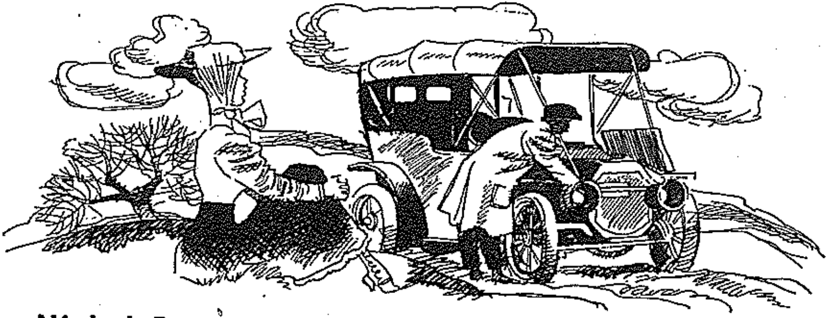
1. During the war, armies and navies had demanded stronger, tougher steels. To meet their rigid specifications, manufacturers of war equipment had sought the help of metallurgists. A new



A program of research was begun in 1922 to find new uses and markets for Canadian nickel.

interest developed in alloys. Nickel alloys were among the most important.

2. During that post-war period of increased industrial activity, there was a constant demand for better materials for the new machines, products and appliances which were invented and developed. Nickel and its alloys were among the most important of these new materials.
3. The automobile, subject in its early years to stripped gears and broken axles, gradually developed rugged dependability largely through the use of strong, tough nickel alloy steels. As more cars were sold more nickel was used. The automotive industry became the biggest single customer for nickel.

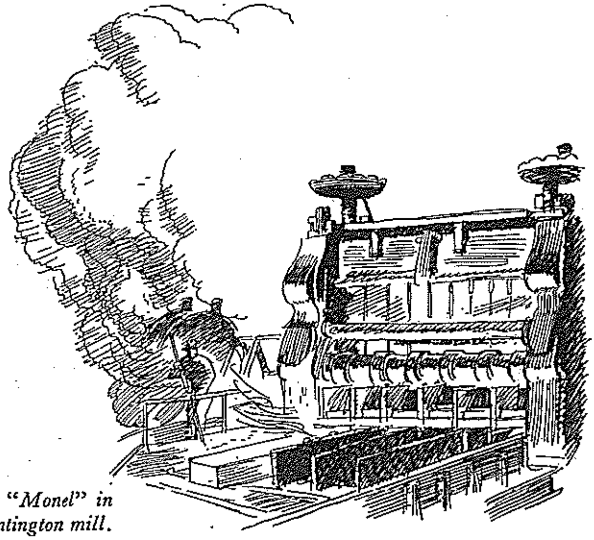


Nickel Research Intensified

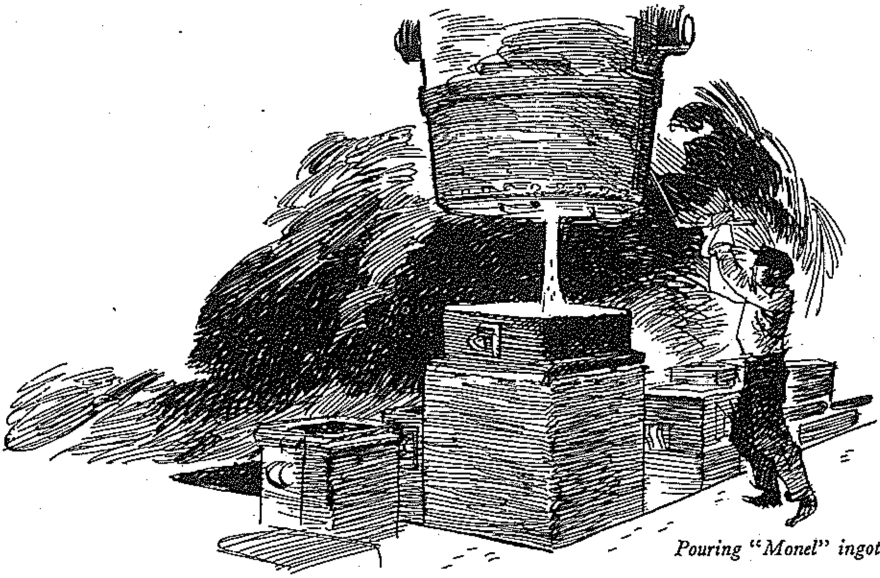
In 1922 Robert C. Stanley became president of The International Nickel Company. He realized that the same qualities which had made nickel pre-eminent in the war could also make it pre-eminent in peacetime industry. Under his guidance, a broad policy of active research and development was begun. Research laboratories were built, and metallurgists with practical experience in the key industrial and engineering fields were employed.

It was believed that the uses of nickel would be increased if the Company could extend the markets for "Monel," an alloy produced direct from the ore in the Creighton Mine containing approximately two-thirds nickel and one-third copper. This alloy had been sold in small quantities since 1905, but its use was limited by the fact that it was not readily available in the standard mill form of rod, sheet, strip and wire. Because of the rolling difficulties and the small tonnages, it was found after trial that it was impracticable to make adequate arrangements for rolling "Monel" on a toll basis.

The answer was the construction of a mill for the production and development of "Monel" and other high-nickel alloys. In 1921, as part of the development program, a refinery and rolling mill was built at Huntington, West Virginia, to produce these alloys from partly refined smelter products.



Rolling "Monel" in the Huntington mill.



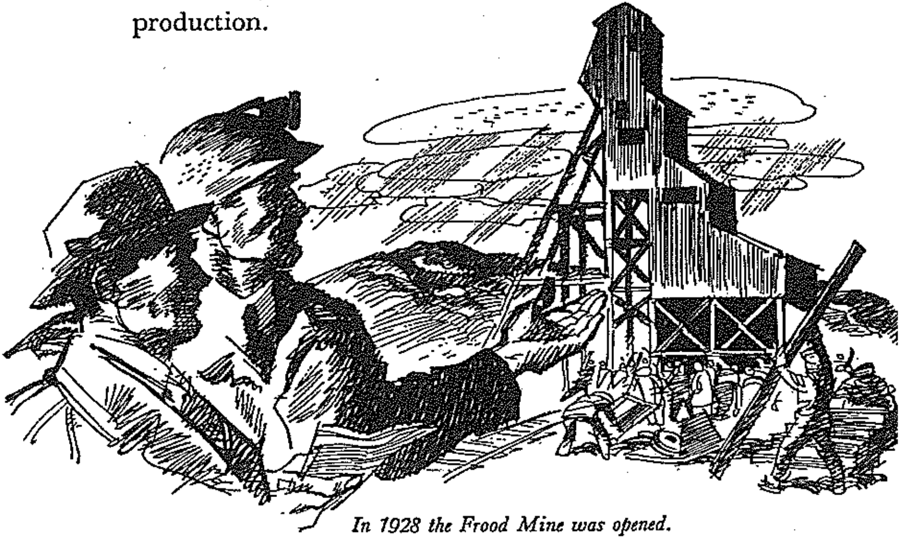
Pouring "Monel" ingots.

"Monel," a silvery-white alloy with important mechanical and chemical properties, has many uses in engineering and in the food, chemical, shipbuilding and many other industries.

At the Huntington mill, modifications of Monel* such as "K" *Monel and "R" *Monel, and other alloys of nickel such as Duranickel,* Permanickel,* Incoloy* and Inconel* have been developed, each with its special mechanical and chemical characteristics. The availability of a wide range of forms of "Monel" and other nickel alloys, made possible by the Huntington mill, has not only expanded the market for these alloys, but has encouraged other producers to develop special alloys, many of which contain nickel. An example is stainless steel, which, at first a specialty, is now produced by many of the steel companies in large tonnages.

**Trade marks.*

Steadily the demand for nickel increased. By 1929 more nickel was being used in the peaceful pursuits of industry than during the peak period of wartime production.



In 1928 the Frood Mine was opened.

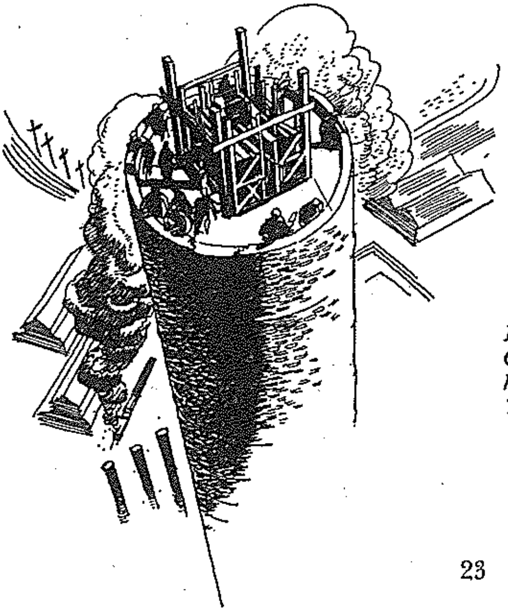
Sudbury Properties Integrated

In the late twenties The International Nickel Company of Canada and The Mond Nickel Company, Limited, each started a mining operation in the Sudbury Basin which proved to lead to the same ore body—the Frood-Stobie—the largest single nickel ore body ever discovered, and the heart of the Canadian nickel industry. If this ore body were developed through two separate operations, it was evident that a large part of the shafts and underground development to extract the ore, as well as the surface facilities to handle it, would have to be duplicated. Only under a single long-term mining plan would it be possible to develop the entire ore body properly so as to ensure the full utilization of all ore.

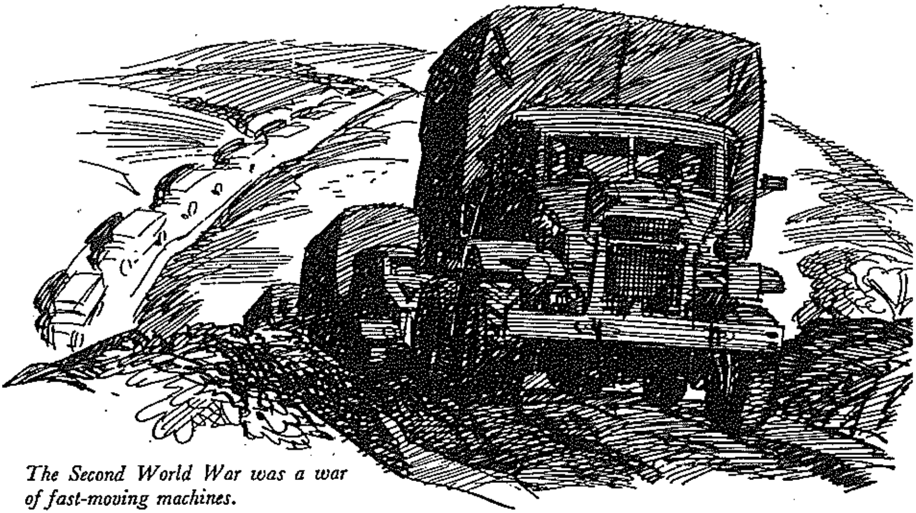
In 1929, The Mond Nickel Company, Limited merged with The International Nickel Company of Canada, Limited. This allowed The International Nickel Company to plan the orderly and effective development of the Frood-Stobie ore body. The Mond refinery at Clydach, Wales, close to the British industrial markets, as well as rolling mills at Birmingham and Glasgow and a precious metals refinery at Acton, England, also became a part of The International Nickel Company. This bettered the position of the Company in respect to European markets, and resulted in an expanded program of research and world-wide development of demand for nickel and nickel alloys.

The Second World War

The Company's policies of constant research and development of new markets which brought about the great expansion of peacetime uses of nickel, and thus made necessary the tremendously expanded production facilities, had also brought the Canadian nickel industry to a position of preparedness when the second world war broke out. In efficiency, in capacity, and in strategic



Building one of the chimneys at Copper Cliff in 1929. This chimney is 510 feet high and 45 feet inside diameter at top. Two other chimneys now flank this one.



The Second World War was a war of fast-moving machines.

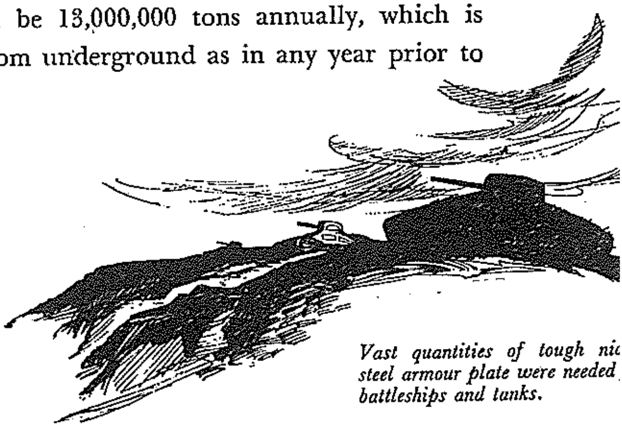
location of its plants, it was admirably equipped to support the war production effort of the Allied Nations.

This was a mechanized war in which victories were to be won by the armies, navies and air armadas with the strongest, toughest, speediest, most powerful machines.

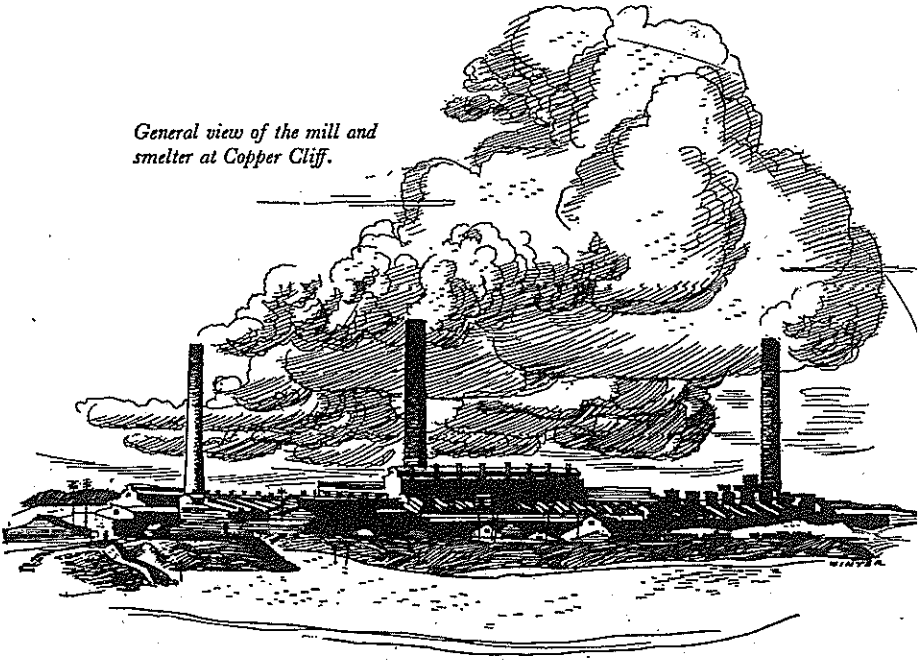
Soon the demand for Canadian nickel for war production made it impossible for the Company to supply the peacetime customers it had taken so long to cultivate. By a system of Government priorities, the total output of Canadian nickel was made available to essential war industries. The Company co-operated with governmental authorities and nickel users in conserving the nickel supply and in recommending substitutions for nickel in uses for which it was not available.

Because of the loss by the Falconbridge Nickel Company of the use of its refinery in Norway, the Company, as an emergency measure, undertook the refining of the entire Falconbridge output. Following the fall of France in 1940, the ores mined and smelted in New Caledonia by Societe Le Nickel were shut off from their refinery in France. To meet this situation, the International Nickel Company installed emergency refining facilities at Huntington, West Virginia, and refined these ores for the United States Government.

To supply the war requirements of the United Nations, the Allied Governments asked the International Nickel Company what could be done further to increase the production of nickel. In response, the Company speeded up its operations in Canada under a program which called for the expansion of practically every step in the production process. With this new program taking shape it was evident that the Frood-Stobie Open Pit Mine would be mined out far ahead of previous schedules. During this period, more than 40% of the Allies' nickel requirements were being obtained from this mine. The Company, therefore, immediately began plans for the expansion of underground operations. Because of this far-sighted policy, the supply of nickel ore will not decrease, despite the fact that by 1953 all the ore will come from the more difficult underground mining operations. To carry out this transition the Company is going full speed ahead with the greatest underground development program in its history. This program has already cost $100,000,000, and will cost roughly half as much more. When these expanded facilities are in operation, the hoisting capacity will be 13,000,000 tons annually, which is twice as much from underground as in any year prior to 1951.



Vast quantities of tough ni
steel armour plate were needed
battleships and tanks.

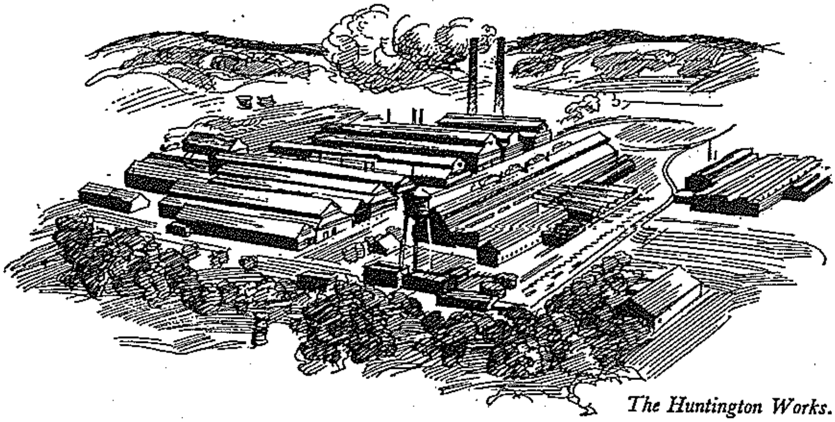


General view of the mill and smelter at Copper Cliff.

International Nickel Today

Today the Company owns 130,000 acres of mineral land near Sudbury, in which the Frood-Stobie and four other underground mines, as well as two open pits, are operated. These mines with the concentrators at Copper Cliff and Creighton and smelters at Copper Cliff and Coniston constitute a single integrated operation laid out to develop, mine and produce a constant supply of nickel geared to the market demand. Long-range planning has brought about the most economical utilization of both low- and high-grade ores and extension of the life of the mines that would not otherwise be possible.

From the smelter at Copper Cliff the bulk of the nickel passes to the large nickel refinery at Port Colborne where pure nickel is produced. All the copper separated from the Company's ores is refined at the Company's copper refinery at Copper Cliff. Some of the power for these operations is furnished by three hydro-electric power plants owned by the Company.



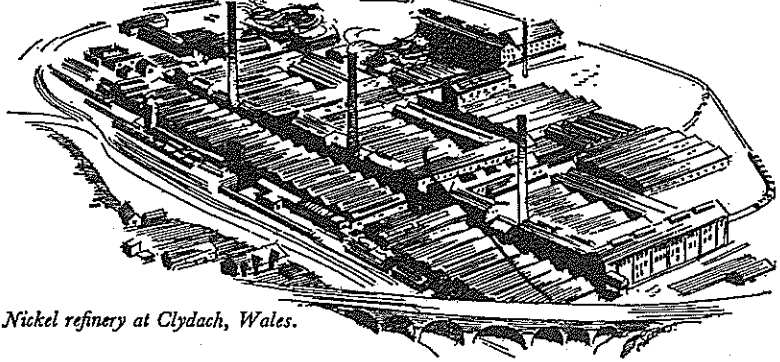
The Huntington Works.

The Company also has a nickel refinery in Clydach, Wales and a precious metals refinery at Acton, England.

The Company operates a nickel alloy rolling mill in Huntington, West Virginia and a foundry in Bayonne, New Jersey; a rolling mill in Birmingham, England; an extrusion and tube mill in Glasgow, Scotland and research laboratories in Canada, England and the United States.

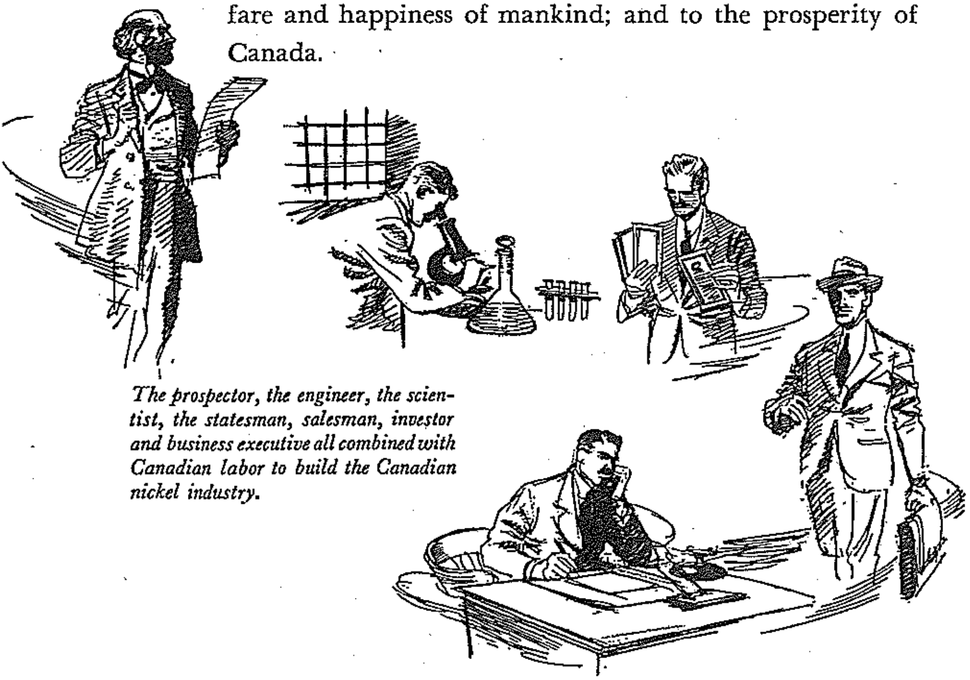
A Successful Operation

The history of The International Nickel Company is the history of a number of men whose judgment time has proved sound. Looking back, the development seems logical and natural; but to look ahead and picture a great industry where nothing has existed before required creative vision, indomitable courage and tireless energy.



Nickel refinery at Clydach, Wales.

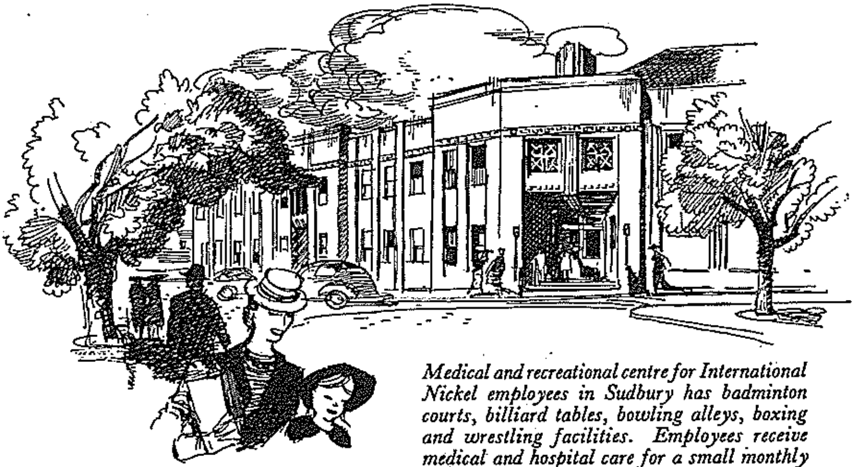
And so the Canadian nickel industry grew step by step— as each of its leaders built firmly and well on the foundations laid by those who had gone before. The prospector and the engineer, the scientist, the statesman, the salesman, the investor and the business executive—each gave his best endeavours. These men contributed their life's work, their skill, their wealth and their knowledge. By ingenuity and skill in processing and constant efforts in developing the usefulness of nickel, they converted an impurity in copper ores into a vital material for modern industry. And they established something permanent and enduring—something which contributes to the welfare and happiness of mankind; and to the prosperity of Canada.



The prospector, the engineer, the scientist, the statesman, salesman, investor and business executive all combined with Canadian labor to build the Canadian nickel industry.

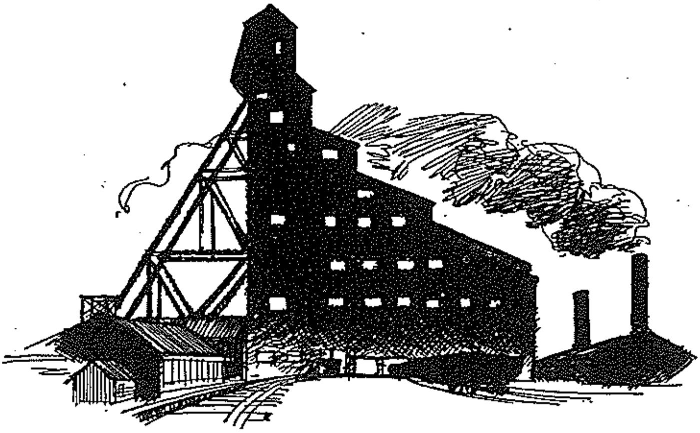
PART TWO

HOW NICKEL IS PRODUCED



Medical and recreational centre for International Nickel employees in Sudbury has badminton courts, billiard tables, bowling alleys, boxing and wrestling facilities. Employees receive medical and hospital care for a small monthly fee.

Sudbury, a thriving city of over 40,000 population, located in that region of rugged rock and crystal lakes north of Georgian Bay, is the centre of Canada's nickel industry. Four miles to the West, at Copper Cliff, are located great crushing, concentrating and smelting plants. Eight miles to the East, at Coniston, a small smelting plant is in operation. Within a radius of ten miles of Sudbury, the International Nickel Company operates four underground mines and an open pit; a fifth underground mine is located 30 miles from Sudbury on the Northwestern rim of the Sudbury Basin. Let us follow the broad, new



highway northward for one mile from Sudbury between low rocky hills to the Frood-Stobie Mine.

Mining

As we approach the mine we see the tall headframes of the three main hoisting shafts silhouetted against the sky, and clustered around them groups of service buildings. Slanting downward beneath the surface of the rock lies a wide body of ore 10,000 feet long and more than 4,000 feet deep. This is the Frood-Stobie ore body with its enormous tonnage of ore still waiting to be mined despite the millions of tons already produced. The distance between the shafts that serve the two sections of the mine is an indication of the extent of the underground workings. Actually they are 5,800 feet — more than a mile — apart.

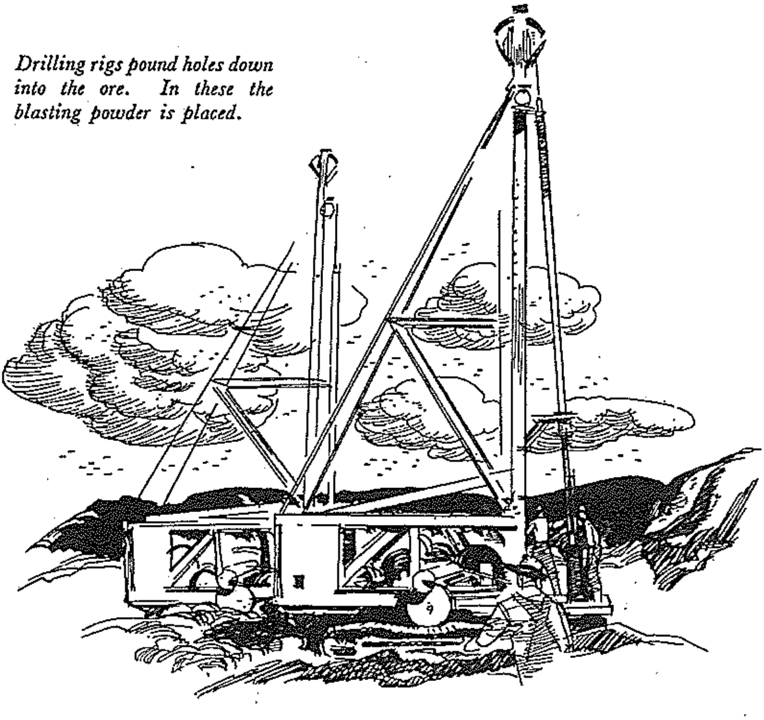
Open Pit Mining

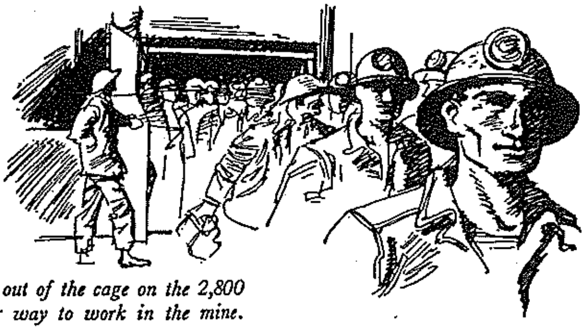
On the surface a huge excavation has been dug out of the ore body and the surrounding rocks, and still the machines cut deeper and deeper. Drilling rigs pound nine-inch holes 60 feet down into the ore. Blasting powder is placed in the set of holes, and once a day, at noon, the charge is fired. About 12,000 tons of ore and rock are shattered with each blast. Then great shovels scoop up the ore into 35-ton trucks, and away it goes to the crusher.

The open pit is being cut down into the rock in steps or "benches" and becomes narrower as it becomes deeper, so surface mining can only be carried on until the two sides of the cone-shaped pit come together at the bottom. Because of this narrowing, the economical depth of pit mining had to be determined at the start and the width at surface planned accordingly. The deepest part of the pit is to be 500 feet below the surface.

Although the crushing plant is actually only about 1,000 feet from the place on the pit floor where the shovels are working, the trucks must travel more than a mile over a road winding upward around the inside of the pit walls before they reach surface with their loads of ore.

Drilling rigs pound holes down into the ore. In these the blasting powder is placed.





Men coming out of the cage on the 2,800 level on their way to work in the mine.

Underground

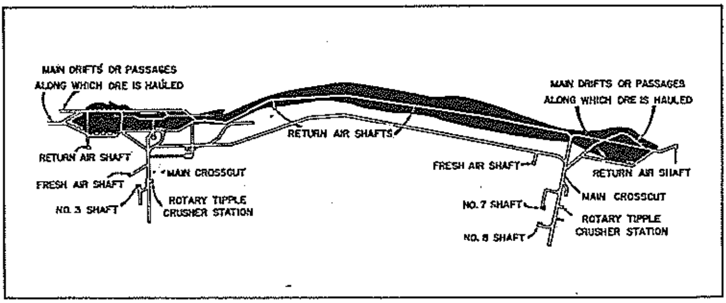
Mining was started at depth in the Frood-Stobie ore body long before open pit mining was begun and the mine has been worked upward and downward from the 2800-foot level. Let us pay a visit to this mine and see what goes on deep down in its underground passages.

Equipped with coveralls, helmet and miner's lamp, we enter the cage and drop down into the earth to one of the lower levels. The cage door opens and we step out into an electrically lighted room cut in the solid rock. Narrow-gauge tracks lead away into long tunnels. We walk along one of these roomy passageways for half a mile or more, then turn into a side tunnel driven into the ore body. Cool breezes sweep along the passageway; to provide good ventilation underground, large fans force air down ventilation shafts; the air circulates throughout the mine and comes back to surface through special return air shafts.

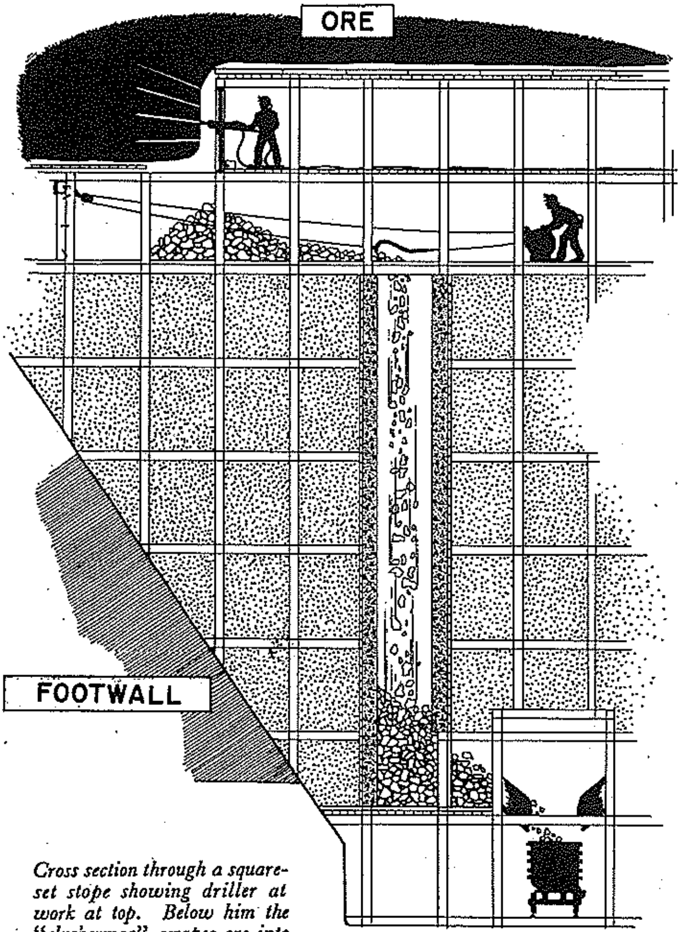
Where Drillers Are at Work

We climb up a series of ladders through a narrow opening in the rock, and finally enter a room where the only light comes from our own and the miners' lamps. This room

is called a "stope". Its walls have a glittering metallic lustre. It is floored with heavy plank. Stout posts support a timbered ceiling. Over at one wall of the stope; the drillers are at work. To the roar of compressed air machines, the long drills pierce the breast of the ore with holes. Powder is inserted, fuses made ready, and at the end of the shift the fuses are lighted and the miners depart. When the charge is fired the whole wall, to a depth of seven feet or more, crumbles and falls to the floor below. The next shift of miners comes on the scene. They timber up the section which has just been blasted and proceed to drill another seven feet into the ore to make ready for another blast.



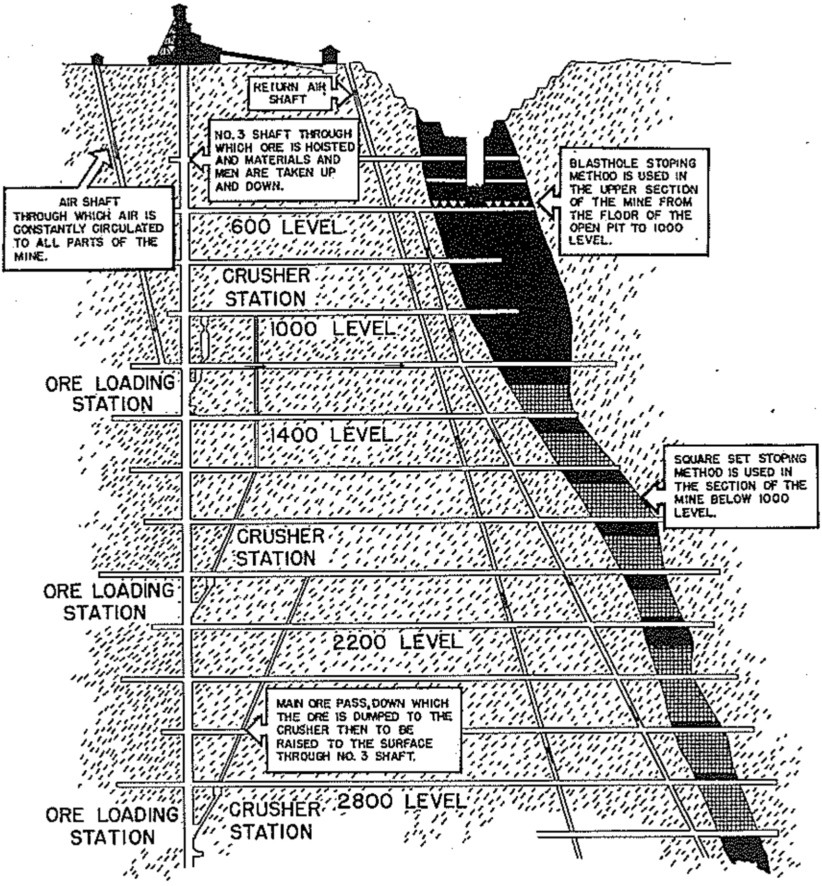
Plan of a level in a nickel mine.



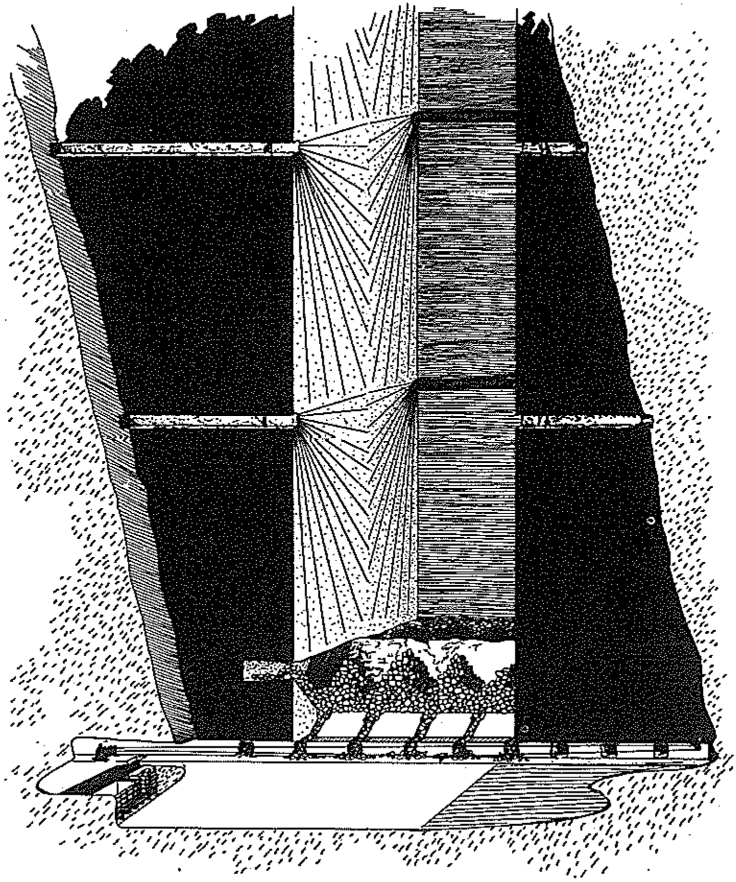
Cross section through a square-set stope showing driller at work at top. Below him the "slusherman" scrapes ore into a chute. Down below it falls into the ore cars.

At the same time on the floor below the drillers, men known as "slushermen," using a hoe-shaped steel scraper drawn back and forth by an air hoist, scrape the broken ore into a chute. So they advance step by step, cutting a slice right across the ore body and removing the ore as fast as it is broken. Then they mine the next slice higher up, but to keep the mine safe, before starting a new slice they fill in the mined sections with sand. This method of mining is called "Square Set."

The sand used for mine fill is obtained from the tailing, or waste material, separated from the ore in the concentrator at Copper Cliff. It is hauled in railway cars to the sand plant at the mine where it is mixed with water and flushed into place in the stopes through pipelines from the surface.



Cross section showing relation of shafts crusher stations and ore passes to the ore body.



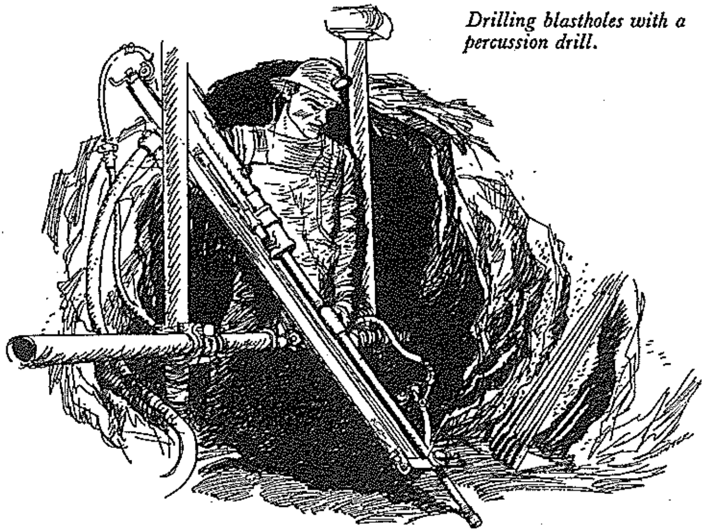
Cut-away section through a blasthole stope showing drillers at work on the sub levels. Below them a slusherman scrapes the ore into cars.

Blasthole Mining

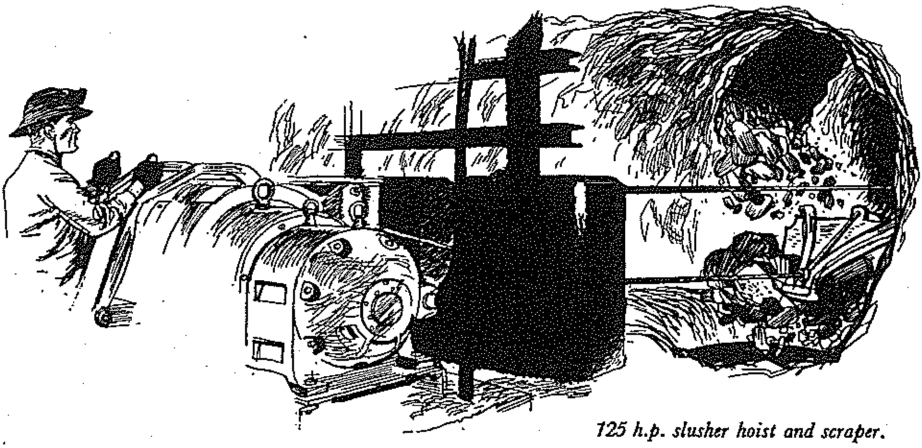
A second more recent method of underground mining called "blasthole" is being used at the Frood-Stobie mine to win ore from the mass lying between the bottom of the open pit and the top of the square set area. The tonnage being mined by the blasthole method is on the increase to help make up for the gradual decline in open pit production.

On a visit to a blasthole stope we find a great underground cavern 300 feet high, 100 feet wide, and 10 to 250 feet long that we cannot enter. We can only look into it from the ends of the small tunnels where the drillers are at work. The tunnels, called "drill drifts" run along each side of the stope for its full length. From bottom to top of the stope there are several such pairs of drifts—one above the other, 100 feet apart.

From the safe vantage of the drill drifts the drillers with their rotary drills and diamond bitted rods or percussion drills and bits with tungsten carbide cutting edges drill fans of 1½-inch diameter blastholes in a predetermined pattern. The holes vary in length from 30 to 75 feet; they are drilled to break a 5-foot slice of ore the whole height and width of the stope face. When the blastholes for four such slices have all been drilled they are loaded with explosives, and electric blasting caps are inserted. The caps are connected into series that are in turn connected to the blasting cables.



Drilling blastholes with a percussion drill.



125 h.p. slusher hoist and scraper.

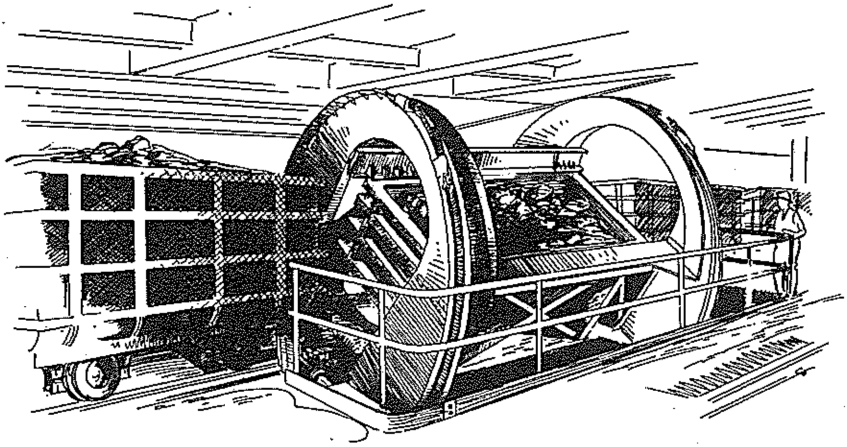
When the miners are out of the mine, at the end of the last shift of the week, the blasting cables are connected to the firing switch; the switch is closed; the shot roars out; the whole face of the stope erupts and 60,000 tons of ore go rumbling down into a heap on the floor of the stope.

The ore fills the boxholes, funnel-shaped openings in the stope floor that lead into "slusher drifts" 40 feet below. Here at one end of each drift a 125 h.p. two-drum electric slusher hoist is set up. The hoist, fitted with heavy wire rope, hauls a massive steel scraper back and forth, dragging three tons or more of ore with it at each pass to an opening in the drift floor. As the ore is drawn away from the foot of the boxholes in the slusher drift, the pile in the stope gradually settles. By the time the pile has been removed another slice of the stope face has been drilled and then another blast is made. The ore broken in one blast is enough to keep the slusher hoist busy two shifts a day for three months.

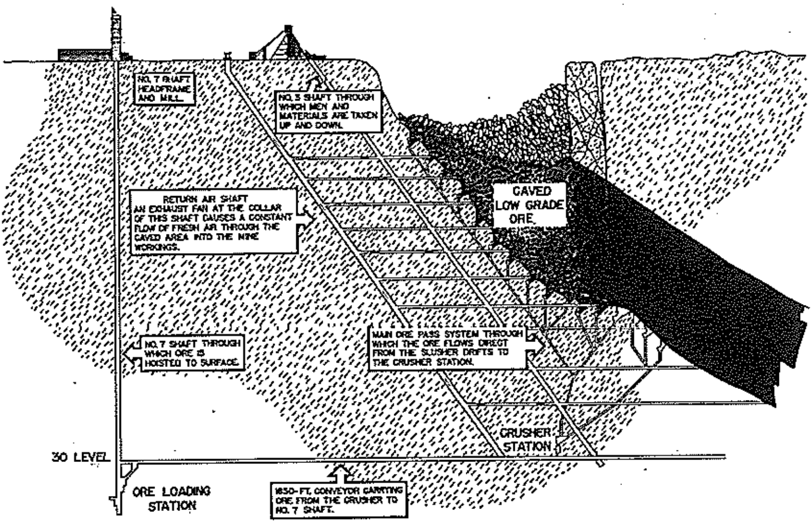
The ore is loaded through the opening in the slusher drift into 12-ton tram cars which are hauled away in long trains by 20-ton trolley locomotives and dumped by a rotary tipple into the massive steel jaws of a crusher which breaks up the larger lumps of ore.

The crushed ore is carried on belt conveyors at the rate of 700 tons an hour to the shafts where it is loaded from measuring hoppers into conveyances known as "skips".

Powerful mine hoists with their steel hoisting ropes whisk the skips up and down the shaft at 3000 feet a minute from the loading pocket to the surface; on each trip a skip carries 15 tons of ore to the bins in the headframe.



Ore cars dump automatically at the rotary tipple.



"Caving" Mining

Another new mining method, called induced caving, has been introduced at the Creighton mine where there is a large body of lower grade ore which could not be economically recovered except by a low-cost bulk system of mining. This ore has a natural tendency to break away from the solid in large slices and to disintegrate from the tension and torsion as it moves downward. Through experiments with scale models in the laboratory, and in pilot operations underground, a system of induced caving was developed for mining the low grade ore body.

The slice to be caved, approximately 80 feet thick by 300 feet long and containing up to 1½ million tons, is undercut, so that as ore from the previous slice is drawn, the new slice breaks away from the solid and moves downward. As the block of ore subsides it tends to disintegrate; furthermore the weight of the ore in the upper part of the mass acts to crush the ore at the bottom.

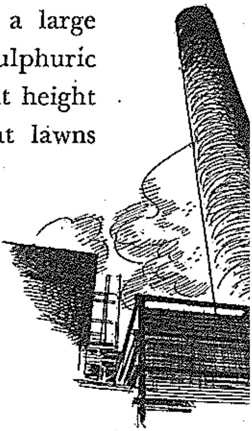
Loading holes for blasting in a drift face.

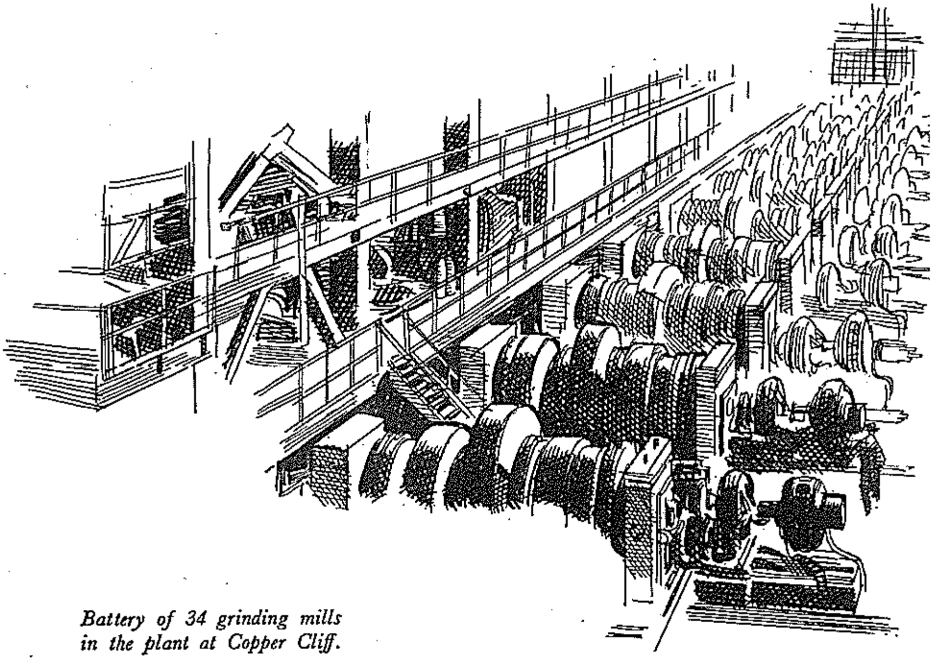
Except that no explosives are required to break the ore from the solid, caving mining differs little from the blasthole method. The broken ore passes through openings into slusher drifts in which it is scraped to ore passes leading to the crushers. The crushed ore is carried by conveyor 1,850 feet to the loading pocket of No. 7 shaft and hoisted to surface.

Crushing, Concentrating, Smelting

As we approach Copper Cliff, three huge chimneys loom up from a vast group of buildings down below. Two of these chimneys are respectively 40 and 45 feet inside diameter at the top and rise to a height of more than 500 feet.

Formerly the sulphur fumes released in smelting the ore killed the vegetation in this district. Now a large part of the sulphur is recovered and used in sulphuric acid manufacture. The balance, carried to a great height through these chimneys, is so well diffused that lawns and gardens now thrive in the Sudbury district.





Battery of 34 grinding mills in the plant at Copper Cliff.

Crushing and Grinding

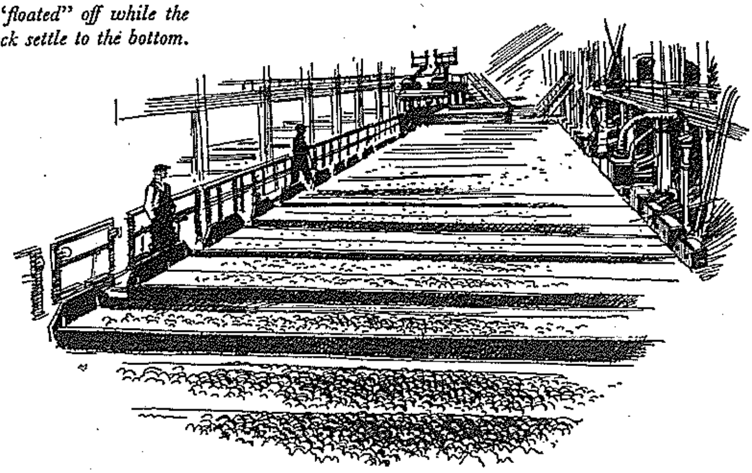
The ore, as it comes from the mine, is composed of rock and a number of minerals which contain nickel, copper, iron, sulphur and a small quantity of precious metals. The purpose of crushing and grinding is to break the particles of rock away from the mineral sulphides.

In a building several times as large as a modern hockey stadium, giant cone crushers and rolls crush the ore to one-quarter inch or less. Then in long batteries of grinding mills the ore, now mixed with water, is ground as fine as flour.

Flotation

In long rows of tanks, by a specialized process, the mineral particles are "floated" off, while the rock particles settle to the bottom. Then in other tanks the copper sulphides are "floated" off and the nickle sulphides settle

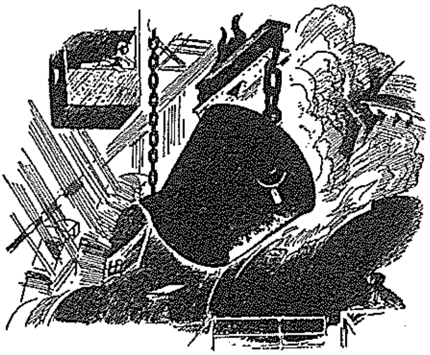
Flotation tanks where the mineral particles are "floated" off while the particles of rock settle to the bottom.



to the bottom. From this separation process two products emerge, one of which contains most of the nickel and some copper; the other contains most of the copper and some nickel. Then in settling tanks and filters most of the water is removed and the two concentrates travel on separate belt conveyors to the smelter.

Smelting

In the huge smelting plant, the nickel concentrate is roasted in great hearth furnaces to get rid of a large percentage of the sulphur. It is melted in reverberatory furnaces, and most of the impurities are skimmed off as slag. Still in a molten state it is conveyed in huge ladles



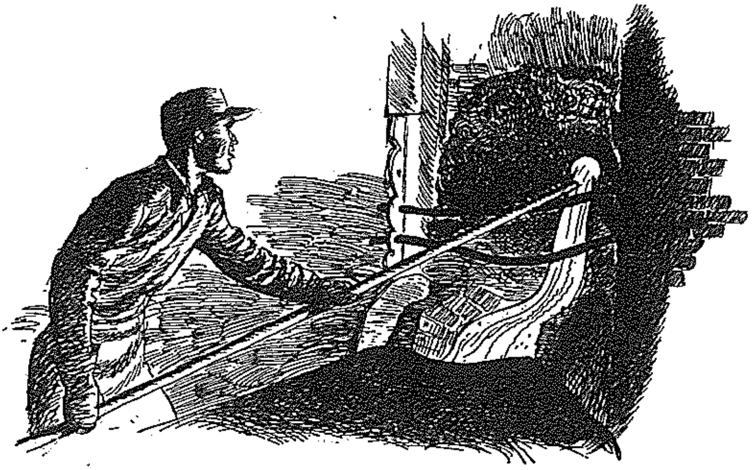
Converters in operation at Copper Cliff.

and poured into the converters. Sand or quartz is added and air is blown into the mixture. This burns off more sulphur and gets rid of the iron.

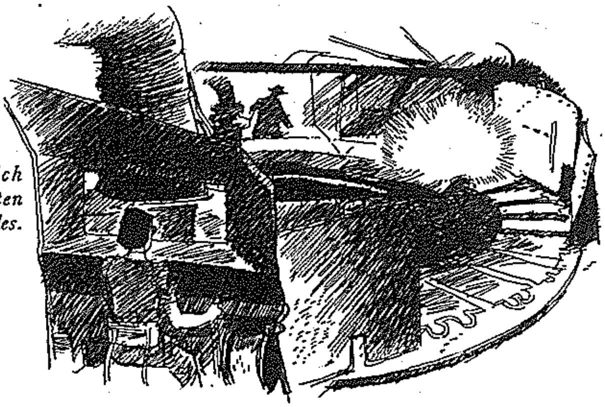
What is left is known as Bessemer matte This matte, formerly treated by our Orford process which served so well for many years, is now put through an improved process known as matte flotation. In the new process, the copper sulphide and nickel sulphide in the matte are separated by subjecting it to controlled cooling, grinding and flotation.

Then the copper sulphide is remelted, blown to blister copper, and transferred in the molten state by means of specially designed "hot metal cars" to The International Nickel Company's copper refinery nearby. This refinery, which produces the Company's O.R.C. Brand copper, is the largest copper refinery in the British Commonwealth.

The nickel sulphide is subjected to a sintering operation to produce a dense "nodular" nickel oxide sinter for refining by both the electrolytic and Mond processes, or for the manufacturing of Nickel alloys and alloy steels.



Skimming slag at 2100°F from a reverberatory furnace.

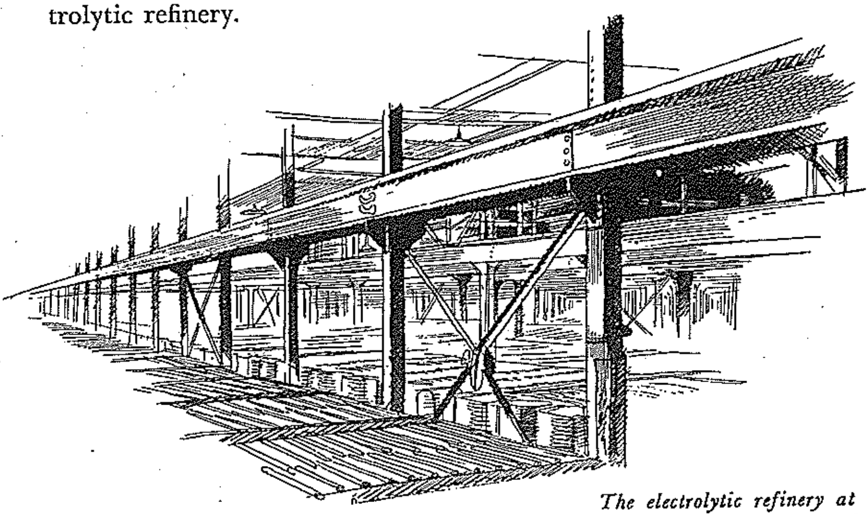


Machine which casts the molten nickel into anodes.

Refining in Canada

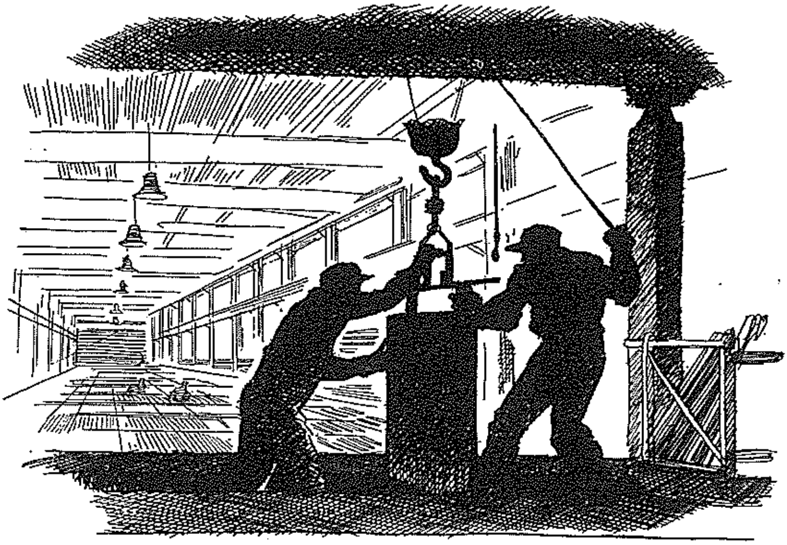
At Port Colborne, Ontario, where the waters of Lake Erie enter the Welland Canal, and close to the plentiful supply of electric power from Niagara Falls, is located the International Nickel Company's great nickel refinery.

Here the sintered nickel product from the Copper Cliff smelter is processed in oil-fired furnaces and poured into moulds. The resulting 425-pound anodes go to the electrolytic refinery.



The electrolytic refinery at Port Colborne covers acres of ground.

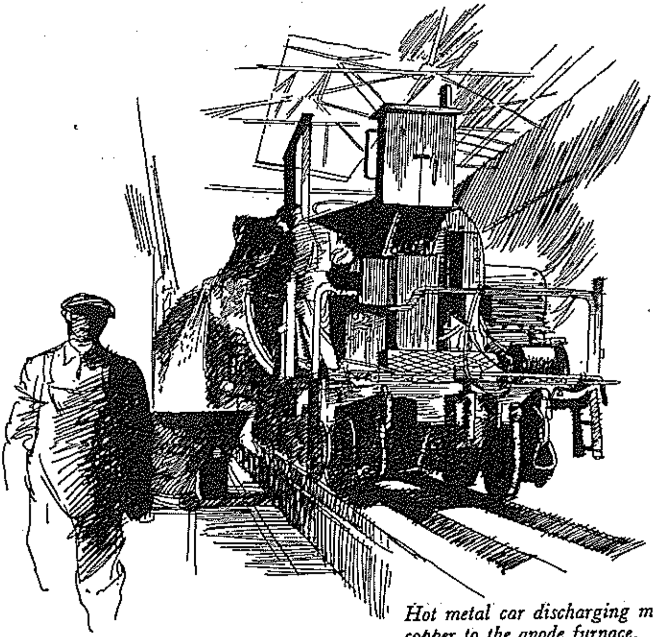
This vast refinery covers twelve acres of ground and is filled with row upon row of concrete tanks. The anodes, consisting of impure nickel and containing a small percentage of platinum metals, are lowered into a nickel sulphate solution in the tanks. The impure nickel anodes are slowly eaten away by the electrolytic process and the nickel is deposited as cathodes. These cathodes which are 99.9% pure nickel, including a fraction of a per cent of cobalt, are removed from the tanks and cut up into the sizes required by the various users of electrolytic nickel. The residue from the tanks contains the platinum and other precious metals. This is concentrated to remove a large part of the impurities, and the concentrate goes to the company's platinum metals refinery in Acton, a suburb of London, England. From it are obtained platinum, gold, silver, palladium, rhodium, ruthenium and iridium. This refinery supplies about half the world consumption of platinum metals.



Removing nickel cathodes (99.9% pure nickel) from electrolytic tanks.

PART THREE

COPPER REFINING



Hot metal car discharging molten copper to the anode furnace.

Situated one and a quarter miles south-west of the Copper Cliff smelter and connected with it by electrified standard gauge railway, is The International Nickel Company's copper refinery.

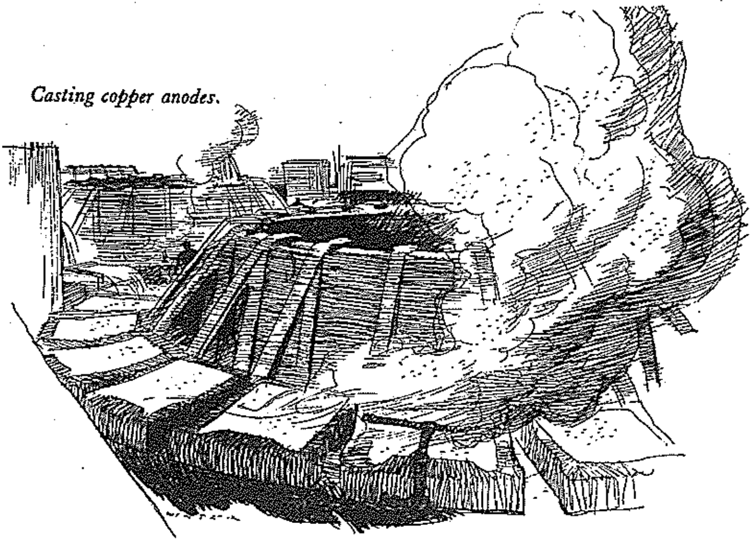
Transferring Molten Copper

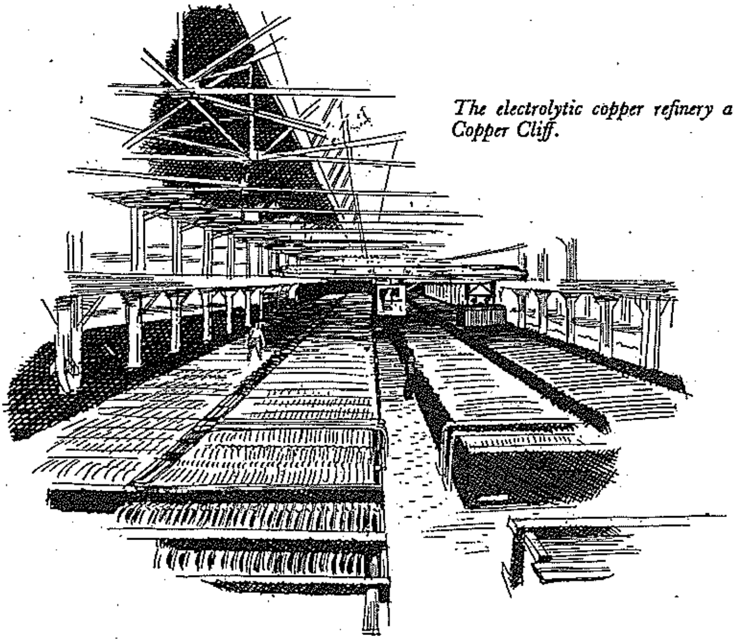
Prior to 1936 the copper produced in the smelting plant was cast in large slabs and brought to this copper refinery, there to be re-melted and refined. To save the large quantities of fuel formerly required to re-melt this copper, the company has devised a method of transferring it in the molten state. Today in the smelting plant, the molten copper is poured into large, brick-lined cylindrical steel vessels mounted on railroad cars. After traversing the mile and a quarter to the copper refinery, each cylinder in turn is rotated on its axis, and spills its white-hot contents of molten copper into one of the three anode furnaces.

Casting Copper Anodes

In the anode furnace the copper is given a preliminary refining, after which the molten copper goes to the casting wheel. This 36-foot wheel has twenty-two moulds around its circumference. As the wheel revolves the correct amount of white-hot metal is poured into each mould. Before arriving at the take-off point the metal hardens into slabs of copper thirty-six inches square and one and a half inches thick with two lugs at one end. These slabs of copper, called anodes, each weighing 580 pounds, are picked up mechanically and cooled in a tank of water.

Casting copper anodes.





The electrolytic copper refinery at Copper Cliff.

Electrolytic Refining

These anodes, which are really slabs of unrefined copper, are taken to the tank house. In this vast building, row upon row, electro deposition tanks cover acres of floor space. Travelling cranes lower the anodes, thirty-eight at a time, into the tanks. Then the electric current goes to work. Slowly the anodes of impure copper are corroded away over a period of twenty-eight days. Steadily the cathodes of copper, over 99.97 per cent pure, are built up in the electrolytic solution of copper sulphate, while impurities settle to the bottom of the tanks.

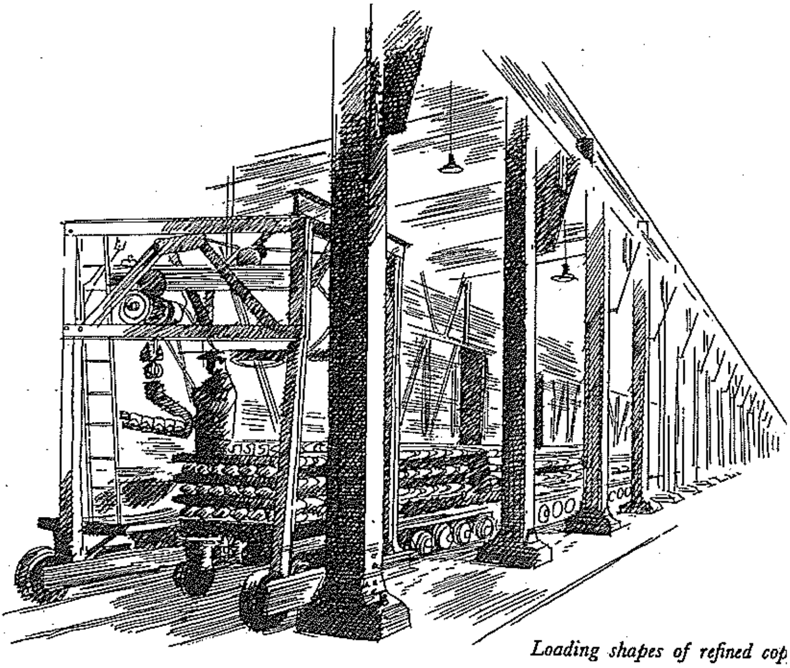
In the production of special shapes required by various branches of industry, the copper cathodes are fed through a letter-box type slot into large electric furnaces. Here they are continuously melted, and cast into shapes suitable for the manufacture of copper wire, copper tube and other products.

Some of the cathodes are sheared to 9 x 36 inch size by a great knife slicing obliquely down, and are then directly ready for shipment to foundries making brass and other alloys.

Recovering Precious Metals

The sludge or slime which collects in the bottom of the electrolytic tanks, contains a percentage of precious metals. By a series of intricate processes, silver and gold are recovered and cast into bars. Platinum and palladium are obtained by further refining processes. Selenium and tellurium are recovered in a separate building, and certain other concentrates are shipped to the Company's precious metals refinery at Acton, England for recovery of metals of the rhodium group.

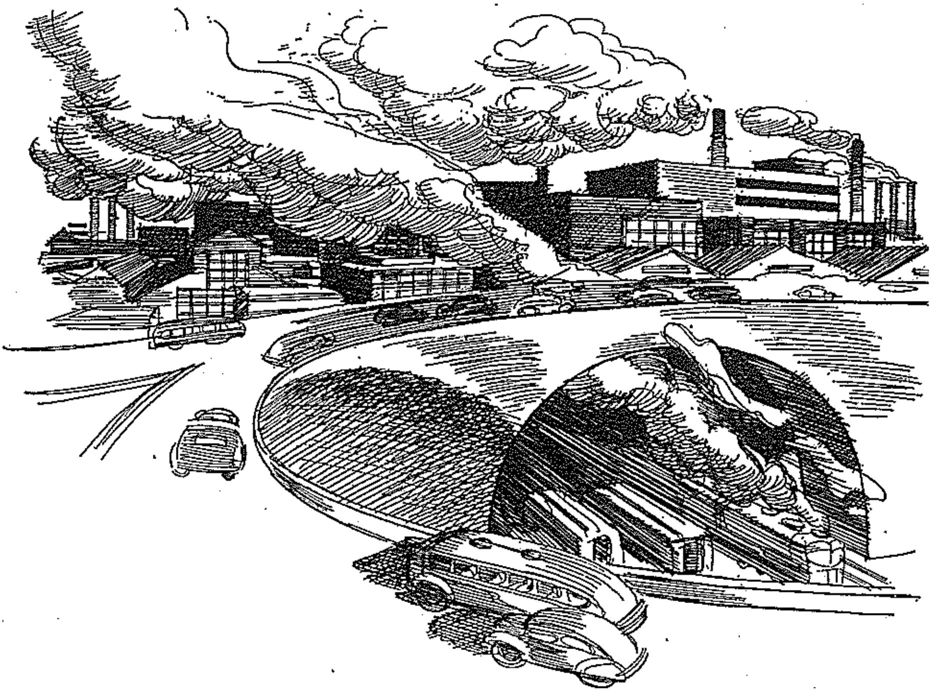
The refinery handles all the copper produced at the Copper Cliff smelter, and also refines copper produced by other Canadian mining and smelting companies.



Loading shapes of refined cop

PART FOUR

WHAT NICKEL IS USED FOR

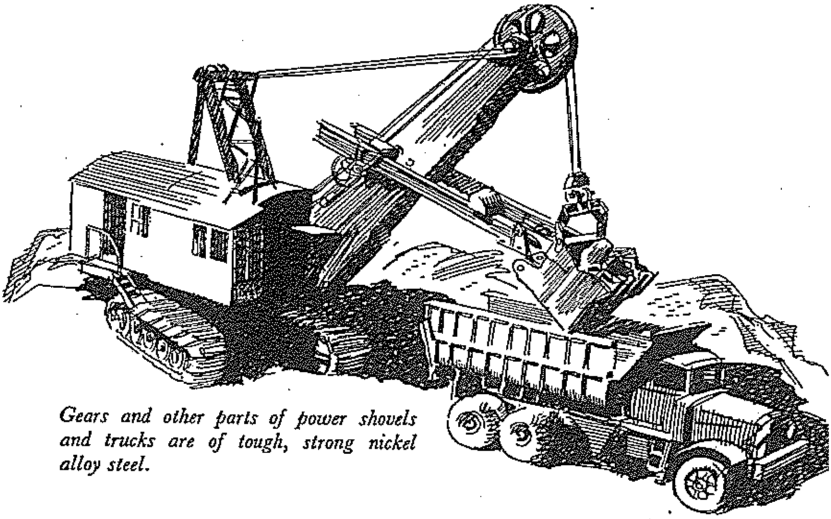


Until about fifty years ago there was little demand for nickel except for nickel plating, for nickel coins, and for nickel silver used as a base for silver-plated ware. Since that time, and especially since 1921, hundreds of additional uses have been discovered for this metal, largely through scientific research.

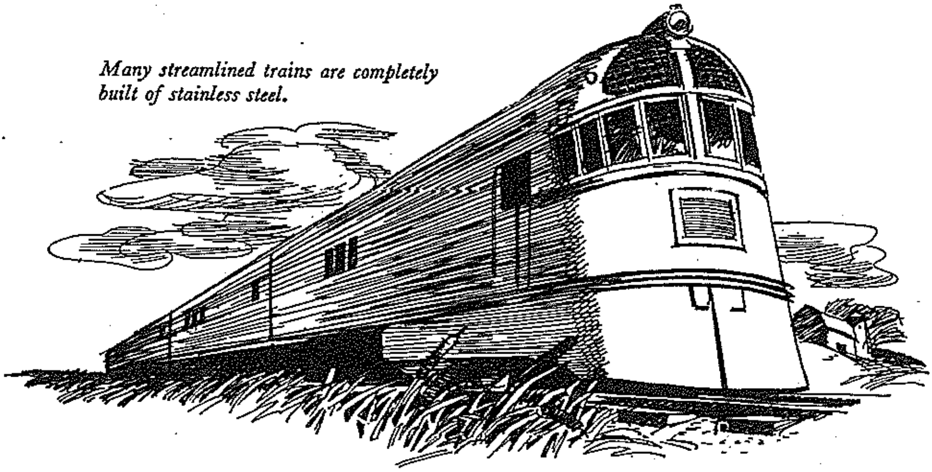
Strong, Tough Nickel Steels

Nickel itself is strong and tough and resists wear; it also imparts these same qualities to other metals with which it is mixed or "alloyed." When added to steel, for instance, it produces an alloy that is stronger, tougher and more resistant to wear than the steel itself.

Because of their greater strength, steels containing from 1½% to 5½% nickel are very extensively used for the gears, steering parts, crankshafts and other vital parts of automobiles The great strength and toughness of nickel steels are even more essential in many parts of trucks, buses, tractors, steam shovels and freight cars because these must stand up under repeated heavy shocks and strains. Nickel steels are used in all types of machinery in mills, factories and shops; in ship propulsion machinery; in the machinery used for drilling, producing and refining petroleum; in the engines and landing gears of aeroplanes.



Gears and other parts of power shovels and trucks are of tough, strong nickel alloy steel.



Many streamlined trains are completely built of stainless steel.

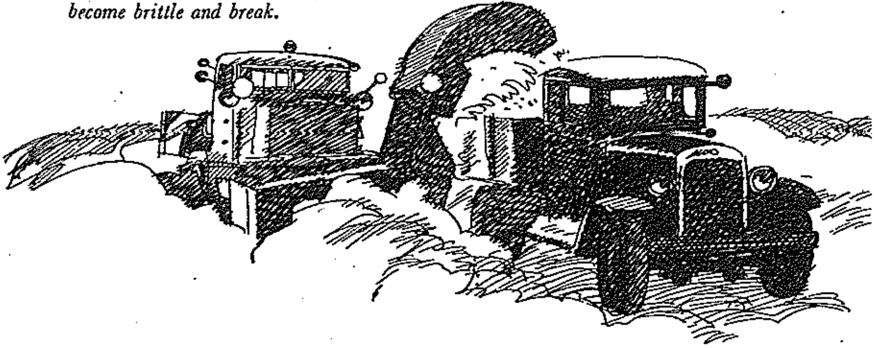
Heat and Corrosion Resisting Steels

Nickel does not rust, and stoutly resists corrosion by salt water, by many acids, caustics and other chemicals. It also stands up under heat. So nickel, when alloyed with steel along with chromium or other alloying elements, helps to make those metals resistant to heat and corrosion too.

Stainless steel, for instance, containing 8% nickel and 18% chromium, is used in hotel and restaurant kitchens and in food processing plants because it resists the corrosion of the food juices and does not contaminate foods. Some modern streamlined trains are completely built with a stainless steel framework and encased in stainless steal sheets so thin, yet so strong, that weight and operating costs are substantially reduced. Ordinary steel sheets would soon rust through—the stainless steel does not even need the protection of paint.

Nickel steels, too, are used in industrial furnaces where they give strength and long service at high temperatures. They are also used in sub-zero temperatures—in cold climates, and in oil refineries and liquid air machinery at temperatures as low as −300° F., where ordinary steels tend to become brittle and break.

Nickel steels stand up in sub-zero temperatures where ordinary steels become brittle and break.

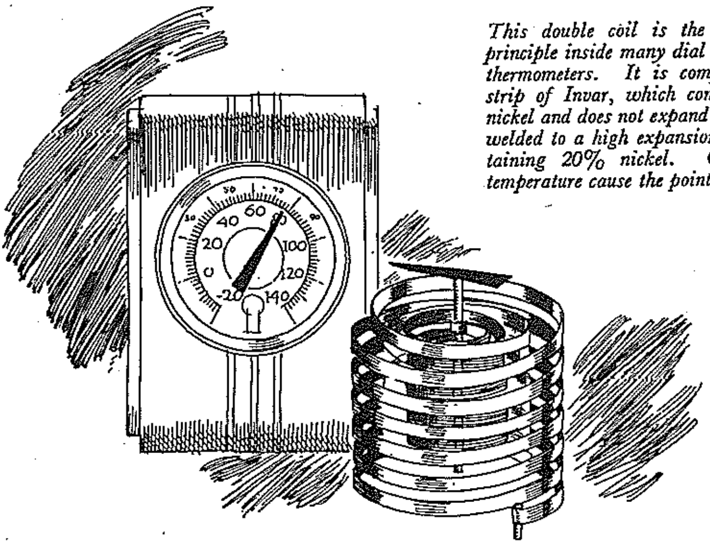


Special Nickel Alloy Irons

Many unusual alloys are required in the intricate instruments and equipment of various kinds being used today, and many special alloys containing from 2% to 90% nickel have been developed for these special services, and for equipment which must stand up at high temperatures and under corrosive conditions.

Through the use of nickel, alloy irons have been developed that are magnetic, others that are non-magnetic. Non-magnetic alloys are widely used in aeroplane instruments, and magnetic alloys in the radio and telephone industries.

Special nickel alloys have also been developed which show practically no expansion or contraction in chang-

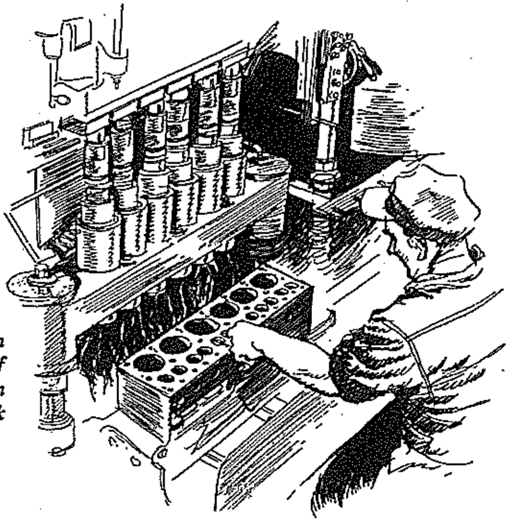


This double coil is the motivating principle inside many dial and pointer thermometers. It is composed of a strip of Invar, which contains 36% nickel and does not expand or contract, welded to a high expansion alloy containing 20% nickel. Changes in temperature cause the pointer to rotate.

ing temperatures — others that expand and contract a great deal in heat and cold. These are widely used in thermostats. A piece of alloy of this type is used in practically every automobile speedometer to offset inaccurate readings which would otherwise result from changes in atmospheric temperatures.

Nickel Cast Iron

In the years following the first World War when the nickel industry was depressed due to lack of markets, nickel research scientists began a thorough study of cast iron. Taking advantage of all experimental work previously carried out by other research scientists, they proved conclusively that cast iron could be improved by adding small percentages of nickel. Nickel makes the metal finer and more uniform in texture. It also increases its strength, toughness and resistance to corrosion.



Precision machine in final operation of polishing cylinders in cast iron cylinder block for automobile.

Since that time nickel alloy iron has been adopted for scores of new uses. It is widely used in the machine tool industry for the beds of lathes and heavy machine tools. The engine blocks and cylinder heads of gasoline and diesel engines are generally made of nickel alloy iron.

Ductile Iron

In May, 1948, The International Nickel Company announced a revolutionary new foundry material developed at the Bayonne Research Laboratory and commonly known as Ductile Iron. This new product, while made in the iron foundry, is unlike ordinary cast iron, is not brittle, but can be bent or twisted as cast. For generations foundrymen had been searching for a material that would bridge the gap between cast iron and cast steel. Ductile cast iron was the answer and has been heralded as the greatest development in the foundry industry since Seth Boyden first made the American type of malleable iron around 1820. Today, ductile cast iron is being widely accepted for a variety of engineering uses and it is expected within the next few years it will become the third ranking industrial material on the tonnage basis.

Nickel Alloyed With Many Metals

In this modern world we find nickel being alloyed with a great number of metals where special characteristics are required. It is alloyed with copper, brass and bronze to give greater resistance to corrosion and wear, or to give a white color; with aluminum to provide a metal that is strong but light in weight; with molybdenum, cobalt, titanium and gold.

Nickel in Everyday Life

Actually nickel is with you and does things for you from the time you get up in the morning till you go to sleep at night.

Let us start with the clock beside your bed. Nickel plating gives it its cheerful, rust-proof shininess. If it is an electric clock, magnetic nickel alloys make possible its compact size and low current consumption.

If the house is cold, you turn on the heat. The valve is of tough nickel bronze. If the furnace is an oil burner—a good oil burner—the fire pot is made of heat-resistant nickel-chromium-iron alloy.

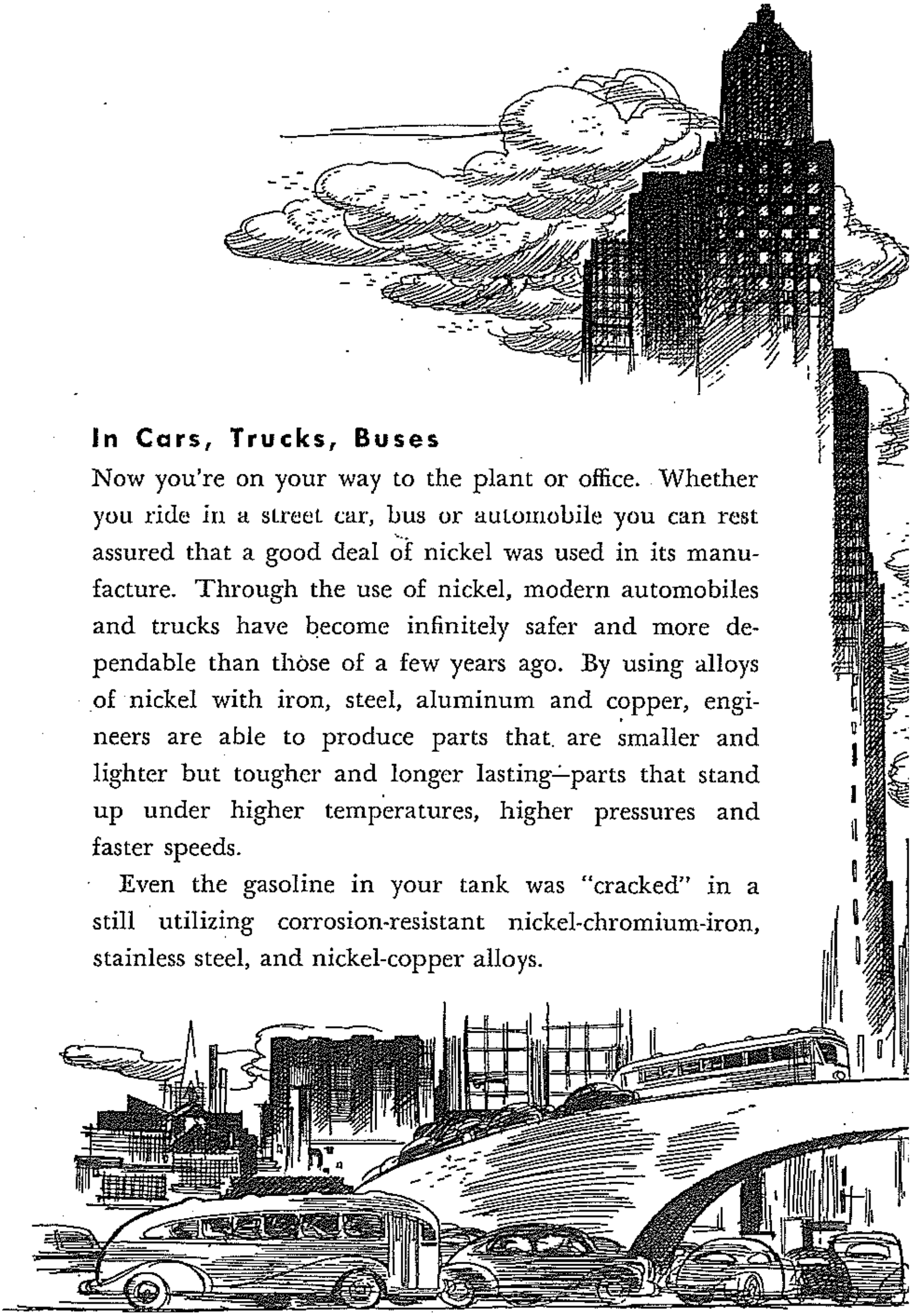
Now you're in the bathroom. The water runs through gleaming fittings of solid nickel silver. As you brush your teeth, remember—in plants where tooth pastes are

made, their purity is guarded by "Monel" and pure nickel utensils. The soap you use was processed in kettles of nickel-clad steel, "Monel" or pure nickel.

Nickel steel and nickel cast iron have been used in the machinery that made your shoes. As for your clothing, "Monel" dyeing machines, since they are not acted upon by the dye solutions, have made possible the delicate shades so popular these days.

At Breakfast

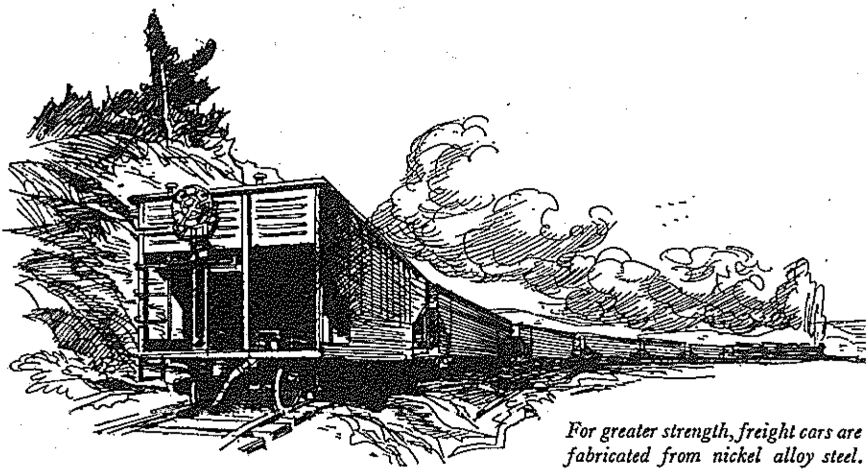
And now for breakfast! In a silver-plated nickel silver percolator you make your morning coffee. Nickel-chromium wire has come into general use for electrical heating elements because it stands heat so well. It makes your toast, and cooks the food on your electric range. In the packing plant where your bacon was cured the equipment which came in contact with the meat was "Monel" — sanitary and easy to keep clean. Even the purity of the salt on your table depends on nickel. In the salt refinery, wet salt and brine rapidly corrode most metals, but "Monel" suffers no ill effects whatever. And as for sugar, filters of "Monel" mesh now give much longer service in sugar refineries than the canvas filters formerly used.



In Cars, Trucks, Buses

Now you're on your way to the plant or office. Whether you ride in a street car, bus or automobile you can rest assured that a good deal of nickel was used in its manufacture. Through the use of nickel, modern automobiles and trucks have become infinitely safer and more dependable than those of a few years ago. By using alloys of nickel with iron, steel, aluminum and copper, engineers are able to produce parts that are smaller and lighter but tougher and longer lasting—parts that stand up under higher temperatures, higher pressures and faster speeds.

Even the gasoline in your tank was "cracked" in a still utilizing corrosion-resistant nickel-chromium-iron, stainless steel, and nickel-copper alloys.



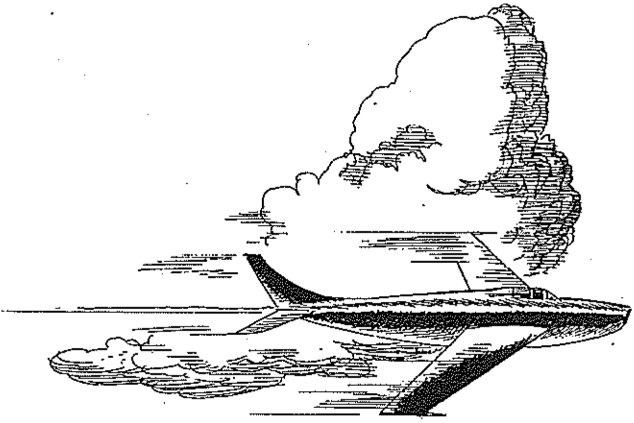
For greater strength, freight cars are fabricated from nickel alloy steel.

On the Railroad

If you have to take a trip on the train, you will be interested to know that sturdier engines and freight and passenger cars are being built today, and at the same time their weight is being reduced, by lighter, stronger alloys containing nickel. In modern locomotives, steam pressures and temperatures have climbed to points that would have been impossible a few years ago. So the locomotive of today pulls a much greater load in proportion to its weight, because of the tougher, stronger, longer-lasting nickel alloys used in its construction.

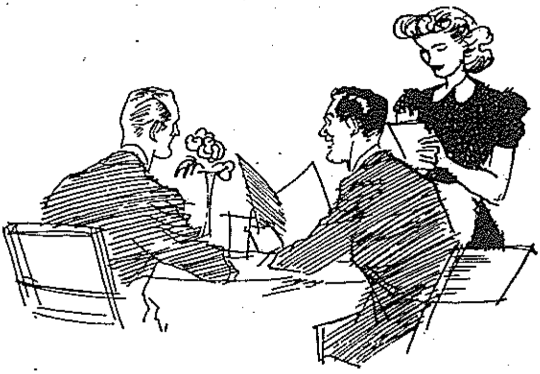
Nickel Has Thousands of Uses

As you walk along the street you see a foundation being dug for a new building. Nickel steel parts give strength and shock resistance to that burrowing power shovel. The life of the tractors down there has been lengthened by the use of nickel alloy steel in parts that must stand abuse. Cranes are lighter and stronger than they used to be, because of nickel steel.



Far up overhead a plane is defying height and distances. Nickel alloys, because of their strength and resistance to heat, have contributed greatly to the efficiency, safety, durability and light weight of the standard aero engine as well as the jet engine.

No matter what restaurant you pick at lunch time, you'll find nickel a big factor in its operation. Back in the kitchen "Monel" and stainless steel are used for sinks, steam tables and other surfaces which come in contact with food. These nickel-bearing metals are good-looking, sanitary and easy to keep clean. While they cost more than yesterday's galvanized steel, they are actually cheaper because they last so long.



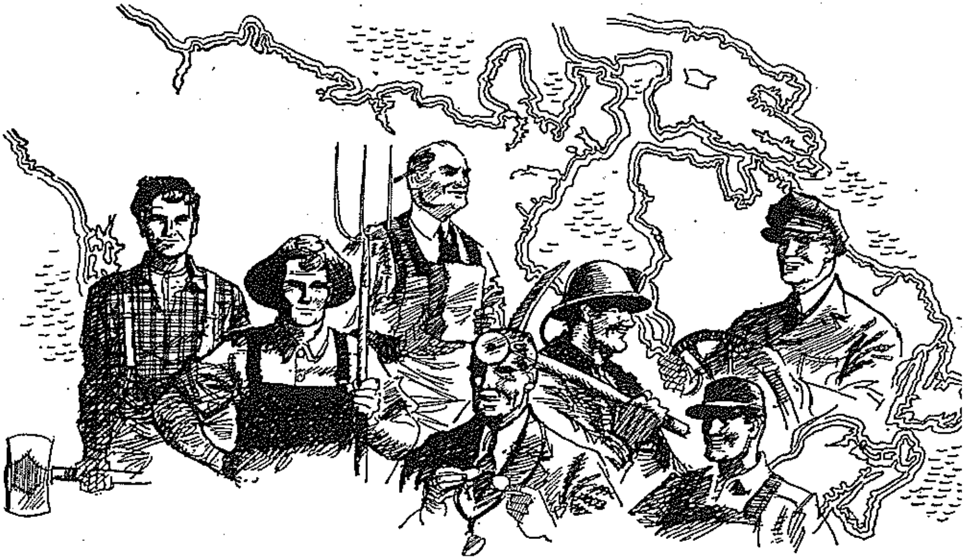
In the Home

Back home at the end of your working day you sit down and turn on the radio or T.V. set. In the tubes for today's radios as well as for the television sets, pure nickel is employed.

After dinner someone suggests a movie. If it's a technicolor picture, nickel has played a big part in its production, for nickel alloys are essential in the special machinery used in developing and transferring the film.

When you return home and you open the door with a nickel silver key. As you settle down to sleep at night and pull the bed clothes up and around your shoulders, don't forget that the sheets were bleached and laundered in machines made of "Monel." Because of its corrosion resistance, it keeps them clean and spotless.

PART FIVE · WHAT NICKEL MEANS TO CANADA



In the city of Sudbury and in the towns and villages located in the mining district in the Sudbury area, about 60,000 people are living today. Practically all these people, whether they be miners, grocers, doctors, electricians or bus drivers, get their living directly or indirectly from the Canadian nickel industry.

About 1700 people are employed in the nickel refinery at Port Colborne. Thousands more in all parts of Canada also earn their living by producing or supplying the products purchased by the nickel mines, mills, smelters and refineries, or by the people who work for the Canadian nickel industry.

Loading timber into the supply cage at the Frood mine.

By the value of its exports, which in some years have exceeded $175,000,000, and by its purchases of supplies and services, Inco makes an important contribution to Canada's economy. In recent operations in Canada alone it has, during a period of one year, paid over $59,000,000 in wages and salaries to an average working force of 14,300; paid $9,000,000 in railway freight; paid $55,600,000 for supplies and equipment; used an

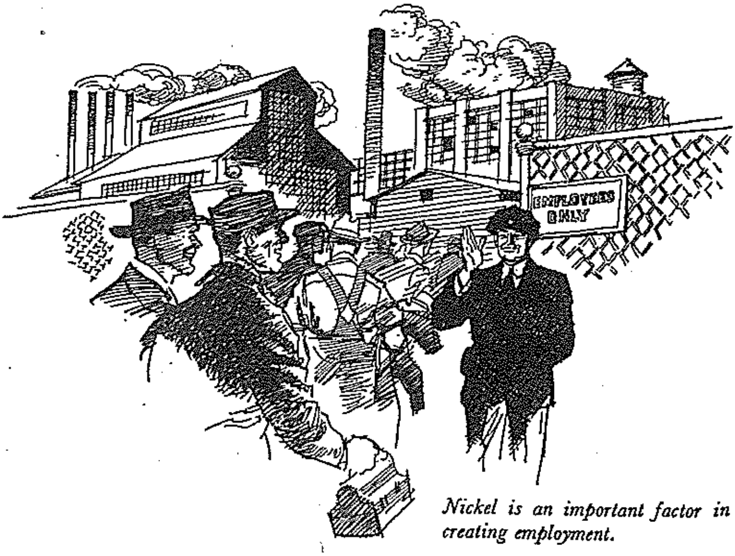
Patient and nurse,
Copper Cliff Hospital.

average of almost 150,000 h.p. of electric power; used over 77,000,000 board feet of timber in the mines; used almost 600,000 tons of coal; used more than 250,000 tons of coke; used 4,500 tons of explosives.

The International Nickel Company purchases hundreds of thousands of dollars worth of other kinds of supplies each year—ore cars, miners' lamps, machinery, coal, drills, boots, overalls, helmets, paint, oil. Canadians in all parts of Canada earn their daily bread producing these things.

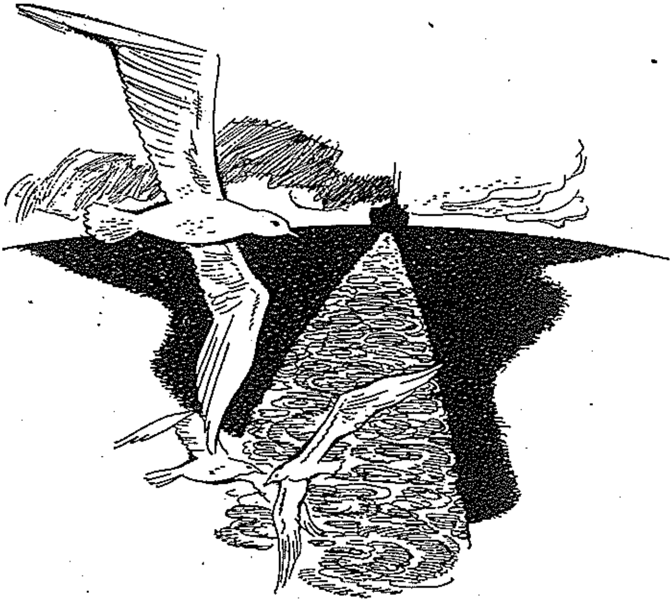
In one year the International Nickel Company paid over six million dollars to Canadian railroads for freight. This represents employment for scores of Canadian railwaymen.

All these people in turn spend their earnings on food products from Canadian farms, on clothing, furniture, groceries, dentist bills, rent, and scores of other items, and so help to create further employment throughout the Dominion.



Nickel is an important factor in creating employment.

Over 95% of the nickel produced from the Sudbury mines is exported to the United States, Great Britain and other industrial countries. Our prosperity depends in a large measure on our exports. The export of Canadian nickel is a substantial factor in helping Canada maintain a favourable balance of trade with other countries.



WRITTEN, ILLUSTRATED
AND PRINTED IN CANADA