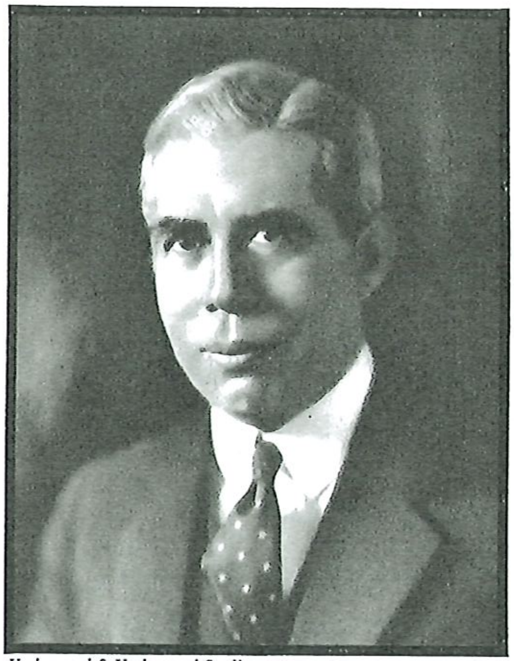
Four Walls Around an Industry

Ninety per cent of the world's nickel comes from one company's mines, is under one man's direction. The company: International Nickel. The man: Robert Crooks Stanley.

THE International Nickel Co. of Canada, Ltd., has about a 90 per cent world monopoly on the physical supply of nickel. This monopoly is founded on the stinginess of nature. There is plenty of nickel in the earth's surface, but most of it exists in forms that would make its refinement prohibitively expensive. Nickel sells for thirty-five cents a pound (compare with aluminum at twenty-one, copper at nine, steel at one and a half), but it takes mines like International's to make even that figure possible. For beneath a few square miles of the surface of Canada, nature has had her one kind moment for nickel. Here are enormous masses of ore bodies, outcropping on the earth's surface and slanting, nobody knows how many thousand feet, down toward the earth's center. The ore is not in veins; it is in deposits. At the Frood mine, for instance, the surface ore body was 300 feet thick and varies from 40 to 200 feet at the 2,000-to-3,000-foot levels now being worked. In addition to nickel, the ore also contains copper—more of it than nickel. International ranks as the sixth largest world producer of copper. The ore also yields a considerable amount of gold and silver and enough platinum to make International the world's largest corporate platinum source (although the Union of Socialist Soviet Republics may be producing more platinum). Chief merit of International's precious metals lies in the fact that they are strictly byproducts. The added cost of getting out the gold and silver and platinum is negligible compared to the major cost of getting out the copper and nickel. So here is a company that was born with a whole collection of valuable spoons in its mouth; and from a nickel standpoint, blessed must be International Nickel, for it has undeniably inherited the earth. And in the first quarter of 1934 it cashed in on its inheritance to the extent of a $5,000,000 profit.

Yet Nickel, always potentially rich, has only recently been prosperous. In the old days the company that had the mines did not have any process for separating the nickel from the copper. Lacking such a process it was merely a copper mine (it was called the Canadian Copper Co.) producing a bastard form of copper. But there were two U.S. companies (the Joseph Wharton company at Camden and the Orford company at Bayonne, New Jersey) with a nickel refining process; both, however, were weak in ore reserves. In 1902 these three companies were consolidated, largely through the efforts of Charles Schwab, now Bethlehem-Steel's emotional Board Chairman, so thereafter product and process were no longer divorced. But nickel was hard to sell. Its chief industrial value is its ability to toughen steel; steels containing from 2 to 5 per cent of nickel do most of the world's really hard metal labor. One obvious use for tough steel is in armor plate for battleships, and the pre-War naval armament races were run off mostly with nickel steel. And during the War, nickel—used also in shells and in bullet jackets—developed almost entirely into a military material. But after the War and after the post-War naval treaties, nickel again became a drug on the market. Biggest contemporary story in nickel is its post-1922 development in industrial alloys. Today nickel is about 20 per cent in the automobile business and not more than 5 per cent in the shot and shell business. And today nickel is making more money than it made even in the War years and making it with as much security as diversification can bring. So there are two major divisions in any story of nickel. First there is the story of mining and smelting. Second there is the story of sales, which is the story of what nickel will do. To Robert Crooks Stanley, Nickel's smart, self-confident, aggressive U.S. President, the sales story is no doubt more vital. But even Mr. Stanley could not sell his nickel without his nickel mines.

BECAUSE even the most sensitive film has limitations, FORTUNE *sent Artist Stanley Wood to Canada to catch the flame and shadow that attend the birth of nickel. His paintings, made in International's mines and smelters, accompany this article. It was in May that* FORTUNE *reproduced his paintings of Boulder Dam.*



Underwood & Underwood Studios

ROBERT CROOKS STANLEY

"During August, 1921, all mining and smelting operations were suspended and the refineries . . . were practically closed." Extract from President Stanley's first annual report. In the first quarter of 1934, the International Nickel Co. made $5,000,000.

Sudbury ore

ABOUT 260 miles north of Toronto and about 35 miles from the northeast corner of Lake Huron, is the town of Sudbury, Ontario. Fifty years ago, Sudbury was the western terminus of the Canadian Pacific. It was then a lumber center, surrounded by forests of pine. But the trees have long since been cut down and their stumps burned over by repeated fires (the beautiful northland here exists only in travelogue descriptions). There is indeed a general lack of vegetation, for it is not many years since the ore smelters roasted the ore in big, outdoor wood fires which burned for months and rolled clouds of sulphur-laden smoke along the ground like a gas attack on the Western Front. So landscape gardening was not encouraged and the chief element in the decorative scheme became the mountains of black slag and the lowlands of muddy tailings with which the metal refinery also surrounded itself. Now the ore is roasted indoors, and the sulphurous smoke escapes through two tall chimneys, the taller of which is 510 feet high. It floats for miles out over the countryside and becomes a good deal less concentrated en route. Thus Sudbury and Copper Cliff (the actual smelting site) now have lawns and gardens, and stretches of green relieve without removing the prevailing note of scarred acres and barren soil.

But Sudbury is today important not for what is on the earth's surface but for what

Paintings for FORTUNE *by Stanley Wood*

NICKEL IS THE LARGEST INDUSTRY IN THE WORLD UNDER ONE ROOF. HERE IS THE ROOF

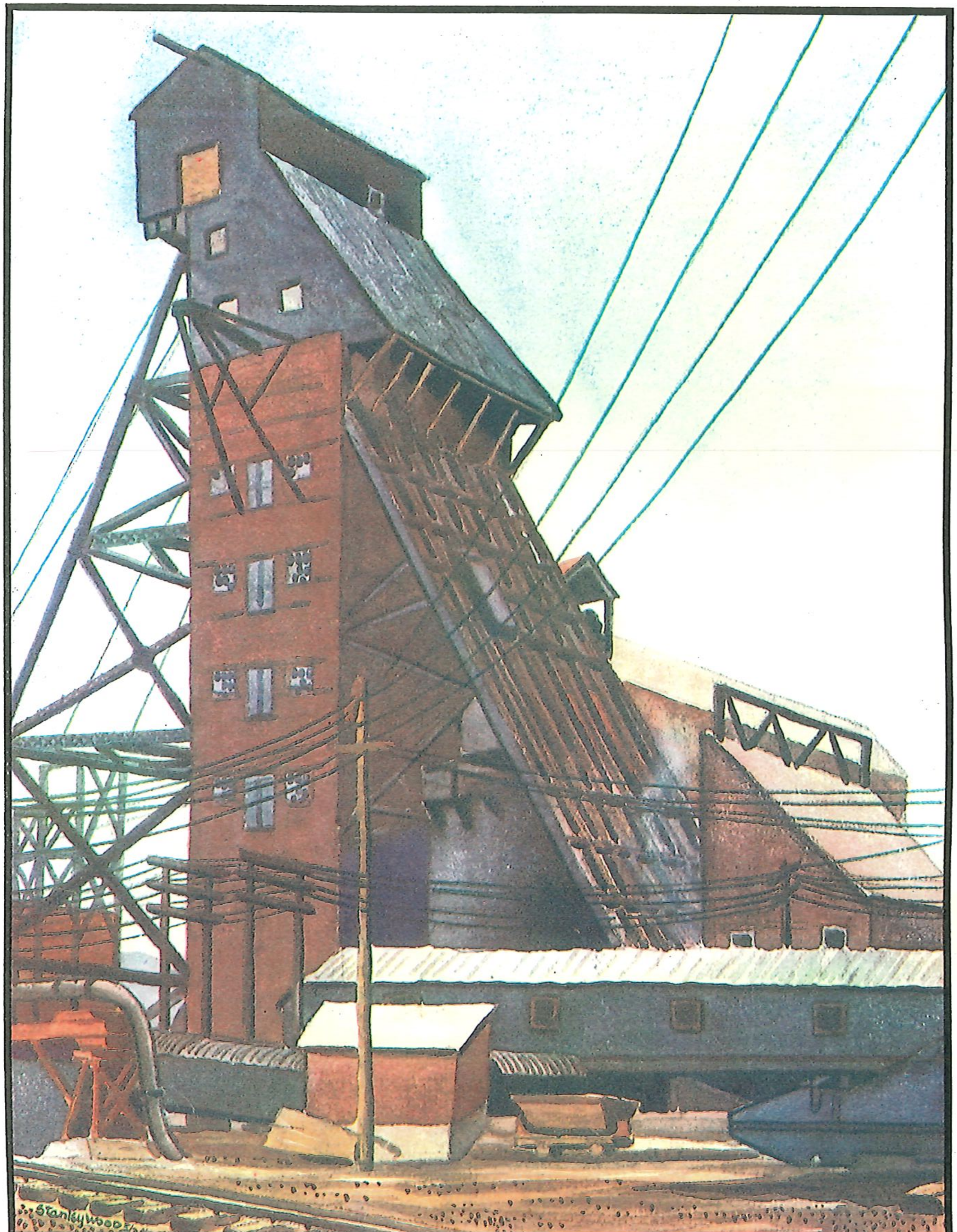
This is the Copper Cliff smelter of the International Nickel Co. It is practically an industry within four walls, for at this plant is smelted nearly 90 per cent of the whole world's nickel supply. The smelter was begun in July, 1928; its first production was in August, 1930. Built by the Fraser-Brace Engineering Co., Ltd., of Montreal, the entire job generated a payroll of $7,200,000, used 35,000 tons of structural steel, occupies 1,000,000 square feet of floor.

is beneath it. The town is on the southern edge of the Nickel Range, a line of rugged hills which mark the rim of the Sudbury basin. The basin itself is a flat area about thirty-six miles long and sixteen miles wide; the hills surrounding it form roughly the shape of an oyster shell. At the foot of these hills and on the inside of the shell is found a kind of rock known as *norite*. The norite is geologically older than most of the rocks surrounding it. And it is along the line of cleavage between the norite and the younger rock that the nickel-bearing ore bodies are found. It is as if some prehistoric nickel god, finding a weak spot in the earth's crust along the edge of the norite rock, had hammered in his big wedges of nickel ore and left them for men to come upon.

Yet although there is presumably some nickel all along the Nickel Range, even in this favored area there are not more than a half dozen deposits of concentrated ore now being mined. The bulk of International Nickel's output is today coming from two mines—the Creighton and the Frood. The Creighton is the old mine on which International Nickel was founded, but though it has been worked for more than thirty years there are still untouched reserves in its deeper reaches. The Frood was discovered by Prospector Thomas Frood, who sold it to the Canadian Copper Co. for $30,000. The property is now worth more than as many millions, but to Mr. Frood, like other prospectors, the bird in the hand was always superior to the bird in the bush. And for a long time the Frood was considered a low-grade mine, for the ore at and near its surface was not high-yield stuff. Samples from drill holes at around 2,000 feet, however, were so much superior that International decided to develop the Frood in a big and deep way. Now it is the major producer in the International group, with indicated reserves of more than 135,000,000 tons and many portions of the ore body still unsounded.

The Frood

THE Frood really requires a three-dimensional explanation, but if you would like to build a model in your bathtub you can readily establish its major outlines. First run some water in the tub. Call the water land and the surface of the water will then



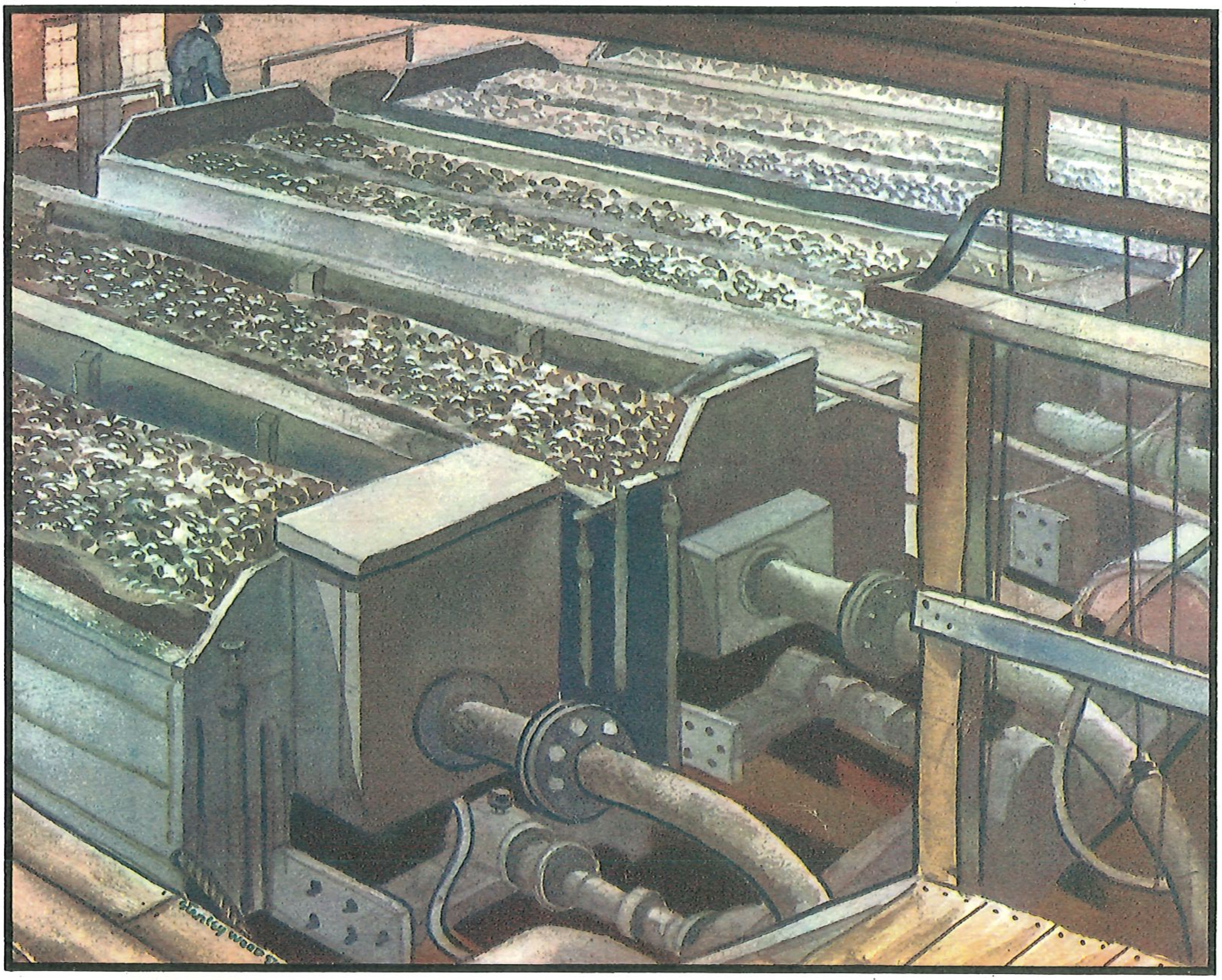
THE HEADFRAME AT THE FROOD. GATEWAY TO 135,000,000 TONS OF ORE

The production of nickel is almost as much concentrated in the Frood mine as its smelting is concentrated at the Copper Cliff smelter. From it is taken 5,000 tons of ore per day, almost three-quarters of International's total production. The mine was discovered in 1884 by Thomas Frood, woodranger and prospector. Mr. Frood sold his claim for $30,000. But the surface ore at the Frood was low grade and the mine was not considered a particularly valuable property. Finally, deep drilling produced some excellent ore samples and the Frood is now being worked at from 2,000 to 3,000 feet below the earth.

be the surface of the earth. Now take a big sheet of glass and lean it down through the water at an angle of about sixty-five degrees —that is, two inches of depth for every one inch of slope. The sheet of glass is your ore body. But remember that the real ore body is about two miles long, from 40 to 500 feet thick, and nobody knows how deep. Now a little way off from the sheet of glass, put a stick down vertically through the water. This is the main shaft of your mine. But the actual main shaft is 3,000 feet deep and 153,000 tons of rock were excavated in its digging. Now from various intervals along your stick—and of course beneath the water—run smaller horizontal sticks over to your sheet of glass. These represent the crosscuts running from the shaft to the ore body. These main crosscuts are spaced at 200-foot intervals from the 2,000-foot to the 2,800-foot level. They are 15 feet wide and 8 feet high and at the 2,800-foot level the crosscut is nearly 2,000 feet long. Remember that these passageways are tunnels through solid rock, were painfully bored at the rate of 8 to 10 feet a day, took as long as seven months to complete.

When your crosscut sticks have reached your glass ore body, your model is almost finished. But you still need one more set of sticks to stand for one more series of passages. For you have so far uncovered only such portions of the ore body as lie at the end of the crosscuts. So from the end of each crosscut lay another stick horizontally right along the surface of the glass. This kind of passage is called a *drift,* because it follows the walls of the ore body so closely that it is said to drift with it. The real Frood drifts are 9 feet wide and 9 feet high and where the ore body is thick enough the crosscut is prolonged and a second, sometimes a third, drift is branched off from it through the very heart of the ore body itself.

There are countless other borings through the rock beneath the Frood's surface. There are three additional shafts, one exclusively for ventilation. There are many short crosscuts between drifts. And the ore body itself is pierced with chutes through which the blasted ore is dumped down to the loading levels and with narrow holes called *manways*—holes just large enough to allow a man to climb down them on a strictly perpendicular ladder. It is via the manways that the miners work their way from one crosscut level to another, and the



IN THESE TANKS SOME OF THE COPPER IS SEPARATED FROM SOME OF THE NICKEL

Most of the elements in the nickel-copper ore do not hang together very closely; if you pulverize the ore you can wash the dirt away from the pay dirt. But the copper and the nickel tend to cling together until death do them part; their separation is the most difficult refining problem. Part of this separation is accomplished in the flotation tanks here shown. Very roughly speaking, you can float and skim off some copper by putting the ore in a tank with the proper reagent. Result: about half the copper content can be separated from the nickel and will then be treated as a copper ore with its nickel handled as a byproduct.

story is told of a foreman who got too fat to squeeze down them and had to stand at the top and yell instructions. But the essential outline is the main shaft that gets you down into the ground; the crosscuts that get you over to the ore body; and the drifts that follow the face of the ore body and allow you to drill and blast against and through it. The actual mining is carried on in chambers called *stopes,* which are started at one level and dug up to the next, giving a gravity flow in the dumping of waste rock and ore. The ore from the loading levels passes through a crusher which reduces it to pieces not more than five inches in diameter, and is then hauled to the distant surface. Whereupon it travels about two miles to Copper Cliff and never does see its home again. The problem of smelting copper-nickel ore has been well licked —stays licked under the capable eye of Donald MacAskill, head man at Copper Cliff.

Copper Cliff

ON PAGE 65 appears Stanley Wood's excellent Portrait of a Smelter. You can get some idea of the scale from the fact that the taller chimney is the 510-footer already mentioned. The buildings took three years to construct (1928-30). Contractors' payrolls were $7,200,000. Into the job went 35,000 tons of structural steel, 1,250,000 hollow tiles, 7,034,000 bricks, 1,000,000 square feet of floor surface, and a strong smell of sulphur. The purpose of all of which is to take 8,000 tons of ore per day, extract the nickel, copper, and precious metals, and dispose of the remainder in slag and tailings. An operation that is performed partly by water and partly by fire.

In a ton of Frood ore there are

95 pounds of copper
47 pounds of nickel.

There are also fractional ounces of platinum, gold, silver, and other precious metals—a content that does not bulk large in volume but is a vital factor in International's operations. For the precious-metal content, amounting to about $4 a ton (compared to about $25 a ton in copper and nickel), is—as we have already noticed—

THE LIGHT PART IS NICKEL, THE DARK PART IS COPPER

Seldom does a metallurgical process come out so clearly that even the lay eye can detect the result, but here is the Orford Process of separating nickel from copper so clearly defined that nobody can miss it. The light metal is the nickel; the dark metal is the copper. But before this chunk of copper and nickel cooled and solidified (see opposite page), the two were apparently inseparable.

almost pure gravy and simply adds over $3,000,000 of almost clear profit to International's earnings.

This leaves about 1,857 pounds of other things, mostly

600 pounds of iron
380 pounds of sulphur
540 pounds of silica
150 pounds of alumina

and some lime and manganese. None of these other things are any good except the sulphur, some of which is recovered in a not very notable production of sulphuric acid. Broadly speaking, what International Nickel gets out of a ton of ore is about

$16.50 of nickel
8.55 of copper
4.00 of precious metals
———
$29.05 of valuable products.

To extract which, it has to get rid of about 93 out of every 100 pounds of ore. Not that the yield is low but that the getting rid of it is difficult.

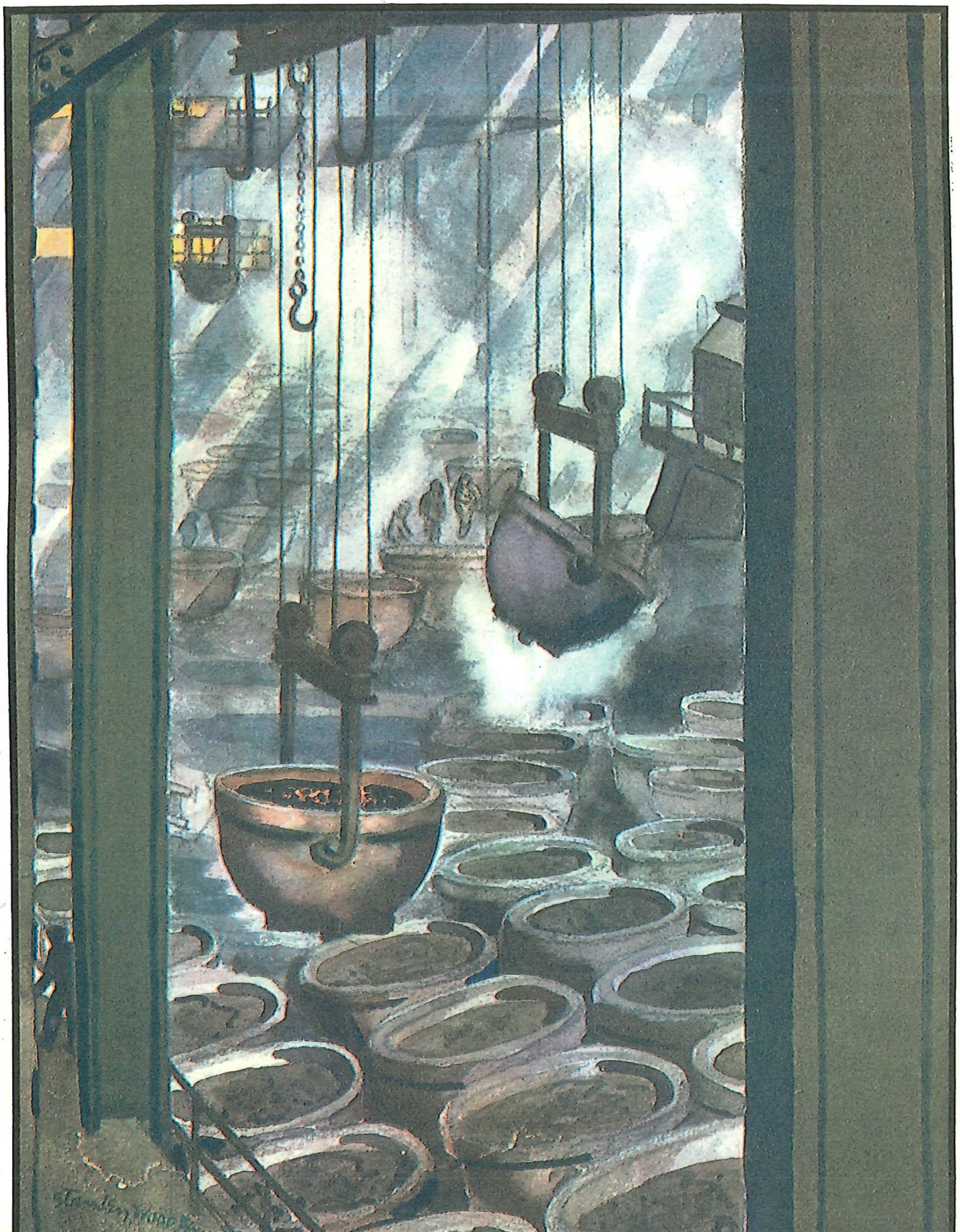
Flotation process

THE first step in the extraction process is a combination of pulverizing and washing. This step takes place in the concentrator which, as the name implies, is designed to concentrate the ore by removing some of the waste material. If the elements in the ore were present in their pure state, and no one was combined with any other, you could smash the ore with a hammer and pick out what you wanted. But the copper is combined with sulphur and iron, the nickel is also combined with sulphur and iron, and there is an iron-sulphur combination which sticks closely to the copper and nickel compounds. The silica, alumina, lime, and manganese, however, are not in combination with the other ingredients and so can be separated from them by mechanical means. The ore is crushed, ground, and finally rolled into such extremely small particles that they will float in water. Then—to put a delicate operation in a few words—the copper, nickel, and iron combinations are skimmed off and the silica, alumina, lime, and manganese are left in the tanks. This rock content is dumped in the form of tailings—a gray, lifeless-looking mush which is to the concentrator what the slag is to the smelter. Almost half the original weight of the ore is disposed of at the concentrator.

But getting rid of the silica, alumina, *et al.,* is only half the concentrator's job. Within the last few years, International has learned how to get a considerable separation of the copper compound from the nickel compound. Just how the trick is turned is a state secret, but after the ore has gone through the flotation tanks and is conveyed to the smelter in the form of a soggy, greenish-looking mud, there is one kind of mud that contains about 27 per cent of copper and little nickel and another kind that contains about 2 per cent of copper and several times as much nickel. It is only with the nickel mud that we shall here concern ourselves, for the copper mud is smelted and refined exactly like copper the world over. The importance of the two kinds of mud lies in the fact that nearly half the copper content of the ore is separated from the nickel before the ore reaches the smelter and therefore half the nickel-copper separation has been neatly and inexpensively performed.

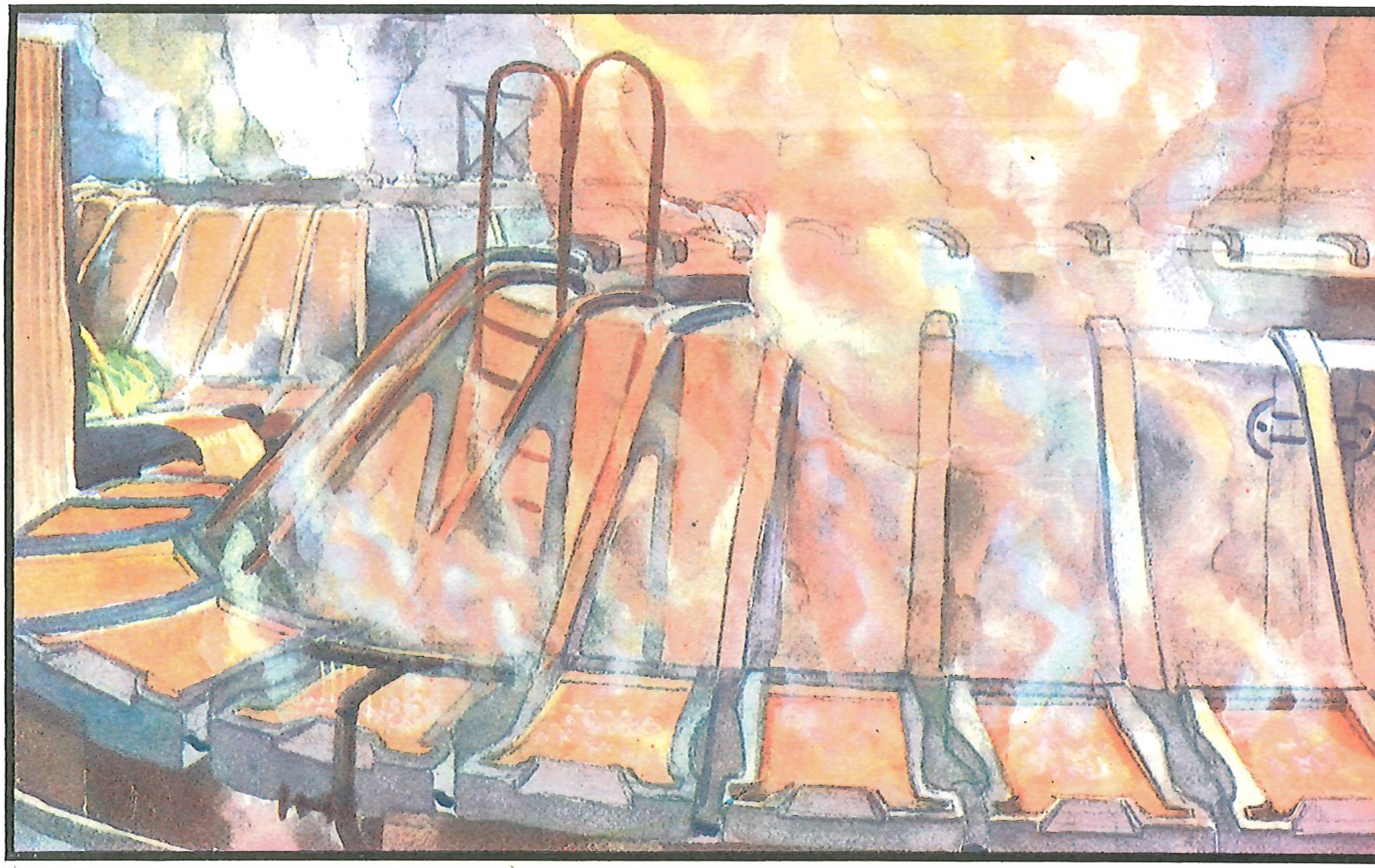
Smelter proper

WHEN the nickel mud reaches the smelter, it contains sulphur, iron, and copper. First treatment is to get rid of some of the sulphur by roasting the ore. After about four hours' passage through a series of roasters—at a temperature of up to 1,500 degrees—about half the sulphur has disappeared. It has gone up the chimney in the form of sulphur dioxide and contributed its bit to the plume of yellowish-white smoke that billows from the big stack. It has also filled the atmosphere of the smelter with an



EACH OF THESE POTS HOLDS SIX TONS OF MOLTEN COPPER AND NICKEL

On the previous page is shown the results of the Orford Process—here are the containers in which the process actually takes place. These pots have been filled from a furnace that contained molten copper sulphide, nickel sulphide, and sodium sulphide. The copper sulphide dissolves in the sodium sulphide, but the nickel sulphide does not. Therefore, when the liquid in the pots has cooled and hardened, the nickel sulphide has settled to the bottom of the pots and formed the *Nickel Bottom*. The copper sulphide, floating in solution, has stayed at the top of the pots and formed the *Copper Top*. Therefore copper and nickel are no longer firm companions.



INTERNATIONAL NICKEL IS ALSO THE SIXTH LARGEST WORLD PRODUCER OF COPPER

Nickel is the main product of International Nickel, because nobody else is much of a nickel producer and International can always get a good price and count on a nickel profit. But there is actually more copper in the Frood ore than there is nickel, and International last year produced about 113,000,000 pounds of copper against 74,000,000 pounds of nickel. So copper refining is an important element in International's work and here is 99 per cent copper being cast into ingots, preparatory to the final electrolytic process of producing 100 per cent copper. Even with nine-cent copper, International makes money.

acrid, biting, sulphur smell. The roasting job is the job that used to be performed out of doors and that had such a bad effect on Sudbury's vegetable life. The ore then goes to the furnaces and converters where it gets a heat treatment in a more intense form. Here the major job is getting rid of the iron, which forms an iron silicate mixed in with the nickel and the copper, all three by now having reached a molten state. The iron silicate is lighter than the nickel or the copper and rises to the top of the molten mass from which it is skimmed off through a slag hole. At which point a tap hole in the side of the furnace is opened and the molten nickel and copper pour out in a beautiful, fiery, orange spout. The principle here is purely the difference in the weights. So now part of the sulphur and nearly all the iron have disappeared, and what you have left is about 35 per cent copper, 45 per cent nickel, and 20 per cent sulphur. (You could have got rid of more of the sulphur by longer heating, but in the next step the sulphur becomes necessary.) It takes from twelve to fifteen tons of ore to produce approximately one ton of this copper-nickel-sulphur combination. This shrinkage is one of the main reasons for nickel's high cost. By the time that all these things have happened to the ore it has ceased to be ore and is called a *matte*.

Orford Process

THIS next step is the Orford Process—the key operation in the smelting job and the process that really unlocked the wealth of the Frood. Nickel gets its name from the devil (Old Nick)—was christened in the early eighteenth century by angry German copper miners who had a nickel-bearing copper ore and couldn't get rid of the nickel. They decided that evil spirits had bewitched the ore, called it *kupfernickel* (devil copper). The Canadian Copper Co. once had the same trouble as the German miners, was having shipments of copper returned as containing impurities—the impurities of course being the nickel. So the process that parts the nickel from the copper is a most important process.

The principle of the separation is simple enough. You melt up the matte and in your molten brew you have copper sulphide, nickel sulphide, and a little iron sulphide. Then you add a substance called niter cake, which contains sodium and sulphur and which forms a sodium sulphide to add to the other three.* The copper sulphide and the iron sulphide are soluble in the sodium sulphide, but the nickel sulphide is not. The result is that the copper and the iron rise to the top of the crucible and the nickel settles at the bottom. The matte is tapped out of the furnace in large pots that carry about six tons (you can see a whole collection of them on page 69). When the contents of the pots have cooled, hardened, and been dumped out on the floor, you can clearly distinguish between the light-colored *Nickel Bottom* and the darker-colored *Copper Top* (again back to page 68, although here, to prove the point, the artist has exaggerated the effect; the nickel is on *top* because the pot is dumped *upside down*). The nickel bottom has about 71 per cent nickel and only 1.75 per cent copper (the rest is sulphur). The copper top has 40 per cent copper and about 5 per cent nickel. It need not further concern us.

Thus the Orford Process, discovered by the late Colonel R. M. Thompson, founder

**More accurately, you add niter cake and coke. The niter cake is sodium* sulphate, *needs the coke to make it a* sulphide.

and owner of the Orford Copper Co. The Colonel, struggling with the inevitable separation problem, was startled to discover, in the discharge from one of the furnaces, several examples of the first nickel bottoms and copper tops ever beheld by the eyes of man. It was obvious that something had been put into the furnace to bring about this strange and excellent result, but nobody knew what had made this particular charge different from the others. So the Colonel patiently put into the furnace some of everything he had in the shop and finally put in niter cake. (How the niter cake ever got into the furnace in the first place nobody has yet discovered.) And once the niter cake was in the furnace, the bottoms and tops again turned up. Now the Canadian smelter has its own niter-cake manufacturing plant and tons of niter cake go into the Copper Cliff furnaces.

There is not much left to nickel production after you have reached the nickel bottom. The rest of the job involves another furnace treatment which burns out the remaining sulphur and results in almost pure nickel. Then the almost pure nickel is made pure nickel by an electrolytic plating process. The nearly pure nickel is put in a tank along with a piece of aluminum sheet, and an electric current passing through a solution of nickel sulphate neatly picks up the nickel in the nearly pure piece and deposits it on the aluminum sheet. The picture on this page happens to show the electrolytic refining of copper (because nickel is refined not at Copper Cliff, but at Port Colborne on the Welland Canal), but the long rows of mastic-lined concrete tanks with the metal suspended in the solution are equally typical of nickel refining. When the nickel finally emerges from the refining tanks it is a piece of pure nickel and the mining, smelting, and refining end of the nickel business is over.

Nickel men

BUT although International Nickel appears so well endowed with natural wealth, the company's business was virtually at a standstill as recently as 1921. Its mines and smelters were shut down, there was no sulphur smell in Sudbury, and the nickel that lay beneath the earth appeared hardly worth raising to the surface. During the War nickel had flourished as a military material. After the War, it was a drug on the market. The history of nickel during the past twelve years has been the history of nickel in its peace-time uses, particularly the development of heavy-duty nickel steels. And that story centers about the work of Robert Crooks Stanley, now Nickel President, and a group of his associates who got their start with the old Orford company at Bayonne.

Mr. Stanley graduated from the Columbia School of Mines, went to work for the S. S. White Dental Co. which was interested in platinum. Also interested in platinum was International Nickel, which hired Mr. Stanley's boss at the dental company and also hired Mr. Stanley along with him. But Mr. Stanley did not spend much time working on platinum, was soon interested in the metallurgy of nickel and particularly in nickel alloyed with copper or with steel. With Mr. Stanley was Dr. John F. Thompson, also a Columbia School of Mines graduate and now the only Vice President in the entire Nickel company. (Mr. Stanley does not believe in superfluous titles; his organization is lean and trim.) A third member of the Orford group was Albion James Wadhams, who had graduated from Annapolis, was stationed on the battleship *Maine* until about a week before the *Maine* was blown up, and fought through the Spanish-American War on the converted yacht *Mayflower*, later the official yacht of U.S. Presidents. Mr. Wadhams, tiring of peace-time naval life, looked around for a shore job, got one tending furnaces in the Orford plant. He is now head of Nickel's research and development. A later member of the Orford group was Mr. Paul Dyer Merica, whom Nickel got from the U.S. Bureau of Standards and who is most responsible for the progress made in recent years in the development of nickel cast iron (Ni-Resist). It will be noticed that none of these men were nickel miners but that they were all interested in experimental work on the uses of nickel.

In their early days with the company, the management was largely made up of men who had learned about metal in the steel business. The late Colonel Ambrose Monell, President of Nickel from its formation in 1902 until 1917, had worked with Mr. Schwab at Carnegie Steel and brought to nickel the steel tradition of production rather than any emphasis upon sales or markets. Indeed, Mr. Stanley and his associates were so isolated from the main stream of nickel that they formed a separate part-time, sideline company through which to carry out many of their experiments—especially the experiments that resulted in the

[*Continued on page 98*]

ELECTRICITY SUPPLIES THE ULTIMATE POWER IN REFINING COPPER

Put a piece of nearly pure copper in a tank along with a sheet of pure copper; have both pieces in a solution of copper sulphate and an electric current running through the solution, and you are all set for electrolytic refining. The current picks ions of pure copper off the almost pure copper and deposits them on the opposite copper sheet. Nickel is refined in the same manner except that you have a nickel-sulphate solution and build up your pure nickel on an aluminum sheet which is coated in such a manner that the nickel will be deposited on it without sticking to it. When your almost pure nickel has been torn down and your aluminum sheet built up, you pull off the aluminum sheet and there you are.

first practical Monel Metal. During the War, everything was subordinated to War-time nickel, and Mr. Stanley directed the Bayonne refinery with a company of soldiers stationed on the premises to prevent any interference with what was virtually the lone source of Allied War nickel. But after the War, when it was necessary to beat the swords into plowshares and when Nickel, from a $10,000,000 profit in 1917, slipped to a $800,000 deficit in 1921, there came the real opportunity for Mr. Stanley and his men. It was now obvious that peace-time uses had to be developed for nickel, that otherwise the production facilities expanded during the War would be nothing but useless overhead. And here was a group of men who had been working on precisely the problems that had to be solved for nickel's peace-time prosperity. So into the saddle went Mr. Stanley and his friends, and there they have been ever since. They were young men then—they are comparatively young men now—and their arrival as Nickel's management men was probably accelerated at least ten years by the post-War collapse of the Nickel company. The stars in their courses may have been said to have fought for Mr. Stanley, but on the other hand Mr. Stanley must be given credit for having already hitched his wagon to them.

Martial nickel

BUT although the Stanley administration has been the administration under which nickel has blossomed as an industrial material, nickel still retains its capacity for war-time uses. And, what with so much war talk, it is pertinent to ask: just how much money does Nickel stand to make from a major war?

Nickel goes into battleship steel and artillery steel. The *Nelson* and *Rodney*, first-class British battleships built since the 1922 naval-limitation treaty, weigh some 34,000 tons, contain about 500,000 pounds of nickel apiece. The 10,000-ton cruisers on which naval architecture has centered since 1922 contain about 100,000 pounds of nickel each. The German Big Berthas, which shelled Paris from seventy-five miles away, counted about 5,000 pounds of nickel. The Big Bertha was a freak weapon designed to scare civilians rather than to kill soldiers, but cannon in general are big nickel users. The French 75's, which during the War were turned out by the thousands, each contained some fifty pounds of nickel.

There is no nickel in rifles, sabers, bayonets, bombs, shells, or shrapnel. Shell casings are of hard chrome steels. Shrapnel is cast iron. Bullet jackets used to be made of a copper-nickel alloy, more recently have been made of a copper-zinc alloy. This copper-zinc alloy, known as *gilding metal*, recommends itself to the more humane military minds because it will go through a man's body without spreading, leaving a round, clean hole that puts the soldier out of action without spreading him all over the place. So

International Nickel

[*Continued from page 71*]

ships and big guns are nickel's chief military markets. A war would bring a large increase in nickel consumption, but mainly as a result of the recent development of nickel steel in the hard-working parts of trucks and ships.

How much nickel does it take to fight a war? In 1917 International Nickel produced 64,000,000 pounds of nickel. In 1918 it produced 68,000,000 pounds. Nearly all this poundage was directly or indirectly for War purposes, so there is a good figure for nickel in the World War. Nickel today could possibly step production up to 180,000,000 pounds and would have no difficulty in disposing of every ounce. Nickel is, after all, a scarce material; the whole 68,000,000 pounds of 1918 looking less impressive when it is translated into 34,000 tons—hardly more than the *steel* content of one big dreadnought. So the only thing that you could say about war-time consumption of nickel is that any war between major powers would use just as much nickel as International could scrape out of the earth's surface. And it would pay International a good fat profit for every pound of it. That is why Nickel shares rise when sabers rattle.

On the other hand, International is hardly in the class of a true munitions maker—either U.S. or European style. And this is the simple reason: even in 1933 it sold 74,000,000 pounds of nickel—6,000,000 pounds more than it sold in 1918. In 1929, best peace-time year, sales were 125,578,000 pounds. Its main chance today is not war but industrial volume. If it would profit enormously from war, the peace-time uses it has developed have a future as great—and infinitely more stable. For Nickel had its fingers burned once by giving in to the lure of plant expansion for war-peak profits. There is a good chance that Mr. Stanley is sincere when he says, "Thank God, we don't have to depend on *that* business any more."

Burlington *Zephyr*

ALL of which brings us back to nickel in its more constructive and peaceable forms. The most spectacular example of industrial nickel is seen in the Burlington *Zephyr*—the ninety-mile-an-hour train which the Burlington & Quincy now has on exhibit at the World's Fair. This train is made of stainless steel—18 per cent chromium, 8 per cent nickel. It is just as light and just as fast as the fast Union Pacific train, the other ninety-mile-an-hour, streamlined flyer and the one built largely of aluminum alloy. The logic of a fast, light, *aluminum* train is apparent to everyone, for aluminum, volume for volume, weighs only one-third as much as steel. Yet the nickel-chromium steel in the *Zephyr* is so much stronger than even the "strong" aluminum alloys that the *Zephyr* makes up for its greater unit weight by using very much less metal. You might say that it is a matter of an inch of nickel against a foot of aluminum, with the smaller cross section compensating for the heavier unit weight. Should U.S. railroads in general take up these super-fast flyers, there might be a lively war between International of Canada and Aluminum of America. But the nickel tortoise appears to have as good a chance of winning as the aluminum hare.

Nickel steels

AS YET, however, there is only one nickel-steel train and the bread and butter of the nickel business comes from less sensational applications. Nickel-steel alloys usually contain from 2 to 5 per cent of nickel. So it takes a lot of nickel steel to use much nickel. Yet nickel steels account for about 35 per cent of nickel production and are by a wide margin the largest users of nickel today.

The virtue of nickel in steel is that it makes the steel tougher. But what is meant by tough steel? Suppose we go back to the days before the development of alloy steels. Even at that time the steel man knew that a little carbon in his steel made the steel harder and that the more carbon the steel contained, the harder it got. But it also got more brittle. Your razor blade is a high-carbon steel. It is extremely hard—otherwise it would not take a razor edge. But it is also extremely brittle and would not stand up under any heavy industrial use. The addition of a few per cent of nickel permits the manufacture of a strong steel that is not brittle, that will stand punishment. It is the hard jobs that nickel steel has to look for, the special working conditions that will justify its high pay.

What are some of these hard jobs for nickel steel? The locomotive offers several. It may have a nickel-steel frame on which to rest its ponderous body; it may roll on nickel-steel axles; its high-pressure steam may be contained by nickel-steel boiler sheet plate and boiler tubes. The automobile has already been cited as the biggest nickel user. Here again nickel takes the hard knocks—in the transmission gears, the rear-axle drive shaft, the propeller shaft, the crankshaft, and the roller bearings. Plowing into the earth's surface is another hard job that nickel handles in the business end of steam shovels and of motor-driven plows. The drills that seek petroleum at a mile or more below the earth are made of nickel steel. So are the highly stressed portions of bridges such as the George Washington across the Hudson and the new San Francisco–Oakland Bridge, which will be seven and a half miles long and contain 3,400 tons of nickel steels (over 200,000 pounds of nickel). It is also nickel steel that rolls steel. If you have ever watched a steel ingot flattened out by being jammed through a series

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of rollers like clothes pushed through the wringer of a washing machine, you will appreciate the fact that the rollers lead a strenuous life. And it is usually of nickel steel that the steel-mill machinery is made.

Notice that in all these applications, nickel is not a new material. It represents an improvement in steel, a better steel for the harder jobs. But a nickel steel remains very much more steel than nickel, and the nickel-steel alloys are made by the steel mill and not by the International Nickel Co. Thus best U.S. customers of International are such companies as Republic Steel, Crucible Steel, Bethlehem Steel, Illinois and Carnegie Steel (both U.S. Steel Corp. subsidiaries), Timken Roller Bearing, and Midvale Co. (locomotives and ordnance). British steel mills are also large consumers of International's export nickel, which runs to nearly 40 per cent of its total production. International has worked both with and for the steel man in the development of nickel-steel alloys and has helped sell them to the railroad, the automobile, and other large users. But it has never gone into the alloy-steel manufacture business and thus it has avoided competition with its customers. In this respect it has differed sharply from the Aluminum Co. of America, another near monopoly with another new metal under its wing. International—which is a great deal more closely a nickel monopoly than Aluminum Co. is an aluminum monopoly—generates very little anti-trust feeling because it sells its customers the nickel without itself selling their nickel-steel alloys.

Next month FORTUNE, again writing about the Aluminum Co., will have more to say about competition with customers. As far as International and Aluminum Co. are concerned, the difference in the policies is largely a difference in the materials. Even an aluminum alloy is nearly all aluminum and a little bit something else, such as silicon. International would be stepping out of its field to sell nickel-steel alloys; Aluminum can sell aluminum, pure or alloyed, and still be in its own back yard.

Monel Metal

IN ADDITION to being alloyed with steel, nickel is also alloyed with nonferrous metals, principally copper. We have seen that the merit of nickel in steel lies in strength. The merit of the nonferrous alloys (mostly combinations of nickel and copper) lies in resistance to corrosion. Best example of the nickel-copper group—and dearest to the International heart—is Monel Metal. It was named for the late Colonel Ambrose Monell (they dropped the final *l* in christening the metal), first President of International Nickel. It was created through making a virtue not of necessity but of opportunity. We have already seen how much trouble the nickel refiner has had with the separation of the copper and the nickel. But suppose he could develop an

International Nickel

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alloy in which the copper and the nickel would be in the same proportions that they were mixed in the ore? Then he would not have to go through any separation process and would save himself much grief. Unfortunately, most of the Sudbury ore mixes the copper and nickel in proportions that do not permit the manufacture of any suitable alloy. But in one section of the Creighton mine there is an ore deposit that has approximately twice as much nickel as copper. And, after many years of trial and error, International succeeded in taking this ore, removing everything but the copper and nickel, and getting Monel Metal out of the combination. In 1921-22 International built at Huntington, West Virginia, a big rolling mill for fabricating Monel Metal into sheets, wires, tubes, and other commercial shapes, now turns out about 2,000,000 pounds of Monel Metal per month.

The commonest form of corrosion is rust, which is the corrosion of iron and steel. Unfortunate fact: iron and steel, man's strongest and most useful metals, are most susceptible to corrosion, as you will notice if you forget to dry your razor blade. Fortunate Monel Metal fact: Monel Metal resists not only the corrosive effect of the atmosphere, but is also resistant to such preeminently corrosive substances as sulphuric acid, chlorine, and caustic soda. Also, unlike most other noncorrosive substances, Monel Metal can be easily worked into sheets and bars and tubes and is as strong as a medium-strength steel. And, finally, it is a silver-white material, susceptible to a high and permanent polish.

Commonest application of Monel Metal is in surfaces distinguished by the fact that anything can be spilled on them. Soda fountain and steam tables, slicing machines and mixing bowls, hospital operating tables and instrument stands—here are Monel Metal applications dependent upon the fact that coffee or ice-cream soda or bits of food or blood will not corrode the Monel surface. A recent Monel Metal gadget is a kitchen sink, which, however, sells for from $69 to $178 and is more likely to be a household product than a household word. Yet the Waldorf has installed Monel Metal sinks in all its housekeeping apartments.

More technical uses of Monel Metal depend upon its resistance to the specific chemicals employed in various industries. The steel maker pickles his steel (pickling means cleaning off the mill scale) in a bath of hot sulphuric acid, uses Monel Metal equipment. The soap maker dissolves his fat and the rayon maker dissolves his cellulose in caustic soda; but the caustic will not dissolve a Monel Metal tank. The Monel Metal washing machine remains impervious to the chlorine bleaches of commercial laundries. Sometimes the freedom-from-corrosion advantage works two ways—not only does the container last longer but no corroded pieces of it get into the contents. Odd employer of this feature is the Ex Lax Co., which mixes its chocolate in Monel Metal containers to be sure that no metal gets into the laxative. And the strength-plus-corrosion resistance of Monel Metal is seen in its use for the propeller shafts of fast motorboats, the Monel shaft transmitting the power of high-speed engines while also resisting the action of the sea water, which would quickly attack a propeller shaft of steel.

Other uses

THERE are many other nickel alloys. *Constantan* (45 per cent nickel, 55 per cent copper) is used chiefly for electrical resistance. *Invar* (36 per cent nickel steel) has the capacity of neither expanding when hot nor contracting when cold, is used in measuring rods, standard lengths, watch parts, and other applications demanding invar(iable) dimensions. A combination of 80 per cent gold, 15 per cent nickel, and 5 per cent zinc makes *white gold*, which looks something like platinum and is used in jewelry as a substitute for it. *Inconel* (78 per cent nickel, 15 per cent chromium) is used mostly in dairy equipment; milk will corrode even nickel or Monel Metal but not Inconel. Stainless steels have already been mentioned with reference to the Burlington train; they also ornament the Chrysler and Empire State buildings and are being experimentally used in destroyers, though for their rust-resisting, not their shell-resisting, power.

Nor should it be supposed that all uses of nickel date from 1921. Pure nickel has been used for nickel-plating since 1840; today the standard automobile trim is a coat of chromium over a coat of nickel. Nickel silver is another old standby, although before the War it was known as German silver. It contains no silver but consists of nickel, copper, and zinc. Knives, forks, and spoons are the commonest manifestations of nickel silver although they usually appear with a coating of real silver plated over the nickel variety. Another nickel-copper alloy is used for plumbing fixtures, especially faucets. Here nickel alone would be too expensive and copper alone would corrode. Pure nickel is used (besides in plating) for small coinage (the Canadian nickel is 100 per cent nickel), in radio tubes, and as a catalytic agent in various applications of industrial chemistry, particularly in the manufacture of edible oils. Yet all the older uses of nickel together account for not more than one-third of nickel production. Since 1923 International has been working on an alloy of nickel with cast iron, feels that the tough cast iron made with nickel may in

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time use as much nickel as nickel steels use today. In the spring of 1934, the nickel of International Nickel was being consumed in the following forms:

	Percentage
Nickel steels in automobiles	20
Nickel steels in other applications (about one-third—5 per cent—munitions)	15
Pure nickel for radio, coinage, chemical industry	17
Nickel-silver and nickel-copper alloys	18
Nickel for plating (as under chromium plating)	10
Monel Metal	9
Alloy cast iron	4
Heat-resistant and electrical alloys	3
Miscellaneous uses including magnetic alloys, nickel brasses and bronzes, nickel-aluminum alloys, and white gold	3

Corporate Nickel

WE HAVE so far spoken of nickel and International Nickel as if they were interchangeable terms. To all practical purposes they are, and have been so since early in 1929, when International Nickel absorbed the Mond Nickel Co., Ltd. This was the company founded by Dr. Ludwig Mond, who had his own process for copper-nickel separation and was for years International's only serious rival. Its mines were in the Sudbury district, so close to International's that a part of the Frood deposit was owned by the Mond company. When the Frood ores turned out to be more valuable than they had been thought to be, Mr. Stanley saw no merit in having both his company and the Mond company putting up competing and expensive smelters to refine the Frood ore. And neither did the late Baron Melchett (Alfred Mond, son of Founder Ludwig). So Nickel got itself a Canadian incorporation (partly to avoid any anti-trust complications with the U.S. Government), split its shares six for one, then swapped the new shares for Mond shares on a share-for-share basis. The Mond company had been producing about one-fifth as much nickel as International. Its properties (including refineries in England and Wales) rounded out International's world grip on nickel. There remains one Canadian mine not owned by International—Falconbridge, Ltd., controlled by Ventures, Ltd., a Canadian holding company for mining stocks. Chief nickel source outside Canada is in New Caledonia (about 1,000 miles east of Australia) where a French company turns out most of the nickel not supplied by International. But competitive nickel does not even threaten International's control of the nickel industry.

Which industry is just about large enough to support one first-class corporation in a very handsome manner. Always remember that nickel is a *pound* metal, like aluminum, and not a ton metal, like steel. International could not dig up more than 180,000,000 *pounds* of nickel a year;

International Nickel

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the U.S. steel industry alone can produce 60,000,000 *tons* of steel in the same period. The company does not report a gross income, but does report poundage sales of its various products. In 1933 it sold:

74,356,969 pounds of nickel
113,682,312 pounds of copper
876,000 *ounces* of silver
77,198 *ounces* of platinum
21,355 *ounces* of gold.

Allowing for the fact that rolled nickel and Monel Metal sell for more than ingot nickel, and taking average 1933 prices for all products, International had indicated sales of

$21,500,000 in refinery nickel
4,100,000 in Monel Metal
3,500,000 in fabricated nickel
8,100,000 in copper
2,400,000 in platinum
600,000 in gold
300,000 in silver

$40,500,000 in everything.

Keep in mind that these figures are designed to show the scale of International's operations rather than to pose as an estimate of International's gross. The figure on refinery nickel may be too high because large users do not pay the list price, but the figures on Monel and fabricated nickel are certainly too low because they do not allow for special shapes in either form. Yet it remains difficult to see how International could have taken in much more than $40,500,000. On which its 1933 net of $9,600,000 was a most elegant profit.

International's 1933 production was more than twice its 1932 production, and the present year is running far ahead of 1933. In the first quarter of 1934 the company made a profit of $5,000,000 against an $80,000 loss for the first three months of 1933. The rise in nickel volume has been instantly reflected in International profits because the price of nickel has been rigidly maintained throughout the depression. Nickel has sold for thirty-five cents a pound *since 1926*. And though a big steel mill may be getting nickel for thirty cents, it was also paying thirty cents seven years ago. The Aluminum Co. has had the same price policy on aluminum, although here imported aluminum and scrap aluminum—particularly scrap—have made it difficult to keep the policy strictly enforced. There is no scrap problem in nickel, mostly because it is difficult to get the nickel out of the alloy. (The only case of a serious generation of scrap nickel came when the sunken German fleet was pulled up from beneath the waters of Scapa Flow and thus restored large quantities of nickel steel to the light of day.) Yet nickel users seem to have no animus against International. They remember that nickel prices were not boosted in 1928 and 1929 and they see the merit of having nickel steady at thirty-five cents rather than fluctuating between prosperity heights and depression depths. The Nickel management is acutely aware of its monopolistic position, bends over backward to avoid anything in the nature of a take-it-or-leave-it attitude.

International has an excellent balance-sheet position. On March 31, 1934, there were $45,361,000 of current assets against $5,657,000 of current liabilities. Inventories amounted to $17,800,000 and cash and short-term loans (the loans are to English banks) came to $18,691,000. Only obligation prior to the preferred and common was $7,757,000 debenture stock of British subsidiaries, of which about one-third was to be called for redemption on June 1. The company has $26,600,000 in two classes of preferred, on which the dividend, regularly paid, comes to about $2,000,000. It also has the gigantic total of 14,584,025 shares of common on which it declared a ten-cent dividend in the first quarter of 1934. International never has been much of a common-dividend payer. Between 1924 and 1931 it put $50,000,000 into modernization and development—chiefly into the Frood mine and the Copper Cliff smelter. This expenditure was made without borrowing a dollar. From 1931 through the first quarter of 1933 there were little profits on which to pay dividends. At recent quotations, International common was selling at around $27, which was about twenty times earnings. War talk—particularly Russo-Japanese war talk—made the stock an attractive speculation. Even without any war, however, Nickel should soon be able to pay more than ten cents a quarter on the common. At its first-quarter rate it would show a $20,000,000 profit for 1934, only a little below its 1929 high of $22,000,000. And there is no longer any necessity for large development outlays.

In Toronto Stock Exchange circles, International Nickel is talked of as an industrial stock and not as a mining stock. There is a great deal of sense to this distinction, for the company has moved far away from the feast-or-famine category in which mining companies customarily fall. The production problem has been thoroughly licked—Donald MacAskill and the other Macs at Copper Cliff can guarantee a flow of refined nickel as certainly as the 200,000,000 or more tons of reserve ore in the Frood and the other International mines can guarantee to supply the smelter with ore. The selling problem will never be licked in the same sense—it never should be, for the future of nickel lies in continued experiment and further new markets. But a great deal of the missionary work in the use of nickel alloys has already been accomplished, and as automobiles and trains and aircraft and locomotives become constantly faster and stronger, as the progress of industry stiffens the requirements made upon its steel, the demand for nickel steels should constantly increase. For fifty years now, men have been digging the Sudbury ore out of the Nickel Range. In the past ten years nickel would appear to have come of age and to have come into its inheritance.