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IRON AND STEEL MATERIALS RESOURCES

Mr. Julius H. Strassburger

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Iron and Steel Materials Resources

15 November 1962

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15 November 1962

LT COLONEL McELWEE: This morning we turn our attention to iron and steel and we're privileged to have with us an international expert, Mr. J. H. Strassburger Vice President of the National Steel Corporation.

Mr. Strassburger, welcome to the Industrial College.

MR. STRASSBURGER: Admiral Rose and Gentlemen:

It's a real pleasure to be here this morning to talk to you on the "Iron and Steel Materials Resources." We cannot start this subject without showing what is required to make a ton of ingot steel. There are various materials that go into a ton of steel, and our first slide here will show you that first of all it takes 4,121 pounds of raw materials going into the pig iron; then 938 pounds of scrap, which, together with your alloy elements, limestone and iron ore, adds up to around 5,359 pounds of raw materials to make a 2,000-pound ingot.

The iron and steel industry in the United States is not located in any one locality. And as you can see from this map of the United States there are 33 states that have iron and steel-producing facilities, showing the widespread location of the steel plants in this country. There have been a great many technological changes during the last decade, and I believe it would be well if we reviewed these changes briefly because they have had a large impact on the type and amount of raw materials required in the making of ingot steel.

Starting with fuel, there is a considerable amount of research now going on in

new methods of making coke for the blast furnace. Instead of the conventional pusher type oven, three groups of companies are working on a continuous coking process. We call the one that we are interested in, "form coke." The purpose of form coke is that instead of taking a piece of coke the size that it comes out of the oven, we can take coal and form it into a predetermined shape and size as well as quality. We can, in this process, desulphurize coal so that we can use high sulphur coals in the future which would open up very much larger reserves of metallurgical coal than we now have. It would also minimize the use of the low volatile coals such as the Pocahontas fields in Virginia and West Virginia, which are not nearly as large as our high volatile coals.

After we leave the coke we come into iron ore. Iron ore beneficiation has been the objective of an improved technology and at the present time there are many low-grade ores which are being beneficiated which only a few years ago were not considered suitable as a blast-furnace feed. In other words, tachonites, speculohematites, and other low-grade ores of only 23% to 38% iron are being upgraded now into concentrates containing over 60% FE, and between 4% and 9% silica. This has had a large effect in improving the operation of blast-furnaces.

One of the reasons why this work has been carried on is, first of all, that the exhaustion of our direct shipping ores has made it necessary for us to look elsewhere for a source of iron ore. And, of course, we are importing ores. But in our own country we have billions of tons of low-grade material that is subject to upgrading. So, that is one of the main reasons for it. The other is that it is economic. The large increase in the cost of facilities, increases in wages, and other increased

costs means that if we can increase the productivity of a given unit we can help both the capital cost and the operating cost per ton of product. And that has been contributory to this change.

Another side effect of the increased iron content of our ore has been the fact that it takes less tons of the richer ore to make a ton of product. This has resulted in a lesser requirement for transportation and storage facilities which is beneficial. For example, an iron ore that ten years ago - an average iron ore contained 51 1/2% FE, - required 1 2/3 tons of ore per ton of iron produced in the blast furnace. The concentrate of 61 1/2% iron requires only 1.4 long tons, these are, or a reduction of 16%. Up until a few years ago the conventional methods of beneficiation consisted mostly of gravity separation techniques. The new technologies now in use and under research are floatation, magnetic roasting, followed with magnetic separation, high intensity methods.

So that, it is now possible to recover high iron content materials from ores that were considered uneconomic just a few years ago. It is even conceivable in the future that the black sands, some of which are located in Florida, containing only 2% to 4% iron, may in the years to come be subject to a cheap concentration method that would open up vast new areas of iron in the future. In the concentrating of these iron ores it is sometimes necessary to grind the ores to talcum powder fineness, something like 90% minus 325 mesh, and the agglomeration of these ores is necessary in order to make them as suitable blast furnace feeds. This has been done by screening out the fines and cindering them, and also by the pelletizing of very fine concentrates.

In the cindering process it has also been found advantageous to add limestone in the cindering to make the ores or the cinder self-fluxing. Now, the result of this practice is a large reduction in the fuel requirements of a blast furnace. Because, in burning the fuel in a cindering plant it has three times the available heat as in a blast furnace. The reason for that is we're burning the fuel completely in a cindering plant - the carbon dioxide - whereas in a blast furnace there is only burnt the carbon monoxide.

In the beneficiation of these low-grade materials like tachonites, they've been converted into pellets which are now being sized at around 3/8 to 1/2-inch diameter - the size of small marbles. This material has been found extremely beneficial in blast furnace practice. It has made the verdance permeable. It has given us gas-solid contact where the gas is going up through the furnace, so that as we go into new techniques of blast furnace operation, the fact that we have these excellent physically-sized verdant materials has made it very beneficial.

In order to illustrate the change that is going on, this next slide will show you the increase in the agglomerated products of 1960 and '61 as compared to '57 and '59. Now, I might mention here that we'll have a lot of slides comparing those same years. And as a matter of information, the '57-'59 ingot production was about 97 million tons, and the 1960-'61 was 99 million. So, any drop-off that you see, or increase, is the result of an increase in ingot production and not a decrease. Now, in the case of agglomeration you'll notice that we are using more agglomerated materials both in total - and on the right you see how cinder has increased. We think that is going to level out, not too much more than 45% to 50% because you'll find

that pellets by 1963 will probably be up in the 20s instead of in the 16% range. The ketz and nodules are not going to increase a great deal.

This improved practice with these agglomerated materials resulted in a large decrease in the fuel requirements in making iron. For example, ten years ago the average coke rate was eighteen to nineteen hundred pounds per ton of iron. Today, or rather, in 1961, the average was 1,400 pounds, and we have many furnaces in the 1,100-pound range today on fuel consumption.

Now we come to our blast furnace technology. There has been a large revolution going on in the method of operating a blast furnace. This new technology includes the use of higher blast temperatures - and by that I mean it was impossible, or not thought possible, to use over a thousand degree blast-heat with our Mesabi ores ten years ago. Furnaces are now being operated at 2,000 degrees. Along with this higher blast temperature, moisture additions, injected fuels, and oxygen are being delivered through the twiers of the blast furnace. And I might mention here that at our plant at National Steel we were the first successful plant to put oxygen into a blast furnace, in 1951. This is being adopted widespread throughout the world today. The success of it was the injection of steam in order to hold the flame temperature in front of the twiers within reason. The new technology of injecting fuels through the twiers is made possible by the fact that these fuels are also endothermic. That is, they extract heat, but not as much as the steam. So that, these fuels can be used to take advantage of high-blast heat and lower coke rates, and the replacement of the coke in the furnace.

I might mention that we have had several programs with the Bureau of Mines

in which we have done experimental work on the injection of natural gas, fuel oil, and coal. This furnace at the Bureau of Mines is a 1% blast furnace. We have found that it correlates very well with our large commercial furnaces, and the results obtained on the large furnaces have been justified.

One of the newer techniques which we are now using is the injection of coal through a blast furnace twier. Now, in Europe 80% of the blast furnaces today are injecting oil. It's a matter of economics. Oil is cheaper in Europe. It's cheaper on the United States Seaboard. But in West Virginia, Pennsylvania, and Ohio, the steel mills are sitting on top of coal mines and coal is our chief fuel. That's why our steel mills are located there. So, National Steel two years ago put coal in a furnace in Buffalo, experimentally, and next month we will inject coal in a 2000 ton-a-day blast furnace in Weirton. This is something which this country has developed and which the Europeans are now following.

In line with this, we have formed a new corporation. Let's call it a paper corporation, called "Blast Furnace Research Incorporated." For the first time in the American steel industry's history we have been able to get 22 companies, 18 American and 4 Canadian, to join forces. And these 22 companies are contributing $2 1/2 million over a two-year period, and are cooperating with the United States Bureau of Mines on blast furnace research. This work is now underway. We are trying out new technologies that we wouldn't attempt on a large furnace because of the hazards of upsetting a large furnace. We expect from this work to develop production increases and fuel savings in improved furnace practices, that we feel will make the United States the leader in this technology.

Another change in iron and steel has been the use of oxygen. This use of oxygen has been made possible by the availability of low-cost tonnage oxygen, and it has resulted in a large saving in fuel - that's the fossil fuels - and an increase in productivity. Today open-hearths are running 50% or more in productivity above what they were a few years ago, and the use of the fossil fuels has been decreased proportionately. For example, a very efficient open hearth of large size, say, three to four or five hundred tons, would use 20 gallons of fuel oil per ton of ingots. Or, roughly, three million b.t.u.s. With oxygen in the open hearth this has been reduced to less than half. In other words, we're down approaching a million b.t.u.s per ton of ingots.

The other development in oxygen has been the top-blowing oxygen converter which was developed first in Austria. It is now being widely adopted in this country on a much larger scale than in Europe. In other words, instead of 30, 40 and 50-ton vessels, there are 200 and 300-ton vessels now operating in the United States. Now, this has also a great impact on resources. Because, where three million b.t.u.s was required in the open hearth without oxygen, the top-blowing oxygen converter uses less than 2,000 cubic feet of oxygen per ton of steel and no fuel in the actual steel-making. What this means is that the power required for the oxygen production amounts to 270,000 b.t.u.s per ton of ingots as compared to three million in the open hearth. So, it's less than 10% and this is having a large effect on fuel.

And you'll find that there is less fuel oil being used by the iron and steel industry today than there was a few years ago. One of the side effects of this oxygen

usage is the ability to use more hot metal. The converter itself requires a minimum of 70% hot metal and a maximum of 30% scrap. Whereas, the open hearth could use, say, 50-50. So, the effect of this oxygen technique has resulted in an incentive to produce more pig iron at lower cost and that is one of the reasons why so much effort is now being placed on the development of blast furnace technology for increased iron production at a lower cost.

Another new development is continuous casting, in which you cast directly from the molten steel into the slab. That is being looked into and several contracts have been let recently in this country. There are some smaller installations in Europe. The Russians have them on a much larger scale than we have. Again, because of our large ladels we've had to go to a multiple installation. This will make another revolutionary effect on steel. It will eliminate all of the capital investment in strippers for taking off the molds, the blooming mills and the soaking pits. And we'll be able to cast directly from the molten steel into the slab. So, it will mean a reduction in capital, a reduction in labor cost, and a reduction in fuel. Because, no fuel is required as in the soaking pit and slabbing mill operation.

Now we come to our basic raw materials. The first one is coal. It is our opinion that there are ample reserves of coal - metallurgical coal, that is - in the United States for a long period of time. And in talking of coal reserves we are talking of coal which is economic to mine. We're not considering coal that's too thin a seam or too deep for economic mining today. The total coal reserve of metallurgical grade in this country amounts to about 11 billion 654 million tons today. This figure shows the coal fields of the United States, and as you can see, the diagonal

lines are the high volatile metallurgical coal. That is located over here in Pennsylvania, West Virginia, Virginia, Tennessee, and down in that area. And that is probably the second largest metallurgical coal field in the world.

Over to the Middle West, in Indiana and Illinois - in that area - we have other high volatile coals, but they are not nearly as good a coking coal as the ones in the Eastern area. And then over in the Middle West - in Utah, Oklahoma and those states - we have other semi-high volatile coals and coals that are not very good metallurgically.

The next slide will show the amount of high volatile coals in our Eastern and Southern fields. And you'll notice that out of the 11-some billion tons, almost 8 billion of this metallurgical reserve is located in Western Pennsylvania, West Virginia, Kentucky and Virginia.

The next slide will show the low and medium volatile coals. Central Pennsylvania is what we call the "smokeless." There's not too much of that, but the billion tons you see there are the high-grade coals which we normally call the "Pocahontas-type," located in Souther West Virginia and Virginia. These coals are a very high quality and are in great demand to improve the quality of the coke. And as I mentioned earlier, if we can develop a process that does not require this coal it would open up vast reserves of coal which are not considered suitable today.

The next slide will show that less than two billion tons of metallurgical coal are located in the South and Western states of the United States. So, we can see no shortage of this raw material. And I'm of the opinion that even at an increased rate of consumption over a hundred and some years of coal reserves - and this

shows the consumption of this metallurgical coal; keep in mind, again, that we produced two million more tons of ingots in 1960-'61, so you can see that the use of coal is decreasing. The reason for that is improved technology. As I mentioned earlier, the coke rates are coming down and this will continue to come down. In other words, on the basis of the same ingot production you'll find that 1962 is using less coal than 1961, and we expect it to go lower in '63.

Now we come to iron ore which is probably the most important raw material that enters into the production of iron and steel, because it is the major source of our iron units. Figure 12 is a comparison of the iron ore consumption for these same years. Again you'll notice a decrease because of the higher-grade materials. We can foresee the use by 1975 of possibly 125 to 135 million tons. Now, the sources of iron ore are shown here for the years 1954 to 1961. That shows the amount of ore from the United States, Canada and overseas. This map shows the reserves of ore that are scattered around the world, and these black triangles are the major deposits. So, we can readily see that iron ore is a raw material that is scattered over the entire globe and is in plentiful supply in most countries.

The United States' consumption of iron ore is shown in Table 4 here, and shows that in 1960 we consumed 108 million. We produced about 88 million. And the rest of it was obtained by imports. The world reserves of ore - back in 1955 the United Nations report showed around 88 billion tons of reserve, now estimated at 300 to 400 billion tons in that area. In other words, there are new reserves of iron ore being discovered as the years go along.

This shows the reserves in the United States and Canada, and you'll notice that

we have, including the concentrates from these low-grade materials, about 30 1/2 billion tons, and the Canadian reserves amount to about the same amount. I might say that at the present time we are importing ores from Canada, Venezuela, Chile, and Africa, and the source of ores - one source of ore is continually in competition with ore from another source. And the location of the ore that any one company uses is usually dependent upon economic conditions, freight costs, and grade.

Now the use of foreign ores in peacetime. The next slide will show that the use of foreign ores has increased from 2 1/2 million tons in 1940 and in 1960 we were up to 34 million tons, showing a large increase in imported ores. In a way, that's healthy because it conserves our own resources. And then, the other slide at the bottom shows the source of these ores from the various countries.

Now the question of iron ore supply in an emergency. Currently the Lake Superior District is only producing about half of the ore used by the United States' steel industry, about 55 million out of 110 million tons. The remaining is imported. If the United States were to be cut off from all imports, including Labrador and Quebec, we would be in a very serious condition. First of all, we do not think it's feasible for the Lake Superior District to increase its tonnage from the present 55 million to more than about 88 million within an immediate time. In other words, if we had an immediate emergency it's possible that they could increase their production about 30 million from these open-pit mines. So, we'd still be short of the ore we need for our 100 to 125 million consumption. And in order to fill this gap the best source is, of course, Canada. It looks to us like the perimeter of defense of the military establishment, if they could protect the Labrador and Quebec mines,

the St. Lawrence Seaway and the Sioux Locks, the United States could maintain its full iron supply without dependency on any source other than North America.

Now we come to limestone which is another raw material used in iron and steel-making. And it's significant, we believe, that the limestone deposits are widely scattered in the United States, and you'll notice that they are very close to the same locations where the steel mills are located. Limestone is a material that is usually delivered at low cost - something like two to four dollars a ton - so, it doesn't merit a lot of transportation and there are a good many quarries close to the steel mills themselves.

The next slide shows the limestone consumption, and again you'll see that this raw material is gradually decreasing in consumption because of the improved technology. And again, we expect this to keep going down for the next several years. And, of course, as we use less fuel we have less ash to flux out, so that is another contributory factor in this reduction in limestone.

Now we come to scrap. Scrap is a raw material in the steel industry. When you visit Russia and see the tremendous emphasis that they put on blast furnace technology, it is because in Russia there is very little generated scrap from the scrapping of equipment and buildings. Whereas, in our country, approximately half of our scrap comes from that source and half from our own production of steel. This will show the scrap consumption over these same years, and you see it hasn't varied a whole lot. It went up a little in '60 and back down again in '61. Again, the use of scrap is an economic consideration. If a steel mill has low pig iron costs and high production, they'll tend to use less scrap. As we go into oxygen we can

use more pig iron and still make very fast heats. So, this is an economic consideration. So, the scrap has sort of leveled off.

The next slide will show a report that was made by the Paley Committee in '57, I believe it was, in which they showed the domestic withdrawals, the total withdrawals, including export, and the additions to scrap, and according to this chart there would be no shortage of scrap over these years. However, on heavy-melting scrap you'll notice that there is a shortage in the years '60 to '62 predicted. This was five years earlier. Actually, this shortage did not develop because fortunately our exports of scrap have decreased a great deal in the last several years. Another reason for this is the improved technology in iron-making has made it unnecessary for countries like Japan and other countries to import large quantities of scrap. In other words, they're becoming more self-sufficient and are not raiding our scrap market. So, as far as scrap is concerned we see no foreseeable shortage in scrap.

As I mentioned earlier, the oxygen steel converters will tend to use less scrap. Continuous casting, by the way, will produce slabs with about a 10% higher yield in the molten metal, so they will generate less domestic scrap. Therefore, the two will balance out pretty well.

Now we come to our additive metals. The first one that we want to take up is Manganese. In talking about high-grade manganese we mean manganese that is 35% plus in the ore and usually up to a 3-inch size down to a 1-inch. We are not very well supplied with manganese and contain only 4% of the world's reserves. And we consume about 14% of the world's production, so it's necessary for us to have large imports of manganese ore. This world map here shows the location of the mangan-

ese deposits, and presently most of our manganese is coming from Africa, India, and South America. Although there are reserves in the United States they are low-grade reserves and we feel that one of the objectives of our research work in this country is a method of efficient recovery of manganese from, say, 10% manganese ores, whereas, today the normal ore, as I said, is 35% or better.

The next slide shows the production-consumption rate on manganese, and as you can see there, our production is a very meager amount compared with our consumption, so we're depending on outside sources for this vital material. Another possible source of manganese in the future, which has never been touched so far, but we can foresee that this could be developed, is the fact that on the ocean floor there are vast quantities of manganese nodules. And it's our opinion and the opinion of people I have talked to, that as time goes on these nodules will be pumped to the surface and the manganese recovered from this ocean floor deposit.

The next material we want to talk of is molybdenum. Fortunately, the United States is self-sufficient and its production is about 150% of its consumption. The output of molybdenum is coming mostly from Climax, Colorado, where a large amount is recovered as a by-product from the Western Periphery Copper Mines, and also from the tungsten operation in California. This map shows the locations of this, and you'll see that the United States is well-supplied with this vital additive in steel-making.

The next slide will show the production and consumption. You'll see that our production is running about 50% of our consumption and that we have about 60% of the world's reserves of this metal.

We come to tungsten now. The United States and Canada together are able to supply about 60% to 70% of our normal requirements of tungsten in peacetime. However, in an emergency the United States would be in short supply if Canada were cut off as a source. However, we could double our production in this country if cost were no object, but if we did so, our reserves would be depleted in less than ten years. Now, this figure shows the location of the tungsten deposits. There are very large deposits in China, and some in Spain, South America and Africa. But as I said earlier, we are supplying about 60% to 70% of our own requirements at the present time. This shows the consumption and production data, and you can see we are producing about 60% of our requirements. Our reserves are 70,000. Canadian reserves are 100,000, but the world reserves are much larger. But as time goes on we will become more and more dependent on other countries for this metal.

Titanium is another material used as an additive. And the United States, when it's considered with Canada - and I keep stressing that, again, because Canada is a big source of iron ores, so we have to consider this North American Continent as a unit - and we're well supplied, taking Canada into account. And the production of titanium from the United States and Canada is about 116% of our consumption.

This shows the location of titanium and most of the titanium at present is being produced in Canada because our deposits are not quite as high a grade as the Canadian.

The next table will show our consumption, production and imports along with the Canadian. Again, you'll see that our reserves are rather meager when we compare them with the rest of the world.

The next metal we come to is nickel. The United States is poorly supplied with this metal as compared with Canada where the reserves are excellent. In fact, International Nickel & Falconbridge can maintain their present production rates for at least 20 years and probably much longer, dependent on the fact that new reserves will be developed.

The next slide will show the world location of the nickel deposits. The one in the United States that you see on the West Coast is in Oregon and it is a relatively small deposit compared with others. But Canada has large reserves, and at the time of the Paley report, 80% of the Free World nickel was coming from Canada. There was 5% from New Caledonia and small amounts from South Africa. Up in Finland the Russians are using the Petsimo Mine which originally belonged to Finland. In addition there are large deposits of nickel-bearing laterites in Brazil, Venezuela, Tanganyika, Celebese, Borneo and the Philippines. And although they are marginal at the present time, the new techniques that are being developed by the recovery of nickel from laterites will probably make it possible for us to develop these deposits in Guatemala, Colombia, and North and South America. So that, we will have another source close to our own country.

The next slide shows the consumption and production figures, and as you can see there, our production is only about 12 or 13 percent of our consumption. And our reserves are 400,000 tons compared to 45 million in the world. So that, we have very meager reserves of this very vital metal. As you know, nickel is used with chromium in the production of stainless steels, but is also used in making very tough alloy steels.

The reserves of chromium are based on ores containing about 48% chromic oxide with 3-inch to 1/2-inch lumps, and we consider a chrome-iron ore ratio of three to one as a good grade of chromium ore. The world reserves of this metal amount to three billion tons of ore - 500,000 tons of it located in the United States. The largest known reserves of chromium are located in Africa. And we were told by one of the producers of this metal that there are places in Africa where you can almost see the chrome ore at the surface and it was the opinion that there are many, many locations where chrome ore is laying that have not been discovered at this time, and particularly in the South African area.

The next slide shows the consumption and production figures, and again you see that we're probably running around less than 8% of production against our consumption, less coming from imports, and that our reserves are just very, very meager as compared to world reserves, and also our production compared to world production.

Vanadium is a metal used for making the toughening of steel, and the known world reserves of vanadium amount to about a million tons of which 70% is located within the United States. The number two source is South Africa, and the third source is Western Australia.

The next slide shows a world map showing the location of vanadium. As you see, the United States there - in the Rocky Mountain area - has this large reserve which comprises, as I said, 70% of the world. This slide shows the production and consumption. You see we're practically self-sustaining on vanadium, and our reserves there are 680,000 out of a million tons.

Cobalt is another metal used as an additive in steel. With this metal we are not very well supplied. We have about 50,000 tons out of over two million tons in the world. The three major sources of cobalt are in Katanga where it's a by-product of copper; Rhodesia; and in Idaho where the deposit is not considered commercial at the present time.

The next slide will show the consumption of this metal in the United States. As you can see, we're consuming something like 4,400 tons of this metal. Our production is about a fourth of that, so we do depend on outside sources for cobalt.

The next slide is on columbium. The world reserves of columbium amount to six billion tons, with only 50 million tons in the United States. Our columbium at the present time is coming mostly from Africa. There is a relatively large deposit in South America. And although you see columbium in the North American Continent - both in the United States and Canada - these are not really developed at the present time because the content of columbium in these reserves is too low at the present time to compete with foreign metals.

The next slide will show the consumption of columbium. By the way, this ia a metal that has only recently come into use as an additive in steel. It refines the grain and makes a tough steel with a very small amount of columbium. And, as time goes on, this metal will be used more and more in steel production, along with the use of it in atomic equipment. As you'll see, we have practically no production of this material either in this country or Canada at the present time because of the low-grade deposits located there. And again, it shows the world reserves and our 50 million out of six billion.

Boron is another metal which is now being used for refining steel and improving its quality. Fortunately, the United States has 121 million tons out of 135 million of world reserves of boron. Practically all of our boron is located in the far West and we are in a very good situation. There is no critical shortage of boron at the present time.

The next slide will show the United States' consumption and production. You see we're almost producing double of what we consume, and as you can see our reserves are a major part of the world's reserves.

In reviewing this situation on additive metals I think it would be well to point out that of all the additive metals, there are only four which at the present time are required from sources where we have to go either across the oceans - either Africa or South America - or some far location. If we can maintain our communications and transportation facilities between Canada and the United States, we will not only protect our iron ore requirements, but also we will protect over half of the additive metals. And the only four metals which are not available to us over a reasonable number of years from either the United States or Canada, are manganese, chromium, cobalt and columbium. The only thing we can say there is that it would be well if we could have sufficient stocks of those materials on hand that in case of an emergency we would not be caught short.

Now, if it would be impossible to maintain the perimeter of defense in order to protect the Canadian sources of these additive metals, then, of course, we should protect ourselves with stocks of those metals. And keep in mind, also, that in case of emergency where possible facilities and manpower would be short, the ability to

have metals already in the refined condition ready to use, is worth something as compared to just having the ores. That is, when you have the ores you have to expend power and facilities and manpower in order to convert these ores to metals, and in times of emergency we may not have the wherewithal to devote your energy to that type of production.

I've had to go through this rather quickly, but it has been a real pleasure to talk to you gentlemen. And that concludes my talk at this time. Thank you.

QUESTION: I have a two-part question. Where are the plants that do the beneficiating for the ores? Are they near the ores or are they near the steel mills? And secondly; what happens to the remainder of the ore products after we beneficiate, say, taconites or something of that sort? Is this economically usable or not?

MR. STRASSBURGER: Those are both very good questions. First of all, in the low-grade ores like taconites and the speculohematites - for example, the taconites out in Minnesota and the speculohematites in Michigan - and up in the Wabash Lake area of Canada which is about halfway up from the St. Lawrence up to Knob Lake, - all of those beneficiation plants are located at the ore mines. Because, your transportation costs would be uneconomical. In other words, it takes from two to three tons of crude to make a ton of concentrate. And if it cost you $2 a ton to transport it by railroad to another site, why, you'd have about a $6 cost of conentrating.

The only exception we could say to that is in Minnesota Reserve does have a concentrating plant where they ship the rock by their own railroad. It's a downhill

grade. They go uphill with the empty cars and they have a very cheap transportation. But again, it's within a close proximity to the ore mine itself. Now, practically all of these concentrating plants have to be located where there is plenty of water, for two reasons. First of all, the process involves wet grinding both in the rod mills and in the ball mills, which requires a large amount of water. And secondly, they must have a place where they can discharge the gang material. Because, if it takes three tons of crude to make a ton of concentrate it means that if they're producing, let's say, eight million tons of concentrate a year - which is what Reserve and Area each are doing now - they would have twice that amount or 16 million tons a year of gang material. And they discharge that into settling ponds. In the case of Reserve they have permission to use just the tail-end of Lake Superior for dumping this material. But it settles very rapidly and does not go out and pollute the lake. It's a very heavy material and they've had permission to do that.

QUESTION: Sir, in your research program is any attempt being made to find a suitable substitute to perhaps eliminate these four additives that are short, as far as our supply is concerned?

MR. STRASSBURGER: I would say that during World War II there were special steels, as you know, developed by the steel industry where they did not have the additive metals usually used. For example, our company developed what they called an "NAX Series" which is a series using zirconium as an additive, along with a small amount of chrome. And there are stainless steels being made today without nickel, for example, with only chrome. Of course, chrome is an additive metal which isn't in this country. I would say that of the additive metals, manganese is

very important because your ordinary grades of steel all contain manganese. But some of the other metals you can substitute and make special alloys which could eliminate some of these special metals.

QUESTION: Sir, could you compare the technological process of the U.S.S.R. with the Free World?

MR. STRASSBURGER: Yes. I was in the Soviet Union on this steel mission in 1958. And I think it was a very good thing that the United States Steel people went to Russia because it did open our eyes to what they were doing over there. First of all, technologically you cannot write these people off. Their metallurgical laboratories and their research are very extensive and they have research laboratories in each of their steel-producing centers that are equal to anything we have.

Now then, when you study their economy over there you must keep in mind that people always use their research and development in the area where they need it the most. In Russia where they were transforming themselves from an agricultural economy to an industrial economy, they need a large amount of heavy steel, and their main source of iron to make the steel was from the ground. In other words, they had to start with virgin iron ore. Therefore, they put a tremendous impetus and concentration on their blast furnaces. I know, some of our people when they went over there were very skeptical. They wouldn't believe they were producing 2,500 tons of iron from a given blast furnace. Well, we did see them doing this, and today in this country there are furnaces producing over 3,000 tons of iron.

I think it was a good thing because there is nothing worse than complacency. And I think some of our people were too complacent that no one was equal to us.

Well, it did show that in the blast furnace they were equal to or better than we were at that time. I wouldn't say they are today. Their open hearths were as good as our best open hearths. In other words, they were no better, but they were right up on the top technology. From there on, starting with their rolling mills, I would say that in general, their rolling mills in '58 were about 25 years behind ours. But keep in mind what we're saying. First of all, they did not have to roll the steels at a high quality surface standard that we require. They have no competition. They don't have one company competing with another, so that, if the surface qualities weren't as good as ours all they cared about was the physical properties of the steel. But today they are building mills patterned after ours.

Now, starting with their iron ore their iron ore technology is not nearly as good as ours. The ores in Russia, in general, will average ten to eighteen percent silica. In this country we do not like to use an ore that's over ten percent, and with our new concentrates we're getting down to the four to eight percent range. The Russians have asked some of our people on this technology to come back again. They haven't gone over, but I know that is one of the places where they could use a lot of knowledge - in the beneficiation of ores.

In pelletizing there is no country in the world that's equal to the United States, and our new Canadian sources, which are United States-owned - most of them - method of agglomerating ores. So, I would say, the main thing in Russia is that their blast furnace practice was geared to give them the iron units they needed because they had to get the iron from the iron ore in order to make their steel.

QUESTION: Sir, you mentioned the desirability of stockpiling four basic metals

that we do not have a sufficient supply of. We also have a high unemployment rate in the United States. Has the steel industry given any thought to the possibility of relating these two problems and made any recommendations to the United States Government, to that effect?

MR. STRASSBURGER: They have not to my knowledge, no.

QUESTION: Sir, in reviewing your lecture you fairly indicated that American steel has most of the raw materials available to it. Now, as compared to the European steel-makers, they don't have that raw material, and yet European steel is beginning to compete with U. S. steel. Would you care to comment on the comparison between European and American steel?

MR. STRASSBURGER: Yes, I would be glad to do that. In fact, I made a recent study for my own information of how much it would cost to make an ingot ton of steel in Europe as compared to this country. First of all, it's rather surprising to find out that the imported ores in Europe land in the Ruhr Valley in Germany, or in Belgium just as cheaply as they do in this country. In other words, when you get ore on an ocean vessel it doesn't make too much difference whether it is transported, say, a thousand miles or 200 miles, there's not too much difference in cost. And competitively, they're buying iron ore from Sweden, Canada, Africa and Spain, and bringing them around into the northern part of Europe at about the same cost as our imported ore.

Secondly, the cheap ores in Europe are the domestic ores. And in Germany, on this study, we found out that domestic ores - where, say, an imported ore was around $11 1/2 to $12 a ton, and their domestic ores cost them $5 to $6 a ton, if you

work the calculation out you'll find that if they used 100% domestic ore they wouldn't have nearly as cheap a product as if they used all foreign ores. So, the more foreign ores they use, the cheaper their steel is. So, from an iron ore standpoint it's no disadvantage because they have to do so much importing. They do have a great disadvantage in fuel.

Coal in Europe, and their coke, I would say cost approximately 50% more in the Ruhr than it does in this country. And by this country I mean the average. There are some places where it costs twice what it does in this country. In other words, we think that their coke in the Ruhr would probably run around $20-some a ton. I was recently in Austria and their coke costs $35. In this country the average price of coke is about $15 as an average of the industry. So, they are at a disadvantage on fuel. And that is another reason why they have used so much technology in reducing their coke rates.

Now, against that, I mentioned in my talk that 80% of the blast furnaces in Europe are on fuel injection - oil injection. Well, oil is just as cheap in Europe as it is in this country. In other words, it's as cheap in Europe as it is on the coastline of this country. So, their fuel oil will probably cost them, I'd say, in the neighborhood of four to five cents a gallon. That's their cheapest fuel. So, the more fuel oil they can inject through their twiers, the less blast furnace coke they use, so if they develop this technology they will have less disadvantage from the fuel standpoint.

Now, against the high cost of coke, of course, they have cheaper labor. The bulk of the plants in Europe do not have the productivity of our plants, but you have

to say that with some reserve, because if you look at the new plants in Europe that are being built, you have to realize that they're all being built on the coastlines. And they're being built so they can develop export trade. For example, starting with England the Steel Company of Wales is at Fort Talbot, right on the water, and they probably have - it's the largest steel plant in Europe - and they probably have the cheapest cost as far as Europe goes. Within 30 or 40 miles of Fort Talbot the new Spencer Works of Richard Thomas and Baldwin is built. You pass it on the railroad, and it extends for seven miles. It's a brand new steel plant for which the British Government furnished $160 million to help build it. And this steel plant - there's no question - is probably the most modern plant that has ever been built because it's the newest.

Then, in France there's a new steel plant that just started operation at Dunkirk. You can see what their thinking is now. They're going to go after world markets, including ours. In Germany you have the plant at Bremen. In Italy there's a plant at Genoa and another one down in Southern Italy, which are being built. So, if they are once on the coastlines they can bring in imported ores; they buy a lot of coal from this country now; and they can ship by water. And I'd say that in general they can compete with us. The only disadvantage they have is on fuel costs and that is gradually being overcome by these new techniques.

QUESTION: Would you please comment on the justification problem in the Great Lakes-St. Lawrence Seway System in the event of damage to the locks and the canals in the event of war?

MR. STRASSBURGER: That is a good question. As you know, practically all

of that ore from the Great Lakes is brought by water into this country, and the ore from Canada is brought down on the St. Lawrence and goes through the seaway and around to the Atlantic Coastline. And just taking the Lake Superior District, in which we have 55 million tons of ore coming in yearly now from that area, there are not enough transportation facilities by railroad to bring that ore in; it would just bring in a small percentage of it. Because, the turn-around time would be so long that there's just not enough railroad cars - I would just make a guess if you could deliver 10 or 15 million tons by railroad you'd be doing pretty well. Also keep in mind that if you start railroading this ore in the wintertime you have freezing problems.

To give you an example of that, we rail ore from Lake Erie down to Weirton - 125 or 130 miles by railroad - and we also have from Labrador and Philadelphia, into Weirton. We very seldom bring iron ore in after the first of December. But even at that period of the year, where we would normally unload over 100 cars in eight hours, I've seen them take eight hours on one car, when it's frozen - trying to dig it out. So that, you not only have the problem of transportation by railroad, but also the fact that if you can't unload these cars quickly you can't make a turn-around on them. In other words, that works against you except for eight or nine months of the year. You have three or four months during which it is very difficult to unload the ores except where you have supplies from warm areas into warm areas.

QUESTION: Another question, Mr. Strassburger, on the four additives where we are dependent on foreign sources of supply. Would you say that our national

stockpile provides the maximum use for those metals in the event of an emergency?

MR. STRASSBURGER: Well, I don't want to get into the stockpiling problem because I'm no authority on it. The only comment I would make on that is this - and this is a personal opinion - that any metal that we have in the stockpile that is not perishable, I think that we should take a very good look before we dispose of those stockpiles. In other words, I think that if we have them in the stockpile, they're not perishable - most of them - and they are a protection to this country. Therefore, I do not think that we should dispose of those stockpiles and face a possible shortage which is unnecessary if we keep the stockpiles. That's just a personal opinion.

QUESTION: We've been hearing about the new oxygen converter which has been casting directly into slab as you mentioned. And it's said that these are going to revolutionize the steel industry. The new converter sounds quite a bit like the old-fashioned Bessemer converter, but casting into slabs of just another size and shape. In other words, it doesn't sound so revolutionary, and it gives the impression that steel technology is actually not very much different than it was a generation ago. Now, if this is a fair observation, could you explain why the rate of technological advance in the steel industry is so much slower than it is in other industries.? And further, even these two processes we've mentioned, why are they the only two major ones we talk about in foreign development?

MR. STRASSBURGER: Well, first of all, as you know, there's never anything new in the world. Sir Henry Bessemer, when he took out the Bessemer Patent in 1856 - he also has a patent for blowing oxygen directly on steel. So that, the idea was not revolutionary. But when oxygen was costing 25¢ a hundred cubic feet, it

was not economic. You can make oxygen today in your own plant for around 2¢ per hundred cubic feet and buy it for 4¢. So, it was the development of large-tonnage oxygen plants that - there is no question that the Linde Company in Germany were the pioneers in this, that made it possible to adopt oxygen as a way of making steel. And, of course, in the use of oxygen, the fuel that melts the steel is within the iron itself. In other words, the oxygen is directed against this molten iron. It burns the silicon and the carbon, and the burning of those elements - those are the two principal elements that are burned out - furnish the heat.

Now, you might say, "Why has this been developed in Europe before it was in this country?" Well, first of all, keep in mind where it was developed. The Austrians developed it. A man by the name of Carl Schwartz in Germany in '39 took out a basic patent on directing oxygen at supersonic velocity onto molten iron to refine it. And I think that patent was seized by our Alien Property Custodian during the war. When the war was over the Austrians were faced with having, first of all, a steel plant at Lintz that was built by Goering. It was designed to have 16 blast furnaces; it had five blast furnaces, quite modern; they weren't as modern as our country even at that time, but they had a capacity of about 5,000 tons of iron a day. They only had two small open hearths and a couple of small electric furnaces. They had no scrap. Fuel was very expensive in Austria, as I said. Coke was expensive.

And here they had all this iron production and all the equipment to make it. So, they seized upon this idea that Schwartz had developed. "Here's a way we can make steel directly out of pig iron and practically use no scrap." And when they developed this process they weren't interested in using the most scrap, they were interested

in using the least amount of scrap. Well, that's how it developed. They started with a five-ton vessel and gradually got up to a 30-ton. When I was there recently they had 50 and 60-ton vessels.

Well, then, in Europe the reason it was adopted also is an economic reason. The bulk of the steel in Europe was either made by the open hearth or the Thomas Converter. The Thomas Converter is a bottom-blowing converter in which after the war there was a lot of oxygen introduced into that bottom blast. But the Thomas Converter was treating high phosphorus irons, but because of the air being blown up through the converter these steels were very high in nitrogen. And as you know, in the late '40s and the early '50s the economy in Europe was such that there were very few automobiles produced, very few appliances, and as we all know, the European economy has changed greatly. If you go to Europe today you have great difficulty crossing the streets because of the cars. And the appliances are being used in the home and rapidly increasing in usage as in this country.

So, when they got into the use of flat-rolled steel that goes into cars, appliances, etc., they could not use Thomas steel. It was too high in nitrogen; it was too tough to bore; it was brittle. So, the question was, they either had to go to the open hearth or to this new oxygen process. Well, the open hearth cost about 1 1/2 to 2 times the investment than an oxygen plant, but also the oxygen plant makes an even lower nitrogen steel than the open hearth. Furthermore - and I mentioned this to some of you people earlier - when the war was over the steel plants in Germany were practically all dismantled by the Allies. Defense plants were just falling apart. I was over there in '49 and they just looked like piles of rust. Also, the

English plants were at least a generation behind ours.

So, these countries, with not only their own governments' help but with United States funds, such as the Marshall Plan, they started to rebuild these plants from the ground up. And naturally, in rebuilding from the ground up they would utilize the newest technologies that were available. And the same thing would be true in this country. National Steel's newest steel plant is in mid-west Indiana. It's called the "Mid-West Steel Plant," in Portage County. We start there with a hot roll band that we ship from Detroit to Mid-West. But as time goes on and this Mid-West plant develops in its production of steel, and we get to the point that we have to put in ingot capacity, - that's what we're doing today; we're working on form coke. Why? Because in Illinois the coals are not good coking coals. So, if we can make a process or develop a process that will use a coal that we're not using today, that's something that we can deliver at a very low freight cost.

And we always say we're not in business to help the railroads, we're in business to make money for ourselves. So, we have to take advantage of the materials that are close by. And it's not inconceivable that when Mid-West builds its steel plant it will be even more revolutionary than what you see being done today. We think the time is coming when the steel industry will be like the petroleum industry. The blast furnaces today, where they used to cast four times a day, are now casting six and eight times. And it takes an hour and a half to two hours for a cast, so, practically, you're casting almost continuously.

We think there will be two tapping holes on the furnace; that the blast furnaces in not too many years will have a continuous stream of iron coming out of them;

you'll treat that continuous stream of iron with oxygen; you'll make steel in a continuous flow right into the continuous casting; from the continuous casting while it is still hot, it may be re-heated a little; it will be going through continuous mills; and from the time you start with the ore into the furnace you'll have the product out in less than 24 hours. Now, that's what we think is coming. These changes are all pinpointing that way. So, I think it's all a matter of economics and national conditions that dictate what's done in each country.

QUESTION: In looking at your various maps of the world which depict the different elements necessary for steel manufacturing, I noted one little country with considerable interest, that seemed to have just about all of these elements with the exception of a couple of additives, and that little country was Cuba. Is that a valid observation, and is it possible that the Soviets will sponsor a steel industry there?

MR. STRASSBURGER: It's possible. Cuba does have iron ore. It has nickel and cobalt, and copper. The only thing we can say about the Cuban ores - because Bethlehem at one time owned the Somalia re-ore, which is a high chrome ore in Cuba, in fact, it's got most chrome and nickel in it - but these ores are such that they will not make what we call basic iron. In other words, they do have the additive metals. If you have nickel in a process you do not get it out in the refining and melting process. So, you end up with an iron ore with, say, too much nickel in it for making ordinary grades of steel. But for special grades of steel it could be used.

It's possible that Cuba could have a steel industry. Cuba has resources, and as you know, each country wants to be nationalistic. There are steel mills being

built in Spain, Greece, Yugoslavia, Venezuela, Chile, and Peru, with the idea that they want to have the national pride of having a steel mill. So, I would say that it would be very possible that Cuba could make their own steel.

QUESTION: From your experience in the organization of blast furnaces and Furnaces Research, Inc., I ask you do you feel that you have enough purview of the industry's research activities to give us an up-to-date estimate of the percentage of either net worth, gross sales, or operating budget that the industry as a whole is spending for research, and how that is varying today in favor of past or future projections?

MR. STRASSBURGER: I don't think that I have the information at hand to give you the percentage. I can say this; that I believe that as of today the steel industry is probably spending four to five times what they spent on research five years ago, and with another few years they'll be spending even more. Youngstown Sheet and Tube is building a new research laboratory. Inland Steel - we just completed ours and moved in in December. Of course, we had research before that, but not on as large a scale.

I would say that only through new technology are we going to be competitive. I think the steel industry realizes that, and I say today - and I've been in the industry for 40 years - and I can remember the complacency of the steel industry not only in this country but in Europe. I was in Europe and was giving a talk on the blast furnaces, and a Scotchman put his hand in his vest and said, "I don't need any American coming over here to tell us how to do this." And I can remember in our country when a man from Holland was over and one of the blast furnace men in this

country said, "I don't need a Hollander to tell me how to do things." But I think that attitude has changed now. The world is compacted into a very small space and the brains are not all restricted to any one country.

There are developments going on even in Japan in blast furnace technology that are far different and could be revolutionary. I think the steel industry and their top executives realize it. And in my own experience I can see an entire turn-about in the attitude of the steel industry from the top down, on research and new methods. But you'll see, as time goes on, we'll be very aggressive, and if we're not aggressive we're not going to stay competitive.

QUESTION: During the past year several of the steel companies that were going to invest in new capital equipment indicated that they were no longer going to do this; that they could no longer afford to. What effect has this had on the modernization of the steel plant in the steel industry in the United States?

MR. STRASSBURGER: Well, I just read in the paper within the last few weeks where the amount to be spent in 1963 is greater than in '62. So, I think there has probably been a turn-around there. I do not think the American steel industry is going to stand still. That might have been talk for publication, but actually there is too much in the way of contracts being let. For example, J&L just started these 200-ton converters in Cleveland. Our company just started 300-ton converters in Detroit. We're making studies for our other plant, what we're going to do. Continuous casting is coming in. I don't think any of these companies can afford to stand still.

I just read in the paper within the last few days that this billion three hundred

million dollars in '63 - I think that is the figure - is being spent not for added capacity, but to make steel of better quality and at lower cost. And I think if you see what has been written within even the last few weeks you'll find that the steel industry is increasing its expenditure next year and not decreasing it.

QUESTION: Mr. Strassburger, I've heard the U. S. steel industry characterized as one of both declining employment and declining output. If this is true, what are the reasons, and what is the outlook for the future?

MR. STRASSBURGER: First of all, the United States as a country, has the largest consumption of steel per capita of any country in the world. In other words, we're approximating somewhere in the range of a thousand pounds per person. And some of our competitive nations, even in Europe it's three or four hundred pounds at best in the countries that have the highest industrialized condition, and other countries are way below that. So, we have reached a point where I believe our consumption of steel will be limited somewhat by population growth; but also keep in mind that there are many metals competing with steel, which we only realize too well.

We have competition from not only aluminum, but we have competition from paper and plastics, and all of that is entering into the picture. In addition to which, as we develop better steels, it takes less steel to do the same job. I just read recently where a new bridge was being built, where they're using high tensile structural steel and there was something like a 20% saving in the steel used.

In your automobiles, naturally the compact car is taking less steel per car than the full-sized car. Now, as the compacts get larger that might erase itself. In the

container industry, when I started with National Steel - I was with Bethlehem for a few years first - back in '24, the average base weight of tin plate was 107 pounds per base box. That's a hundred sheets 14 x 20. Today the average base weight is around 85 pounds. But a lot of container cans are now being made at 55 and 60-pound base weight, and therefore less tons of steel are going into these products. So, even though the use of cans is expanding, it might mean that the tonnage going into the cans could level out even with an expanding market.

And in that line I might mention that in our research work we have already rolled tin plate - to give you an idea a hundred-pound tin plate is about .010 in thickness - ten thousandths of an inch. The 55-pound is 0055. We've already rolled plate 0005, which is like aluminum foil in thickness, and we're trying to develop uses of this foil. There's no question, as time goes on there's going to be higher strength steels used. And in making this light-gauge steel it's harder and stiffer; it has more tensile strength than the older heavier steel even for containers. So that, all of this is pointing to a lesser use of steel per unit.

You can make it cheap enough, and it has always been the experience of industry that if you can make a product at a lower cost you can expand its use. I remember back in the early '30s General Motors said that if they reduced the price of a Chevrolet in those days by $10 they opened up the market by several hundred thousand more cars - just $10 difference in price back in the days when a car cost $500. So, you can see what price means.

LT COLONEL McELWEE: Mr. Strassburger, on behalf of Admiral Rose, I thank you very much for a most informative and interesting morning.