IRON AND STEEL MATERIALS RESOURCES

Mr. J. H. Strassburger

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Reviewed by Col E. J. Ingmire, USA on 30 December 1963

INDUSTRIAL COLLEGE OF THE ARMED FORCES

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DR. WORSLEY: Admiral Rose, General Stoughton, Gentlemen: Those of you who have been studying plastics and other glamorous competing materials may wonder whether the old saying that as steel goes so goes the Nation is now old hat. On the other hand, those who may have had a stake, large or small, in Wall Street, on Black Monday, May 1962, right after rather vigorous action opposing steel price increases, may feel that there is life in the old cliché yet.

In any event there is ample reason why today we should hear about the latest developments in iron and steel materials resources. So the College has disturbed the retirement of our speaker today and lured him all the way from Arizona, from which he commutes to West Virginia as Consultant to the National Steel Corporation.

It is my pleasure, therefore, to welcome back to the College again Mr. Julius H. Strassburger.

Mr. Strassburger.

MR. STRASSBURGER: Admiral Rose, General Stoughton, Dr. Worsley, and Gentlemen: It is a real pleasure to have the opportunity to come back again and talk to the College here. My subject will be "Iron and Steel Materials Resources."

There are many materials required in the production of an ingot ton of steel. So we want to start out by putting a slide on to show what goes into making a ton of steel. As you will notice there on the slide, there are 4121 pounds of iron ore, 2163 pounds of coking coal, over 1300 pounds of limestone, almost 400 pounds of scrap, and 938 pounds of scrap and other materials which go into the actual ingot production.

The production of iron and steel in the United States is not confined to any one area. This figure on this slide shows the States and the location of steel plants in the major centers of the United States. Significantly, 33 States have iron and steel producing facilities. So the iron and steel industry is not confined to any one area, and it consists of many large and small plants , which some people do not realize.

The technological changes during the last decade have had a very great effect on the amount and type of raw materials which are used in iron and steel making. I might say here that I think that the United States and North America is far ahead of any nation in the world in the preparation of its raw materials. As we go on you will see the significance of this.

In reviewing this new technology, first we start with coke, because that is the fuel used. Where coke has been made over the years in byproducts, in slot-type ovens, where the coke is pushed out every 17 to 18 hours periodically, several companies have their own programs. U. S. Steel has its own program, and our company, along with 3 or 4 others, has another program to continuously make coke of the desired size and shape. Experimentally, pilot-plant work is now under way which has indicated that we can take actually a coal that is not considered metallurgical today, and, with one grade of coal, we can make a piece of coke which is superior in physical properties to some of the cokes that we have to blend coal for today. So this project is still being developed. Within the next 2 to 3 years we expect to see the first commercial plant built. Also this process enables us to take a high sulphur coal, of 2.5 to 3 percent, for example, calcine in that coke, and we can take that down to .5 percent. This again has a great impact on coal reserves.

Now, in iron ore beneficiation, there is probably no field where technological advance has been any greater that in the iron ore industry. Vast reserves of iron ores that were previously considered unsuitable are now being exploited and used in the making of iron in this country. The taconites, hematites, and other low-grade ores, with only 28 percent FE content, are now being upgraded to 60 to 66 percent, with silicates down to 4 to 9 percent.

To show the vast progress in this field, when I was here last year about a 62 to 63 percent iron was considered high. Now we are producing and projecting plants with 68 and 69 percent FE and only 3 percent silicate, which means that we have a much purer material.

The reason for this development is two-fold. First there was the exhaustion of the direct shipping ores in the Mesabi and other ranges in the Lake region, and, secondly, it was economic. The vast increase in wages and the cost of capital equipment made it necessary to utilize higher-grade materials so that the production of iron and steel could be attained at a much greater rate and quantity from the same capital investment.

Another effect of the higher iron content required for a ton of pig iron required a lesser amount of transportation and storage facilities. For example, back in the early fifties the average iron ore in this country was about 51.5 percent FE, and it required 1.67 long tons of this material to make a ton of pig iron. Today a 65 percent concentrate requires only 1.33 tons. That's a reduction of 20 percent. That 20 percent carries all the way through transportation, storage, and charging the furnace. So, when you see the iron ore consumption on a chart decreasing, that does not mean that we are producing less iron. We might be producing the same amount or even more.

The conventional methods used in the beneficiation of iron ore were gravity separation. The new technologies are using floatation, magnetic roasting, magnetic separation, and high intensity work. Recovery of the usable iron concentrate materials is now considered quite economic. It is conceivable that in the future the black sands, such as on the Coast of Florida, with only 2 to 4 percent FE concent, could be used. You might wonder why. These sands can be handled easily with big construction equipment, can/magnetically separated with high intensity, and upgraded rather easily.

The next step is physical. In addition to improving the ores chemically, we have to agglomerate them, because ores being beneficiated have to be ground so fine that this 325 to 400 mesh material has to be agglomerated in order to stay in the furnace. At present the direct shipping ores are being screened so that the fine, minus 3/8 inch ores are cindered, and the coarse ore is charged to the furnace direct. Also we add limestone in the making of cinder. Cinder is a process in which you take the fine ores and mix them with coke grease, grind this all together, add limestone, and put it over a traveling grate and cinder it about 2200 to 2300 degrees. The effect of this cindering has contributed to a lower coke rate in making iron.

For example, it takes only 100 pounds of coke to calcine limestone in a cindering plant, but, if you put it in the blast furnace, as was done in the past, that takes 330 pounds. So there is a tremendous saving in fuel.

In the beneficiation of low-grade taconites, as I mentioned, it takes 80 or 90 percent through a 325 mesh in order to separate the silica from the iron. This material is now being converted into pellets. You have probably read about that. That is where both the United States and Canada are leading the world. At the present time there are 36 million tons per year capacity of pellets. By the end of next year there will be over 50 million. This compares with only 2 to 3 million in the rest of the world at the present time. So the billions of dollars that have been spent by the iron and steel industry in this taconite pellet program are very significant, because the American steel industry today is not asleep; it is aggressive. You will find, as I mentioned earlier, that when the Soviet Union says they are not going to spend any more money on iron and steel plants it is very possible, because, when we were over there, they were far behind in the preparation of their raw materials, and they are going to probably emulate what this country has done. Blast furnaces used to produce 1500 tons of iron, and with the same facilities we are now producing 3000 to 3400 tons of iron today. So we think that is probably what they are thinking of there.

Also work is under way using flux pellets, that is, putting limestone in the pellet. I personally am very much interested in metallized pellets. In other words, instead of stopping at 65 percent iron we are working now to get up to 85 percent iron, where 60 percent of the iron is in the metallic form, and you could go even higher. It's a matter of economics. So, in the future, with this metallized pellet, where coke rates have been down from the 1800 to 1900 pound, this next slide shows the production of agglomerated ore. This shows the 1961-62 average as compared to the 1957-59 average.

You will notice that the total production there is 67 some million tons a year. You will see that cinder is leveling out around 46 percent. This 1962 production is only 20 million tons of pellets. In 1963 we have 36 million tons. In 1965 there will be 50 million tons. You can see where these pellets are going to go. They are skyrocketing as far as capacity goes. That is very, very significant.

This development has made it possible, within a 10-year period, to reduce the coke rate from an 1800 to 1900 pound range per ton of pig iron down to 1000 to 1200, with some furnaces even down in the 900 pound range.

With these metallized pellets, by the way, it is conceivable that the coke rate can get down to 500 to 600 pounds. In fact, it may mean that we will be making our iron in cupolas instead of blast furnaces. We do not care what the facility is. It's whatever is going to produce the iron in the most economic manner.

The improvement of blast-furnace technology has used, in addition to burden improvement, higher blast temperatures, the injection of moisture, fuels, and high top pressures with the use of oxygen in the blast. Considerable work has been done at the United States Government Bureau of Mines experimental furnace at Brewston, and I might mention that I happen to be intimately connected with it. Blast Furnace Research Incorporated is a nonprofit organization of 22 steel companies, including U. S. Steel, who have their own facility. They came in, and these 22 companies have put in $2.5 million over a 2-year period for the experimental development of new blast-furnace practices.

The next slide will show some of the work that we have done in the past on this facility. This slide shows the reduction in coke rate when increasing blast heat from 1400 degrees to 2000 degrees. As you will notice, the two lower curves are with moisture in the blast and with CH-4 or natural gas injected. We have made a 300-pound reduction in coke rate. The lower two curves are with oxygen and natural gas and the upper curve is only with moisture. It is significant that we can make this big reduction.

The next slide shows the same practice and how the production increased.

In other words, this is a 1 percent blast furnace so that, at 1400, where we started at a little over 1500 tons a day, this shows that with this injection we can get up to, without oxygen, around 1850 tons, and, with oxygen, up to around 2200 tons. With this practice we go to work.

The next slide will show, when we start using pellets, on the lefthand side, that 1300 and something is with cinder and coarse ore. Then, as we use different pellets, you will notice we come down in coke rates well under 1000 pounds per ton in that lowest curve. Again, the use of pellets increases production. Where production would be, say, 1900 tons a day, it can get up as high as 2500 on this furnace.

I might mention that records have been made in the last six months in this country. First 100 percent pellets produced 2800 tons of iron in up to 3 hours, and then in an hour mixture of pellets and cinder it averaged 3400 tons of iron per day. We are projecting practices in the future, and within a few years you will see furnaces producing 4000 and then 5000 tons of iron from the same size furnace that used to produce 1500 tons.

Oxygen steelmaking has had a big impact on steelmaking. We are leaving the iron now and going into steel. There has been an increase in productivity in the open hearth by injecting oxygen through vertical lances, through the roofs, of over 50 percent. Then the next step was the oxygen block-blowing converter, in which there is no conventional fuel used. It requires only about 1800 to 2000 cubic feet of oxygen to make a ton of steel. This has an impact on the energy resources of the country. The fuel oil fire in open hearth requires 3 million BTU's per ton of steel. This process, using only oxygen, requires 270,000 for the production of 30 kilowatts to make the oxygen. This development, though, has had a secondary effect on the requirement for greater hot metal. In other words, although this process was known in the early fifties, it was not adopted in this country on a large scale until this blast-furnace development came along, because, where an open hearth can use 40 to 60 percent hot metal, the top blowing oxygen requires approximately 70 percent. So it was only when we could get more iron and make it cheaper that we could afford to go to it.

The next slide shows the increase in oxygen capacity in the United States from 1955 to 1962. Although this shows only a little under 6 million tons in 1962, at the present time there is 11 million this year, and at the end of 1965 that curve will be up to 22 million. That's what is on the drawing boards and contracted for today.

This is another rapid development. I might state that at one of our plants that you are familiar with, in Detroit--I was there last week--our oxygen converter, which is a 300-ton vessel--and keep in mind that this started out with a 2-ton experiment, and the first vessels were around 30 tons, and everybody thought the Americans were out of their minds when they talked of 200 and 300 tons--instead of making a heat an hour, which is usually projected, made 29 heats last Thursday, 8100 tons in one day, and so far this month it is averaging 332 tons an hour. This compares with a good open hearth of about 50 tons an hour.

You can see the impact of this on steelmaking.

Another development is continuous casting. This is now being developed commercially. Several plants are installed and starting to operate. That casts the metal directly from the ladle into the slab. In other words, it eliminates the ingot step. We do not have to use the castiron molds to pour the metal in and it eliminates the transportation of the ingots to the rolling mills. It eliminates the stripper building that strips the mold off the ingot. There are no soaking pits for reheating it, and no slabbing or bluing is required. So the result of this development is going to be a reduction in the capital investment, labor cost, fuel requirements--another step in streamlining steel so that in time this will be a continuous process, the same as petroleum refining. We can visualize that coming in the future.

Another new development is vacuum degassing. It might be interesting to you men to know that this is being used on the ordinary carbon steels. Vacuum degassing equipment is on order today. We have one treating 300-ton ladles of steel, ordinary low carbon steel, which will have a capacity of over a million tons a year just from one unit. The reason that this can be applied now to the ordinary grades of steel is because of the space program. The space program, with its impact on vacuum technology, has lowered the cost of the hardware for producing vacuums to a point where it is now economic to use this technology in the low carbon grade steels.

What will this do to steel? Well, it will make it more competitive with other materials. It will deoxidize the steel by removing the gasses, particularly the oxygen, with vacuum, instead of using deoxidizers, like aluminum, silicon, and so forth, so that we will have less oxide, less inclusions in the steel, better surface, better drawing qualities, and the general quality of the product will be improved.

Now we come to the basic raw materials. Of course coal is the first one we want to talk on. The reserves in the United States of coal for making iron and steel are ample for a very long period of time. This country has over 11 billion tons of metallurgical coal, which is considered of vein thickness and mining conditions which make it economic to recover.

This slide shows the various coal fields in the United States. You will notice the main locations of metallurgical coal. They are in the Eastern and the Southern fields. Then in the far West there are other coals which are not as good metallurgically as the coals you see in the Eastern and Southern regions on this map.

This table shows the high volatile coals in the Eastern and Southern regions--Western Pennsylvania, Northern West Virginia, Southern West Virginia, and Eastern Kentucky. You will notice that this is in millions of recoverable tons. So there are almost 8 billion tons of these reserves.

The next table will show the metallurgical reserves of the low and the medium volatile coals. This is what we call the Pocahontas type coal. It runs 17 to 18 percent volatile compared to the 30 to 38 percent volatile coals. There again, these coals are mostly in Central Pennsylvania, but the better ones for metallurgical work are in Southern West Virginia and Virginia. As you see there, we have 2 billion and some tons.

By the way, this country is blessed with this type of coal probably to a greater extent than any other country in the world. This coal is now being exported as far away as Australia. That is a problem, because, as we export this coal, we are giving away something that is of great value to us. But the development of the other methods of making coke may make the use of this coal not as important as it is at the present time.

The next table shows the coals in the Southwest and Western part of the country. You will notice they are in Southern Alabama, Arkansas, Colorado, and the far West. There we have about 1 billion 700 million tons of reserves.

So we can see no shortage of metallurgical coal in the production of blast-furnace coke for this country for a good many years, and the technological improvements in iron making are going to extend these reserves into the future.

This slide shows the consumption of coking coal in 1961-62 as compared to the average of 1957 to 1959. The actual steel production is about the same in all of these years, the average. So you can see that the use of coal is coming down because of the improvement in iron ores and the concentrates with lower coke rates. This probably will come down more as time goes on.

Now we come to iron ore. There is no question that iron ore is the most important raw material going into iron and steel, because that's where we get our FE, and without the FE we couldn't even get started.

This slide, Figure 12, shows the comparison of the iron ore consumption in 1961-62 as compared to 1957-59. As I mentioned earlier, this lower consumption does not mean less iron, it means a high-grade ore, because these are tons, and this does not take into effect the FE. The ore consumption at the present time in this country is averaging about 109 million long tons per year, and by 1975 we foresee the need for about 125 to 135 million.

The next slide shows the sources of iron ore from the years 1854 to 1962. This is both domestic and imported ore. You will notice that 25 to 30 percent of our ore is coming from Canada and other foreign sources. There is actually no shortage of iron ore in the world.

The next slide shows the principal iron ore deposits in the world. Practically every country has iron ore, and each year there are new deposits. As the lower-grade ores become usable the reserves will be expanded.

On that previous map are shown large reserves which are located in all the countries of the world. This slide shows the consumption of iron ore for 1961 as compared to the 1955-59 average. As you will notice there, the United States production was about 71 million out of that 109 million that was required.

The Canadian reserves also are usable in this country. As you will notice, the United States imports from Canada. These imports come to between 8 and 11 million tons in that period of time. The United States and Canadian production together is between 89 and 100 million tons a year. At the bottom there, the world production is close to 500 million tons yearly.

The imported ores into this country come from Canada, Venezuela, Brazil, Peru, and Liberia. Which furnaces in the United States take their ore from what source is often dictated by such items as transportation course, quality, structure, and so forth. Ore from one iron ore source is always in competition with ore from other sources. The higher-grade, direct shipping ores from Venezuela and Liberia are now being used competitively in this country.

This slide shows the United States reserves, which amount to about 30.5 billion tons at the present time, and the Canadian reserves, which are almost the same. You can see that in North America we have a total reserve of about 60 billion tons of iron ore for our steel industry.

This slide shows the use of foreign ores in peacetime, starting with 1940, where we used 2.5 million tons, and in 1945 only 1.2, during World War II, and now, at the present time, we are using between 25 and 35 million tons yearly of foreign ores. This is a good economic condition, because, as we use foreign ores, we keep our own reserves and do not use them up as quickly.

This slide shows the countries we get our foreign ores from. It shows the various cointries and the amount of ore shipped from each country.

What about the sources of iron ore during an emergency? Currently the Lake Superior region is producing about 55 million tons of ore, or about 50 percent of our needs. The remaining tonnage is imported. If we were cut off from imports, including Labrador and Quebec, we would be in a serious condition. During an emergency, the production of the Lake Superior District could be increased from 55 to 88 million tons rather quickly. The iron ore requirement, amounting to 120 to 125 million tons, would leave a serious gap if we were cut off from ore imports. So that the maintenance of the Labrador-Quebec ore delivery to this country is really very important.

It is our opinion that the perimeter of defense of the military establishment should protect the Labrador-Quebec line, the St. Lawrence Seaway, and the Soo Locks, if this country is required to maintain its iron ore supply during an emergency period.

So much for iron ore. Another raw material which goes into iron and steel is limestone. Limestone is a flux material which is used to remove the impurities from the iron-and-steelmaking process.

This slide shows the limestone deposits which are scattered throughout the United States in about the same areas as the iron and steel plants. Limestone is a material which is relatively cheap. It ranges around $2 to #4 a ton delivered, compared with iron ore, which is around $16, and coal, which is around $8. So that you cannot afford to pay much freight on limestone. Usually steel plants are located where they can get their limestone within a few hundred miles.

The next slide shows the limestone production for consumption in 1961 and 1962, compared to the 1957-59 average. Again, because of the new technology, you can see that the limestone usage is decreasing as the grade of ore material is improved.

Another raw material that goes into iron-and-steelmaking is scrap. Actually, 50 percent of the ingot tonnage produced is made from scrap, of which about half of the scrap comes from the steel mills' own operations, called home scrap, and half of the 50 comes from purchased scrap. The use of scrap is relatively stable. As the oxygen steelmaking process comes into the picture, it is possible that the use of scrap will be reduced somewhat, because this process uses only 30 percent scrap. But then, again, other companies which do not have the oxygen process will probably increase their use of scrap. Scrap has been stabilized in the last five years. As iron and steel production increases, scrap does not skyrocket in price, because there is more supply than demand.

The next slide shows some information developed at Bethel, showing the additions to scrap, as projected from 1940 to 1966, the withdrawals, and the total withdrawals for domestic and export. As you see, the projection of this shows that we will have sufficient scrap available.

The next slide shows the heavy melting scrap. Although this slide shows that there would be a shortage of heavy melting scrap projected at the time this was made, actually that shortage did not develop, because the exports declined during this period. I might mention that the foreign countries, particularly Japan, which were the big importers of scrap from country, because of the improvement in their blast-furnace factories using iron ore, are not in the market for scrap like they were before World War II.

So we see no real shortage in the scrap situation. The decision on how much scrap to put into steelmaking is purely economic. There are adequate supplies of hot metal and scrap for an integrated plant. The use of pig iron and scrap is dependent usually on the relative price of the two commodities. If you have the choice, you like it in open hearth.

The higher blast-furnace productivity and the technological improvements, as I mentioned earlier, have resulted in a decrease in the cost of hot metal which makes it more economic to use.

The development of continuous casting, which I mentioned, reduces the scrap from the ingot process from about 15 percent scrap down to about 5 percent. It is possible that there will be less scrap generated within the steel mills, which could have an impact on the purchased scrap.

Now, in addition to these basic raw materials of coal, iron ore, limestone, and scrap, many additive metals are used in making steel. Manganese is one of them. It gives toughness to steel. The position of the United States on high-grade manganese--manganese ores containing 35 percent or more MN--is very poor. We have only about 4 percent of our supply. We consume about 14 percent of the world production. It is necessary for us to make large imports of manganese.

This slide shows the manganese deposits in the world. The largest reserves are available in India, Africa, and Brazil. These sources, naturally, would be endangered in case of war.

The next slide shows the consumption of this vital material and the production and imports. As you will note, our consumption is running about 1,718,000 tons of ore yearly. We produce only 46,000 tons. So it is necessary for us to import a large amount of manganese ores for our steel production.

There is a possible future source of manganese. This has not been used up to this time and need not be used in the immediate future but in the far future. This is the ocean floor. As you know, in the floor of the ocean there is a mineral wealth which has never been developed. The ocean floor in many areas is covered with manganese nodules. It is only a matter of developing the technology of mining on the ocean floor to obtain these minerals. When that is developed it is possible that manganese will be available in large quantities at a low cost.

Another material used in making steel is molybdenum. Fortunately, the United States is self-sufficient in this mineral. Large supplies are readily available from domestic mineral deposits. Actually, the ratio of our production to consumption is about 125 percent. In other words, we are producing more than we are using. Sixty-four percent of our complete output comes from Climax, Colorado, and the balance of it comes as a byproduct from our Western copper production. So the reserves in this country at the present time are sufficient for over 40 years for our present rate of consumption and export.

This slide shows the major deposits of this mineral in the world.

You will notice that we really have the greatest amount of it.

The next slide shows our production and consumption of molybdenum.

You will see that they are in thousands of pounds. We are using about 40 million pounds a year. Our production is 51 million pounds. In the Canadian production they do not put much impact on it. The reserves of this mineral are large, and as you will notice we have the major share, a little over 60 percent, of the reserves of molybdenum in the world.

Tungsten is another metal which is used for toughening alloy steels. The United States and Canada are able to supply between 60 and 70 percent of the normal peacetime requirement. In an emergency, the United States would be in short supply. However, we could double our production if cost was no consideration, but under such circumstances we would exhaust our tungsten reserves in about 10 years' time.

This slide shows the location of the major tungsten deposits throughout the world.

The next slide shows our consumption and production of this metal. Again you will see that this is in short tons now. We consume about 5500 short tons of the metal--not the ore. You will notice we are producing about 70 to 80 percent of that. The reserves of this are in other countries than the United States and Canada. We have a small amount of reserves, compared to the rest of the world.

Titanium is also used in iron-and-steelmaking. The United States, together with Canada, is well supplied with titanium. The ratio of the

United States and Canadian production to our consumption is about 115 percent. There are many known potential reserves of titanium which have not been developed at the present time.

This slide is again a world map showing the major titanium-producing areas, also the major deposits where there is little or no production at the present time. Those areas with the open centers have not been developed. Those shown in black are actually producing mines.

This slide shows the consumption and production of titanium in thousands of short tons. You will notice that our consumption of ilmenite and rutile amounts to almost a million short tons a year. We produce over 800,000 tons and import about 200,000. Again, our reserves of titanium are not great, compared to the rest of the world.

Nickel is also a metal used in making steel, particularly to make tough steel and for the stainless varieties. The United States is poorly supplied with this mineral. However, when you take Canada and add it to our reserves, we are well taken care of and have excellent reserves. Both International Nickel and Falconbridge in Canada can maintain their present production rates for over 20 years or longer, and actually there are new nickel deposits being found in Canada and also in other parts of the world. There are the laterite formations in South America and Central America which are now being studied, and these will add to the reserves of nickel.

This map again shows the major nickel deposits. You will note that the Western Hemisphere is well supplied with this vital material. The nickel-bearing laterites are found in Brazil, Venezuela, Africa, the Celebes, Borneo, the Philippines, and many other places throughout the world.

The next slide shows the consumption and production of nickel. Again you see that we produce about 13,000 short tons of nickel as compared to our consumption of 119,000. But the United States-Canadian production has more than doubled our usage. Our reserves are very small. The United States-Canadian reserves, though, are large, and amount to about 6 million tons, out of the world production of 45 million.

Another metal used in making steel is chromium. Again it is used for the production of not only the tough steels but the stainless varities. The chromium reserves, the world reserves, which we usually base on ores containing 48 percent chromic oxide and material in relatively large size, say, between 1/2 inch and 3 inch, amount to about 3 billion tons, with 500,000 in the United States. The largest known reserves of chromium are in Africa. They have tremendous reserves in that continent.

This again is a world map on which we show the reserves of chromium. It really doesn't show the true picture, because those two spots in Africa have the largest deposits of chromium that have ever been found. They are a large source of this metal for this country.

This table again shows the consumption of chromium in short tons of chromite. We are using 1,130,000 short tons of this ore a year. You will notice that we are not producing chromium. It is practically all from imports. Our reserves are relatively very small compared to the

3 billion tons of the world reserves.

Vanadium is another additive to metal. The known world reserves amount to about a million tons. Fortunately, 680,000 of this million is in the United States. The major source of vanadium is a byproduct from the production of uranium. That is what made it possible for us to develop this metal. The second source is in South Africa and Western Australia. But the United States, as I say, contains about 68 percent of the reserves of vanadium.

The next slide shows the consumption and production of this metal. As you will notice we use about 2300 short tons of vanadium, and our production is more than double what we are using. This shows that our position in vanadium is good.

Cobalt is another metal being used as an additive to steel. The world reserves consist of a little over 2 million tons, of which only 50,000 are in the United States.

The major sources of cobalt are in Katanga, where it is a byproduct of copper, Rhodesia, and Idaho, where it is not commercial. So again Africa is the main source of cobalt.

This slide shows our consumption and production of cobalt. We are using about 5600 short tons a year and our production is very minor. As you see, we are dependent on imports. We have very small reserves of this metal.

Columbium is another metal which is coming to the forefront in steel production, in making fine-grained steels and steels of high strength.

The world reserves of this metal consist of about 6 billion tons, and only about 50 million are in the United States. The deposits of columbium are in South America, Canada, and Africa, mostly. Although the Canadian deposits are not being used at the present time, the indications are that the Canadian production could be increased considerably.

As you will notice there again, our production is nil, and we are depending on imports of this metal.

Boron is another metal which is used for producing cleaner steels, and the world reserves of this metal consist of 135 million tons, of which 120 some are in this country. We have the largest reserves of boron of any country in the world, as this world map shows. Ours is practically the only major deposit.

The consumption of this material is shown on this table. You will notice again that we are producing almost double what we are using, and again it shows our reserves as the major part of the world's.

In summarizing the resources of the iron and steel industry, we see that there is no shortage of coal, there is no shortage of iron ore, in North America--there could be a shortage if we were dependent on only the United States. Limestone is in plentiful supply. Scrap is in plentiful supply.

The metals that we are really short of in this country are manganese, chromium, cobalt, and columbium. But in general the technological developments are going to work to the benefit of our reserves, even in the making of high-strength steels. Factors are being developed today so that in the mechanical rolling of low-carbon steels they can be made to have higher strengths. In other words, where we used to use tin plate that averaged about 100 pounds for base box, that would be around 10 thousandths of an inch in thickness, we are now using steel of 4 thousandths or 3 thousandths in thickness. We are rerolling the steel and giving it mechanical properties by rolling it that we didn't have to do with alloys.

So that other developments, such as this vacuum degassing and other processes should help us produce stronger steels, and it is possible that with the metals we have we can use our ingenuity to take care of our requirements.

But the protection of Canada is vital to this iron and steel industry, as you know. Not only do they have iron ore in Canada but they have tremendous reserves of nickel, which is an important component in the high alloy steels.

It has been a real pleasure talking to you gentlemen this morning. I hope that I can answer your questions later if you have any.

Thank you.

DR. WORLEY: Gentlemen, our speaker is ready for your questions.

QUESTION: Sir, in the last 2 or 3 years we have read quite a bit about the U. S. version of blast-furnace technology being unfavorable with Western Europe's technology. You say we do the best in ore preparation, so we should do quite well in production. Can you compare how we stand with other countries?

MR. STRASSBURGER: Do you mean just blast furnace or steelmaking also?

STUDENT: After the ore preparation is all through.

MR. STRASSBURGER: I would say, starting with the blast furnace, that about the time when we went to the Soviet Union in 1958, they had blast furnaces producing 2600 and 2700 tons of iron a day. There was no question that they were producing more iron from a given furnace than the Western world was. They had not used anything new. They had adopted high blast heats and flux cinders and the technologies that had been developed in the West, but they had no scrap practically at all. Russia was not an industrial country. They had no automobile industry or consumer goods that resulted in scrap. So all of their FE units had to come out of the ground. In order for them to produce steel they had to produce it from the iron.

They started and tried to get everything they could out of the blast furnaces, which were American furnaces. The original furnaces were put in back in the thirties. Then they expanded those furnaces and started to build larger ones.

Well, I think it was a good thing that we went to the Soviet Union, because some of our people were getting to be a little complacent. When we came back the industry in our country started to move ahead at a much faster rate. Today there are many companies producing over 3000 tons of steel a day, even though the Russians have built larger furnaces than ours. Our largest furnace is a little over 30 feet in diameter, and the Russian furnaces are around 32 or 33 feet. But actually, our 28-, 29-, and 30-foot furnaces today, from what we can find out, have higher production rates than the Russian furnaces.

The Europeans always tended to use higher blast temperatures than we did in this country. They were the pioneers in that a good many years ago. Again, you might wonder why. There is always an economic reason. In this country we were blessed with coal at relatively low cost. In Germany and on the continent in Europe, coal is an expensive commodity. As you know, we can ship coal into Europe cheaply. When I was over in Great Britain we could ship coal into Wales cheaper than they could deliver it to their own plant 15 miles from the mines. So that there was never the incentive to save fuel from the cost standpoint that there was in Europe.

But today, with labor costs in this country as high as they are, it is economic. Coal went from, say, $2 or $3 a ton delivered up to
and
$8 and $10 dollars,/iron ore, instead of costing $3 and $4 like it used to, now costs $15 , all as the result of labor. Labor is the prime cost in all of this. It's the cost in mining, it's the cost in refining, it's the cost in capital equipment. So when your labor rates go up to what they are in this country, they have put a tremendous incentive on getting costs down.

As far as ironmaking goes, there is no question in my mind that in this country we are as far ahead as eny country in the world in technology of ironmaking. I will say in Europe that Germany and France, particularly

Germany, are running blast furnaces now at 2000 and 2100 degrees blast heat, whereas in this country I think the highest blast temperature is 1900 degrees. Again, they have the incentive to double the cost of their fuels. We are coming up to them. You just can't put blast temperature in a furnace unless it's designed for it.

But, as I mentioned, in the burden preparation we have been ahead.

Now, when it comes to iron-and-steelmaking, this is a very controversial question. A lot of people say, "Well, why didn't we develop this oxygen steelmaking, which was started in Europe?" First of all, we did use oxygen in the forties and the early fifties, lancing through the doors and lancing through the roof, and the steel production from open hearths was increased by about 50 percent by oxygen lancing. But this oxygen top-lowing process, which was developed in Europe, was originally for small vessels which are not of interest to us. Secondly, at the end of World War II, and even in the fifties when the Korean War was on, this country had built a large amount of steel capacity which was brand new.

In Europe, as you know, on the continent particularly, those steel plants were wiped out, dismantled and bombed out. In fact, when I was in Germany in the early fifties they said that the best thing that ever happened to them was the dismantling of their old steel furnaces, because they were antiquated. They had to start from scratch again. So in Europe there was always the tendency to use more pig iron than there was in this country because of the shortage of scrap. So that in the European steel plants, with their old Thomas converters, which did not make the grade of steel they are making today with oxygen, they always had large amounts of blast furnaces. In the Goering works in Germany and the one in Austria, I think there were eight blast furnaces in one plant and sixteen in the other. As you went through the Ruhr you saw twice as many blast furnaces as you would see in this country, because they used more iron, they didn't have the scrap.

So, when this oxygen process came in, everybody said, "You can do this at a lower capital cost." You could do it with a lower capital cost if you didn't have to build new blast furnaces and coke ovens. But, if you had to build new blast furnaces and coke ovens, and one unit cost over $50 million, it was not an economic process.

But, in the ensuing years, as I mentioned, the technology of blast-furnace practice developed to the point where we got 50 to 100 percent increase in iron production. As soon as that was developed then we started to go into oxygen steelmaking.

I would say today that within a few years this country will be the leader of the world in the production of oxygen steel. As far as the finishing operations are concerned, there is no question that we were always the leader there, that is, after the ingot was made. There was no country in the world that was as far ahead as we were on the mechanical equipment for rolling the steel and processing it.

QUESTION: Sir, several spokesmen for the steel industry of the United States have viewed with alarm the rising imports. What is the expectation for our competitive position with Western Europe?

MR. STRASSBURGER: Of course, imports always worry any industry. There is only one answer to it. You just can't cry about it. The thing to do is get out and make your own production better and cheaper. I think that is the attitude of the industry. You have to just become more aggressive.

We do have much higher labor costs than the rest of the world, but I think you will find that everything is being done today. There is a tremendous amount of capital being put into modernization so that we can compete.

I don't think the steel industry is going to be seriously hurt by these imports as long as they maintain reasonable tariffs on them. We do have to maintain our higher standard of living in this country. There is no use going backward on that. But I think technology is going to keep us ahead.

QUESTION: The Japanese have been making great strides in the development of steel. Are they using methods similar to ours?

MR. STRASSBURGER: Fortunately, yes. At the end of World War II through the War Department, people were sent over to Japan to see what could be done in their blast-furnace practice to minimize the use of scrap. They started to use this flux cinder that I mentioned. Today the Japanese blast furnaces have the lowest coke rate in the world. There are averaging down around 900 and some coke rate. They take large furnaces and even underblow them. By underblowing them they run them at lower than capacity in order to get a slower movement of gases up through the furnace to get economy. So in their blast-furnace practice they are using the very latest practices. They are adopting the oxygen. They are using oxygen converters. They are going into continuous casting. They are going into vacuum degassing. There was one vacuum degassing unit they saw in Germany. They went back and evidently built it on their own. Then they went back to Germany and asked that company if they could buy the services of someone to tell them how to run it. So that shows how they adopted that.

There are very progressive. They are the fastest growing country in the world on steel production. There is no question about it.

QUESTION: What changes have resulted in man hours required to produce the kind of steel we use?

MR. STRASSBURGER: Of course it depends on what you finish it into. You take a plant with a capacity of 3 million tons a year, going into light rolled steel for flat rolled products. It will require about 10,000 employees. I can't give you the man hours right now, but it takes about 10,000 people to produce 3 million tons of steel a year, flat rolled. If you were producing just structurals and heavy plates, it would probably take 30 percent less. It all depends on your finished product.

The farther you go down in gage the more labor it takes. Again, with mechanization and computer controls, even that labor is being reduced today.

QUESTION: Sir, will you comment on the influence of computers on the production and distribution of steel, not only in the manufacturing process but also in the timely delivery of orders to customers?

MR. STRASSBURGER: I think first of all that computers are now being used on the oxygen converter. The whole charge is being computed on a computer. You feed in the temperature of the hot metal analysis and you get the amount of scrap you should charge and the amount of flux. Information is now being gotten to actually control the oxygen blowing, the time, and all of that. So that is all under computer control. There are blooming mills and slabbing mills which are computer controlled. We have an 80-inch hot mill at our Detroit plant which is probably the fastest mill in the world today. By the way, the Japanese duplicated it. It is completely computer controlled. You can go up into the pulpit and you can push one button and the mill is controlled all the way from the furnace right through to the coiled steel.

There is no question that computer control, while it doesn't save much labor, gives much better control. It controls gage automatically. If the gage tends to waver a little bit the computer picks it up right away. It's a big improvement.

As to the commercial end, I haven't been in on that, but I know that the computer is being used and will be used more and more in the control of inventories and getting the distribution taken care of. I believe that the use of computers will expand many fold over what it is today. We are just breaking the ice right now.

QUESTION: Mr. Strassburger, in view of the new production process with the attendant capital investment required and the investment in raw materials per ton of steel, do you see any change in the competitive position of iron in industry and perhaps a resurgence of small companies making lower investments?

MR. STRASSBURGER: Yes, some of these new technologies will allow some of the underdeveloped countries to go into iron and steel making without the large investment they have had to use before. In other words, instead of going into coke ovens and the use of metallurgical coal, it is possible for them to minimize the use of these fuels which they do not have and to go into smaller units.

There is no question that it is getting more economic to use smaller units than it was, say, 10 years ago.

Does that answer your question?

STUDENT: What about the United States? Will there be any change in the competitive position of the large companies?

MR. STRASSBURGER: Well, I think that today the smaller company has just as good a competitive opportunity as they ever had. I mentioned the scrap situation. In the fifties the scrap went as high as $60 or $65 a ton, when normally it was selling for around $40. Today scrap is selling for #25 to $30 a ton. So, as these big companies put in the tremendous investment for these new oxygen steel processes, which minimize the use of scrap, some small outfit can put in electric furnaces and go on a 100 percent scrap charge and be competitive. That is what is happening.

It's always a matter of economic balance.

QUESTION: With new processes coming out, the wages expected, and the make-rules and so forth which steel fought to a draw not too long ago, do you anticipate that this will be a big issue coming out in the labor-relations situation?

MR. STRASSBURGER: Because of these new technologies? I do not think so. I think that the people in the steel labor union realize that, if we are going to maintain our industrial superiority and keep our industry rolling, we have to keep modern. David McDonald has already mentioned that. He has come out in favor of automation, not against it. It's the same in the coal industry. John Lewis recognized that years ago. He would rather have fewer men in the union and have them earn a living wage or a good wage, than to have more men and have them starving. That's why the coal industry in this country produces 3 to 4 times the amount of coal they do in Europe, because we mechanized. They are starting to mechanize over there.

You can't stop progress. That's been the history from the time of the first mechanical device. This question of automation is not new. It was brought up years and years ago.

QUESTION: You mentioned manganese nodules on the ocean floor. Do you know of any companies that are trying to develop the mining of these nodules? If so, what is the progress?

MR. STRASSBURGER: I do not know right now of any doing that. I would say that, just as we are getting oil offshore, as time goes on it is a matter of equipment for mining on the ocean floor, and that will be developed as soon as the necessity makes it economic.

QUESTION: Sir, would you give us some idea of the quality of steel that is produced in the United States and in other countries, and the effect of this quality on the imports into the United States?

MR. STRASSBURGER: Actually the steel that has been imported into this country up until recently was a lower-grade steel--for example, concrete reenforcing bars, fencing wire baling wire, and steel of that type were the imports coming into this country a few years ago. It had quite an impact on the mills that were producing those products in this country. They were the cheapest types of steel.

As far as the flat rolled products were concerned, until the countries in Europ and Japan started to put in modern hot strip mills and cold mills, there was very little of that material being shipped in, but recently there is. On the West Coast there are galvanized sheets coming in and some cold rolled steel, and on the East Coast there are some flat rolled products.

I would say that their quality is as good as ours, but no better.

QUESTION: I have two questions. What do you expect in the way of a reteil price decrease due to the new technology? And why do we import about 15 percent more manganese than we use?

MR. STRASSBURGER: To give you the second answer first, I think the reason that we import is that there has been a buildup of inventory on manganese. It is something we are short of, and there is the tendency in some years to build up inventories on that. I think that is the reason for that. As you know, that has been stockpiled.

As far as the price decrease is concerned, there have been some adjustments in price, but the price of steel has been relatively stable, as you know. In other words, if you look at the index of steel you find that it has advanced only 2 percent in the last 5 years, but labor costs have gone away up. So that actually the new technologies are allowing us to take care of higher labor costs with the same pricing.

I do not look for any real reduction in the price of steel. The history of the economics of the country has been a small amount of inflation year by year, so that, if the steel price has kept constant I think that is a good accomplishment.

QUESTION: Sir, certain labor spokesmen have said with regard to unemployment that industry has a great deal of unused capacity. What is the nature of any of the unused capacity in the steel industry? Is it economic?

MR. STRASSBURGER: Well, as we modernize our plants, naturally the incentive is to use the lowest-cost equipment. So the unused capacity is usually the equipment that will require higher cost than the new equipment. So I would say that the steel industry today is operating at 70 percent of its ultimate capacity, but I would say that the 70 percent that is operating is the most efficient. You might have seen that the profits of steel have been up relatively good this year, because they have spent a lot of money on modernization and are starting to get a payback on this new equipment.

QUESTION: Sir, theoretically slag dumps should serve as stockpiles for metals, so that North America can consequently become self-providing. As the industry made any progress in the economic reclaiming of metals from dumps?

MR. STRASSBURGER: I know that the slag dumps are a source of manganese. During World War II and even afterwards there was considerable work done with government authorities such as the Bureau of Mines and experimental stations in order to get manganese out of slags. It can be done, but it is considerably more costly than the importation of manganese orees. But there is no question that that process should be developed further so that in case of emergency, when cost is no object, we could do it.

Right now it is not economic. It is too low a grade material compared to the natural ore.

QUESTION: Sir, in some of the recent literature one can read that there seems to be a serious challenge to steel from the nonferrous metals, such as aluminum. What has the industry done about this?

MR. STRASSBURGER: There is no question that there is always competition, and plastics and the nonferrous metals are threatening some of steel's profits. The only thing we can do to combat that is to make better steel and keep the price down.

Naturally, as these new commodities are developed they make inroads into our markets. At the same time we think we can make inroads into the other markets as time goes on. When something new is developed, if it does the job better there is no use in trying to evade it. You might lose markets in certain commodities but you'll gain them in others.

I would say that the main result of the development of these plastics and nonferrous metals is that I believe that the rate of steel production is not going to increase nearly as much as was forecasted several years ago. In other words, it is going to flatten out a little more than they anticipated.

It does have a definite impact.

QUESTION: There has been some comment that the steelmaking process is rather wasteful of certain of our national resources, notably water. The newer mills have gotten it down so that the steel company uses relatively few gallons of water, but the older mills use tremendous amounts. Is this a serious problem?

MR. STRASSBURGER: That is rather a difficult question to answer. Let's put it this way. If it is necessary to keep the consumption of water down it can be done. The Fontana Mill is a shining example of that. They get their water out of deep wells, and I believe they operate the mill on 5,000 gallons of new supply a minute, whereas a mill in the East might use 20 times that much. Even today we are trying to control discharges into the rivers, and we are using cooling towers and recirculating our water. Where water is used purely for cooling, we can see no reason why, if we have plenty of water available, and it costs less to pump fresh water, cooling water cannot be used in large quantities.

If you did not have the water, then you would have to recirculate it. If it is a matter of pollution, there is no question that we are recirculating those waters that contain acids and oils, and we are working very hard on ways to do that purification.

QUESTION: Sir, on the utilization of barter agreements overseas to procure these rare minerals, do you think we are doing enough in this country to barter agricultural products?

MR. STRASSBURGER: I think that if we are going to try to help these underdeveloped countries, it certainly is to our advantage to obtain the materials that we are short of in exchange for our agricultural products, rather than to provide, let's say, money. It is better to give what we have in excess for them.

QUESTION: You mentioned $16 a ton average cost. What percentage of any steel cost is attributable directly to labor?

MR. STRASSBURGER: I think the $16 I mentioned was the cost of iron ore delivered to some of the Lake plants in that area, in the Pittsburgh area. That's just the cost of the ore delivered. What percentage of that is labor? I would say that 80 percent of it can be traced back to labor. When you come right down to it, even your big shovels that are used out there in making the shovels use labor. If you go all the way back, labor is the biggest item in any cost. The actual material that goes into it, and even the fabrication of that material takes labor. So the labor cost is very great in these commodities.

QUESTION: Would you comment on the importance of the St. Lawrence Seaway Project to the steel industry?

MR. STRASSBURGER: The St. Lawrence Seaway is the avenue of transportation for bringing the iron ore and the concentrates and pellets from the Canadian mines in Labrador and Quebec into the Lake region, which is Cleveland, Chicago, and down into Pittsburgh. If you could not bring it in that way that material would have to be brought down to Philadelphia, Baltimore, and New York, and then transported across the country.

So that the St. Lawrence Seaway is a much shorter route. If it all had to be brought down the Atlantic Coast I do not believe we would have the rail equipment at this time, in case of emergency, to bring it inland to the steel plants. So it allows us to handle the Canadian ores in bulk carriers and at much lower cost than we could do it otherwise.

QUESTION: Is there any future for a coal pipeline in the steel industry?

MR. STRASSBURGER: I do not think that the coal pipeline is going to be of any real advantage to the steel industry unless we get into this new method of making coke. As far as the coke ovens are concerned, you do not want to have too wet a coal going into the coke oven--just 5 or 6 percent moisture. So you would have to grind this coal. I don't think this would be economic now.

In the other process you do have to grind it so that you would have it ground. But I don't think that the coal pipeline has the potential for the steel industry that it has for the public utilities. I don't think that it would come in there.

We have looked into that. Consolidation Coal developed the pipeline, and this is one of the companies we are closely associated with. We have even looked into the injecting of coal slurries into a blast furnace. On this Bureau of Mines furnace we recently injected Wyoming coal, which is 20 percent moisture. In a coal slurry you would have a little over 30 percent. The result of this experimental work shows that the 20 percent moist coal definitely was limited in how much you could inject, compared to a coal with only 5 or 6 percent moisture.

So I don't think that it has a really big potential.

DR. WORLEY: Mr. Strassburger, thank you for leaving the climate of Arizona and coming here as our consultant today.