

20 September 1948

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PROBLEMS OF MATERIAL SUPPLIES IN  
STEEL PRODUCTION

20 September 1948

MR. HALLECK A. BUTTS: General Holman, guests, good morning, gentlemen. Today we shall devote our attention to that part of the course in resources which deals with the important requirements of the iron-and-steel industry. The importance of the industry is so well known that we won't talk about that, but we must consider the political and economic changes that have occurred since the conclusion of the war. We are not necessarily "viewing with alarm"--but we should reappraise, in the light of present events, the potential of our iron and steel industry.

We, as customers endeavoring to buy consumer goods, have been told occasionally that we could not have them; and the answer has been, sometimes, that it was due to a shortage of steel materials. A little further evidence of that, of course, is the publicity regarding the gray market. Also, we have undertaken a large responsibility in the European Recovery Program, which calls for millions of tons of steel. They are asking for pig iron and scrap, and there is a demand for mining and agricultural machinery. It is a rather formidable sum if totaled up.

So it is evident that the iron-and-steel industry has some problems regarding its supplies and materials. Mr. Charles Parker, of the American Iron and Steel Institute, whose biography has indicated to all of you his excellent qualifications to discuss this subject, will talk to us this morning and will be with us again in our seminar this afternoon. Our subject is "Problems of Material Supplies in Steel Production."

It is my pleasure to introduce to you, Mr. Charles Parker.

MR. CHARLES M. PARKER: Thank you, Mr. Butts. Good morning, gentlemen. I feel very happy to have received the invitation to address this class. I have worked hard on this paper. I am sorry that it contains so many numbers, but I understand that you will each receive a mimeographed copy of it.

There is one thing I would like to impress on you. Each time that your heart beats and pumps five ounces of blood, the steel industry is producing 29,000 pounds of steel.

The problem of procuring adequate supplies of raw materials for the steel industry in peace and war has been discussed extensively during the past few years by many people of varied interest, intent and competence.

The arrays of statistics presented have varied, naturally, one from the other according to the specific premises upon which the compiler based his argument, the authorities (real or pseudo) consulted, and the general school of political or economic thought or both, to which the compiler belonged.

In discussing raw material problems with you today, I am going to make some assumptions and reservations and take some exceptions to ideas which are presently current relative to steel production and its concomitant raw materials problems. In doing so, I shall endeavor clearly to explain each premise, assumption, reservation or exception so that you may intelligently evaluate any conclusions that I may draw.

My first assumption is that in the next five years there will be no revolutionary changes in the presently known methods of producing coke, blast furnace hot metal, or liquid steel. And I intend that statement to concede that the steel industry will continue to expand its use of high pressure blast furnaces and oxygen in steelmaking, and possibly to use oxygen in blast furnaces and bessemer converters. But the fundamental processes will remain largely as they are.

As a corollary to part of that assumption, I take exception to statements or predictions that the sponge iron process will be used in the near future as a tonnage producer of iron as a raw material for steelmaking.

One such statement is as follows:

"Sponge iron can be used in steel furnaces as a substitute for scrap. While costs of production have been prohibitive in the past, a continued shortage of scrap accompanied by higher scrap prices would make the use of sponge iron economical." 1/

That statement is inaccurate in its first premise except in so far as minute quantities of sponge iron made from carefully selected exceptionally high grade raw materials have been successfully used for special purposes. General experience has been as follows: 2/

"Extensive experiments have been made on the use of sponge iron as part of the metallic charge in open-hearth furnaces. The oxidizing nature of the open hearth furnace causes high losses of iron in the slag and the high content of siliceous materials in the sponge iron greatly increases the slag volume. Both of these factors result in slowing down the rate of steel-making and increasing the consumption of labor, fuel, refractories, and flux. The suggestion has been made that sponge iron briquettes be melted in a cupola. Aside from the fact that oxidation losses would be high, slag volume greatly increased, refractories consumption much larger and coke requirement raised, the idea

1/ National Resources and Foreign Aid. Report of J.A. Krug, Secretary of the Interior. October 9, 1947.

2/ Report of the Advisory Committee on Metals and Minerals of the National Academy of Science to the War Production Board on the Madaras Process for the Production of Sponge Iron, July 7, 1942.

has no theoretical advantage over the blast furnace, except that part of the coke is replaced by natural gas. The sponge iron could be charged to the iron blast furnace to increase output per furnace, but this procedure also has no theoretical advantage over the straight blast furnace process.

In a paper read before the General Meeting of American Iron and Steel Institute in May of this year, Earle C. Smith, Chief Metallurgist, Republic Steel Corporation,<sup>1/</sup> also refutes the statement relative to the use of sponge iron and, in addition, suggests a successful alternate.

"An actual heat of steel made with no scrap gives an indication of the real power of the open hearth process to provide for direct reduction. A heat made in Republic Steel Corporation's Cleveland District in 1942 charged 437,530 pounds of hot metal, and also handled 90,910 pounds of Cliff Shaft lump ore, and 37,000 pounds of 66.5 percent Fe magnetite sinter. Think the figures over! A single heat reduced 57 tons of ore in 9 hours and 40 minutes. Only the Krupp-Renn furnaces handled more tons per hour and the Krupp product was not steel, not even desirable melting scrap."

The Krupp-Renn furnaces were originally designed to reduce nickel from lean silicate ores, and they were successful. Adapted to sponge iron production, units were built at the Hermann Goering works in Germany. The relatively small quantity of metal produced by those furnaces commonly contained 0.50 percent sulphur, and up to one percent phosphorus, exceedingly poor melting stock according to American standards. Basic pig iron, mainstay of the basic open hearth process, contains only one-tenth of the sulphur and two-fifths of the phosphorus contents credited to the Krupp-Renn process.

Many steel companies have developed less drastic procedures than the foregoing which make possible the use of substantial quantities of iron ore to replace scrap in the open hearth. Clyde Denlinger, Superintendent of the Steel Division, Bethlehem Steel Company, Lackawanna, N. Y.,<sup>2/</sup> in discussing open hearth charge ores generally, gives data from 43 open hearth shops which confirms the Smith data and also the feasibility of using the open hearth furnace as an economical means of direct reduction.

1/ Experience to Date on Iron Production by Methods other than Coke Blast Furnace; Direct Reduction. Earle C. Smith. Yearbook, American Iron and Steel Institute. New York, 1948.

2/ Open Hearth Charge Ores. Clyde Denlinger. Yearbook, American Iron and Steel Institute. New York, 1945.

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In using iron ore in this fashion, high grade lump ore is necessary and about one pound of coke must be charged for every three pounds of ore in order to promote the necessary chemical reactions. Because of the additional quantity of cold materials charged into the furnaces the time necessary to manufacture a heat of steel is increased about 4 percent. Otherwise operations are normal.

There is another aspect of the problem which is all too frequently overlooked by proponents of direct reduction processes. If any such process were to be developed in the near future which was competitive with the blast furnace either technically or economically, or both, we should still have to operate every coke oven available in order to secure the coal chemicals so vital to the public health and welfare and to industries other than the steel industry.

We should then be confronted with the problem of disposing of some 50 million tons of coke. Synthetic chemistry is not yet ready to handle amounts of carboniferous materials which remotely approach that figure, but coke could be used on a large scale for power production with minor changes in existing equipment. Some day these relationships may change; it would be foolhardy to say that they will not, but such a change will not come soon. I think, therefore, that we are justified in studying our raw materials requirements from a conventional point of view.

As of 1 January 1950, it is expected that the steel industry of the United States will have capacity to produce 64.8 million net tons of by-product coke, 70 million net tons of pig iron and blast furnace ferroalloys and 96 million net tons of ingots and steel for castings. The net or short ton of 2,000 pounds will be used generally throughout this discussion, and all statistics direct or derived not otherwise credited are from annual statistical reports of American Iron and Steel Institute. Only slide rule accuracy is assumed; figures given, except actual production records, are rounded off and are of the correct order of magnitude; they are used only to convey ideas.

The metallics to produce such a quantity of steel must be derived from blast furnace iron and scrap--there are no other sources. The necessary scrap must be a combination of home scrap, that is scrap arising within the steel industry as a result of manufacturing operations, and purchased scrap. The quantity of home scrap available for recirculation depends to a high degree on product mix and the kind of specifications to be met within each category of product. Product mix is the term used to describe the tonnage produced of the various products such as plates, shapes, bars and sheets, and the relationship they bear, one to the other. Yield of useable

product from ingots varies, the yield of carbon steel bars is approximately 75 percent; of alloy steel bars 67 percent; and of stainless steel bars, only 65 percent. For the purposes of this discussion, I have assumed conditions similar to the years 1943 and 1944 in order to give my calculations a bias toward war emergency conditions.

I have chosen those years, too, because they embrace the high tide of much military development and construction, and in the absence of better information as to weapons and material, theatres of operation and style of combat they provide a working basis for estimate. Moreover, they were years in which many other industries competed with the steel industry for raw materials and manpower.

The blast furnaces of the steel industry provide hot metal and certain ferroalloys for steelmaking, and pig iron for the foundry industry.

To produce at full capacity, that is 70 million tons of pig iron, blast furnaces in 1950 will require 66.5 million tons of coke based on the 1947 consumption of 0.950 ton of coke per ton of iron. That consumption figure is up 5.5 percent since 1943 and 7.1 percent since 1938. The trend has been so steadily upward for the past ten years that it would not be safe to predict more than a reduction in the rate of increase or a halt in the increase. I have chosen to assume only a halt in the increase.

Steel producers are taking steps which are designed to improve that situation. Those steps include more selective mining and blending of coal, washing of coal, more selective mining and classification of iron ores, and an increased use of sintered ores. In addition, increased use of pressure top blast furnaces holds promise of increased production of iron and decreased consumption of coke.

In operating a blast furnace under high static top pressure, the amount of air or "wind" is increased approximately 18 percent over normal operation, top pressure is increased substantially by throttling the exhaust gases, and blast pressure is increased about 34 percent. Iron production is increased 11 to 20 percent, coke consumption is decreased about 13 percent and flue dust is decreased 30 percent.<sup>1/</sup>

Prior to Pearl Harbor, and in the early days of World War II, the question of increasing blast furnace output from existing furnaces by the use of dry blast was a subject of discussion by the Institute Committee on Manufacturing Problems. In operating a furnace with dry blast, moisture is removed from the blast by refrigeration, the theory being that the moisture tends to retard chemical reactions and wastes coke in decomposing the moisture.

<sup>1/</sup> Operation of the Iron Blast Furnace at High Pressure. J. H. Slater. Yearbook. American Iron and Steel Institute, 1947.

Strong pressure for more pig iron during the war influenced a number of steel producers to install dry-blast apparatus before facts or figures could be developed by pilot installations.

The Committee on Manufacturing Problems has followed the results of those installations with interest and hope, but to date no reliable information has been developed to prove that any benefit has come from their use, particularly in the steel producing sections of Northern United States. In fact, some plants have abandoned them to save the apparently useless expense of operation and maintenance.

In order to secure the 66.5 million tons of coke required for capacity operation of blast furnaces in 1950 it will be necessary to provide 94 million tons of coking coal; approximately 66 million tons of high volatile, and 28 million tons of low volatile.

The yield of coke from coking coal was 70.7 percent in 1946, 70.8 percent in 1943 and 70.7 percent in 1938.<sup>1/</sup>

It is apparent that although the yield of coke from coking coal has remained almost constant the quality of coke has deteriorated. The ash content of coke has increased from about 6 percent to about 12 percent, because the best coal has been mined and mechanical mining and loading bring more debris to the surface. Moreover, larger quantities of strip-mine coal are being used. In addition, the sulphur content of coking coals has risen and the mechanical properties of the resulting coke, its size, porosity and ability to bear the burden of ore and limestone have deteriorated.<sup>2/</sup>

That means that additional limestone must be used to flux off the impurities in the ore, a fact reflected in the statistics. In 1944, an average of 778 pounds of limestone was used per ton of pig iron produced. By 1946 that figure had risen to 812 pounds, an increase of 4.3 percent.<sup>3/</sup> For 1947, limestone consumption was 824 pounds per ton of iron, an increase of 5.9 percent over 1944 and 18.7 percent over 1938 when 694 pounds were used. Incidentally production of 70 million tons of blast furnace products would require 29 million tons of limestone; to produce 96 million tons of steel would require an additional 6 million tons and one million tons of dried lime.

In order to save time in open hearth practice and thereby increase the number of heats tapped per month per furnace, and also to conserve raw water resources, the Committee on Manufacturing Problems intensified work done at Corby in England on the desulphurization of hot metal<sup>4/</sup> and also proposed some new approaches to the solution of the problem.

<sup>1/</sup> Minerals Yearbook, U.S. Department of the Interior. Bureau of Mines. Government Printing Office 1939, 1945, 1947. Washington, D. C.

<sup>2/</sup> Steel Facts, No. 88. February, 1948. American Iron and Steel Institute, New York.

<sup>3/</sup> Ibid.

<sup>4/</sup> Development in Production Metallurgy of Iron and Steel. George B. Waterhouse. Yearbook. American Iron and Steel Institute, New York, 1947.

The quantity of sulphur and silicon delivered to the open hearth in hot metal materially affects furnace practice and performance. If sulphur is high, that is in excess of 0.050 percent, (the limit set by many specifications for steel) a larger limestone charge is necessary to flux off the sulphur. That causes the formation of a heavier than normal blanket of slag on the molten steel which in turn reduces heating efficiency and therefore increases fuel consumption. It is obvious that these two conditions also affect transportation problems.

A method of treating hot metal with granulated soda ash was developed which reduced the sulphur content of the iron by 30 percent.

The problem of removing excess silicon from hot metal is analogous to the problem of removing sulphur. Excess silicon requires heavy limestone charges to prevent the acid-forming silicon from attacking the refractories of the basic open hearth furnaces. Moreover, larger quantities of low silicon iron can be charged thus improving furnace practice and yield. Melting is also more consistent because extremes in composition are generally not encountered, but if they are, more efficient use can be made of off-grade hot metal because high and low sulphur, silicon and manganese contents can be mixed and treated successfully.

A method of using mill scale, the iron oxide resulting from rolling mill operations, to reduce the silicon content of hot metal was developed. The reaction is very rapid oxidation of silicon and reduction of iron, equivalent to the first minute of a bessemer blow. The manganese reduced is recovered by using the slag formed during the reaction in the blast furnace. More than 98 percent of the casts treated come within 5 points (0.05 percent) of the desired percentage.

The increased impurities in coking coal and the increase in limestone consumption decrease the quantity of air which can be blown into a furnace, because of the poor physical condition of the burden such as reduced porosity and small particle size. This, in turn, reduces the reactions within the furnace with consequent loss of production. Some furnaces have reported "wind" reduction as high as 7 percent.

In addition to the coke used in blast furnaces the steel industry uses coke in its foundries, for steaming and heating purposes, for sintering, and for a multitude of miscellaneous purposes. Such use of coke would amount to an additional 1.8 million tons which would require 2.5 million tons of coal.

In addition to coking coal the industry would require for the production of 96 million tons of ingots some 15 million tons of coal for steam, gas, intraplant transportation and many miscellaneous purposes.

To recapitulate, then, the steel industry would require 111.5 million tons of coal to produce 96 million tons of ingots, and 70 million tons of pig iron and blast furnace ferroalloys.

That figure of 111.5 million tons should be looked at with a great deal of scepticism, however, because it represents only a part of the fuel and energy requirements of the industry. In 1944, for example, the year of its highest production, the steel industry consumed 2.06 billion gallons of fuel oil, 202 billion cubic feet of natural gas, 308.5 million gallons of tar and pitch and 12 billion kilowatt hours of purchased electricity.

The industry's energy requirements for metallurgical and manufacturing purposes were, then, distributed as follows:

ENERGY REQUIREMENTS FOR STEELMAKING

<u>Source and Quantity</u>	<u>Btu Value/</u>	<u>Total Btu</u>	<u>Percent</u>
		<u>10<sup>12</sup></u>	<u>of total</u>
Oil 2.06 billion gal.	140,000/gal.	286.4	9.5
Coal 94.2 million tons	14,000/lb.	2,637.6	87.5
Nat. Gas 202 Billion cu. ft.	950/cu.ft.	19.2	0.0
Tar & pitch 308.5 Million gal.	160,000/gal.	49.4	1.6
Purchased elec. 12 billion Kwh.	3,411/Kwh	41.0	1.4
		<u>3,033.6</u>	<u>100.00</u>

Those figures do not include energy requirements for mining and general transportation.

If for any reason, the industry should be required to reduce its consumption of fuel oil, natural gas and tar and increase its use of blast furnace gas, coke oven gas and producer gas, a load might very well be imposed upon the coal mining and transportation industries which they might be unable to bear. Producer gas, for example, delivers 142 Btu per cubic foot; blast furnace gas 95 Btu per cubic foot.<sup>2/</sup>

1/ The Making, Shaping and Treating of Steel, Camp and Francis. United States Steel Corporation, Pittsburgh, Pa., Fifth Edition 1940.

2/ Ibid.

In addition, steel production might suffer severely because the present degree of efficiency of the industry is made possible only by the current combination and balance of fuels, each of which differs from the other markedly in efficiency regardless of Btu value.

Average thermal requirements for melting steel in open hearth furnaces vary with many conditions surrounding the melt. It is reasonably safe, however, to assume an average requirement of 4.5 million Btu/ per ton of open hearth ingots. Total heat and energy requirements of the industry referred to production of ingots and steel for castings as a statistical base are approximately the equivalent of 1.2 tons of coal per ton of steel.<sup>2/</sup>

Incidental to a survey of heavy tonnage fuels, the electrode consumption of electric furnaces should also be considered. Average consumption of graphite electrodes is 12 pounds per ton of electric furnace ingots. Based on complete utilization of an electric furnace capacity of 5.4 million tons consumption of electrodes would be 32,400 tons, not an inconsiderable figure.

In 1943 the industry shipped to foundries 17.6 percent of its production of pig iron. What might be shipped in the future under emergency conditions is at best an estimate. Advances which have been made in foundry techniques and in the development of cast irons and steels for special purposes lead me to believe that the quantity of iron shipped to foundries will increase rather than decrease. On the other hand, while my colleagues agree that the production of cast ferrous metals will increase many of them feel that the necessary iron units will be derived essentially from scrap. I shall therefore analyze requirements from both points of view.

First, let us assume that 20 percent of total maximum pig iron production, 68 million tons in 1950, is shipped to the foundry industry

The Making, Shaping and Treating of Steel. Camp and Francis, United States Steel Corporation. Pittsburgh, Pa., Fifth Edition, 1940.

"In general comment on the use of fuel in American iron and steel practice, we were surprised to learn on apparently good authority that in Germany, Belgium, and France considerably greater economy of fuel in the best steel plants is obtained than in America. We were told at several plants that the total use of fuel was practically one ton of coal per one ton of ingots. We did see more fuel saving applications in Europe than we see in America. Fuel has been relatively dear and labor cheaper in Europe. We know their use of manpower per ton of ingots has been much higher. In the future we will undoubtedly see more effort along the latter line in Europe." Personal communication from R. J. Wyszor, National Security Resources Board.

(allowing for production of 2 million tons of blast furnace ferroalloys), or 13.6 million tons of iron. There would then be left some 54.4 million tons of hot metal to charge into steelmaking furnaces.

Incidentally, the iron shipped to the foundry industry would require 26.4 million tons of scrap at foundries based on 1943-4 ratios of 66 percent scrap, 34 percent pig iron and approximately 8.9 million tons of coke (nearly 12.6 million tons of cooking coal.)<sup>1/</sup>

To reach capacity production of ingots and steel for castings, open hearth furnaces, electric, and bessemer converters would have to be utilized fully. The 96 million tons of capacity is divided approximately as follows:

Open Hearth	85.3
Bessemer	5.3
Electric	5.4

In production of bessemer steel it is possible to use only 6.5 percent scrap while in electric furnace production it is desirable that the metallic charge consist of about 97 percent carefully selected scrap and 3 percent pig iron.

To maintain most efficient operations, then, would require 5.6 million tons of hot metal and 0.4 million tons of scrap for bessemer converters and 5.6 million tons of scrap and 0.2 million tons of pig iron for electric furnaces.

The foregoing iron tonnage for converters is predicated on a yield factor of 88 percent hot metal to ingots. For electric furnaces the yield is 93 percent.

There would then be left to charge into open hearths about 48.6 million tons of pig iron. The loss in converting pig iron to steel is approximately 10 percent. That loss consists chiefly of the elements carbon, phosphorus, manganese and silicon which pass into the slag or are otherwise lost, and iron lost as iron oxide in the slag.

Effective iron units delivered from open hearth furnaces and derived from pig iron are, therefore, 43.8 million tons. It would appear then, that the scrap necessary to produce 85.3 million tons of open hearth ingots and steel for castings is 45.2 million tons based on a metallic yield from scrap of 90 percent.

<sup>1/</sup> Minerals Yearbook. U.S. Department of the Interior. Bureau of Mines. Government Printing Office. 1944. Washington, D. C.

	<u>Scrap</u>	<u>Pig iron or hot metal</u>
Open hearth furnaces	46.2	48.6
Electric furnaces	5.6	0.2
Bessemer converters	0.4	5.6
<u>Credit for ferroalloys</u>	<u>2.0</u>	
Blast furnaces	2.1	-
Foundry industry	<u>26.4</u>	<u>13.6</u>
	78.7	68.0

To recapitulate, to produce 96 million tons of ingots and steel for castings would require 50.2 million tons of scrap and 54.4 million tons of pig iron.

I have not attempted to account specifically for the metallics yielded from 2 million tons of ferroalloys because to do so would complicate the calculations and unduly extend the discussion. I am attempting to define the approximate limits of the entire problem and to emphasize its magnitude. Therefore, I have credited the ferroalloys to scrap to reconcile the calculations.

If shipments of pig iron to foundries were reduced to 10 percent of total iron production or 6.8 million tons of pig iron, then the scrap required by the steel industry would be reduced to 43.4 million tons and that required by the foundries would be increased correspondingly.

If the 50.2 million tons of scrap required under the first premise were 64 percent home scrap and 36 percent purchased scrap according to the 1943-4 pattern, we should have requirements of 32.2 and 18 million tons respectively. <sup>1/</sup> The purchased scrap total is very close to the purchased scrap average of 16.9 million tons for the years 1941-6 inclusive.

<sup>1/</sup>"The ratio of total scrap to total pig iron consumed in all types of furnaces for the last 10 years has fluctuated in a very narrow range, averaging about 51 percent scrap and 40 percent pig iron. The total scrap consumption in the iron and steel industry for the period, 1941-1947, inclusive, averaged over 52,000,000 tons per annum, of which about 55 percent was home scrap and 45 percent purchased grades."  
 R. J. Wisor in Ferrous Scrap Report, National Security Resources Board. Washington, D. C. July 1, 1948.

In 1943-4 home scrap comprised 34.3 percent of ingots and steel for castings. Applying that same percentage to 96 million tons gives 32.9 million tons. It would appear, therefore, that purchased scrap might be reduced by some 0.7 million tons and still provide adequate metallics. It would be dangerous, however, to rely too heavily on that conclusion. It should be noted here also, that the foundry industry would simultaneously be in the market for large quantities of scrap as previously noted.

We can now calculate the quantity of iron ore necessary to produce 68 million tons of pig iron and 96 million tons of ingots and steel for castings.

For 1947 the quantity of iron ore consumed in blast furnaces was 1.748 tons per ton of iron produced. That represents a decrease of 3.4 percent over 1942 the 10 year peak and an increase of 2.5 percent over 1939 the 10 year low consumption year. However, in 1942 scrap of 68 pounds per ton and cinder and scale of 248 pounds per ton were charged while in 1939 scrap comprised 76 pounds and cinder and scale 296 pounds.

For 1947 scrap had decreased to 60 pounds largely because proper grades were not available, and cinder and scale to 254 pounds. Large quantities of mill scale are being used to reduce the sulphur content of hot metal before charging into open hearths. Once again, it is not safe to assume that the use of iron ore will show a downward trend in the near future although the rate of rise may be checked by beneficiation and use of sinter. The silica content of ore has increased slightly - about one percent - and the iron content is down slightly - about one-half to one and one-half percent. In addition suitable grades of scrap are not being made available as they were in the past. Many manufacturers which operate foundries have learned how to use advantageously in their cupolas both their own and purchased turnings and berings and iron and steel scrap and probably will continue to do so for economic as well as technical reasons.

On the other hand, it does not seem likely that the quantity of ore consumed per ton of pig iron will increase substantially. Therefore, we may safely set our consumption figure at 1.75 tons of ore per ton of iron or 119 million tons for capacity operation of blast furnaces in 1950.<sup>1/</sup> Of that quantity 85 percent would have to be secured from the lake region.

In addition to the ore used in blast furnaces 6.4 million tons of open hearth ores would have to be provided for normal steelmaking practice.

If the open hearth furnaces were to be used as partial direct reduct units than that quantity of ore would have to be increased substantially. Assuming that the practice suggested by Smith and confirmed by Denlinger

<sup>1/</sup> See Appendix A.

were to be used throughout the industry in conjunction with oxygen in open hearth furnaces and assuming that a maximum direct reduction amounting to 15 percent of open hearth capacity were achieved, we should have increased total ingot capacity to 108.8 million tons and increased open hearth ore usage to 31.4 million tons assuming a 51 percent iron content in the ore used; a conservative figure, incidentally, for open hearth grades. We should not, however, increase consumption of blast furnace ore or scrap. Consumption of coke would be increased by about 8.9 million tons (11.7 million tons of coking coal.)

There is grave doubt, however, that the necessary quantities of open hearth ore are available. Even now some steel companies find it necessary to go as far afield as Venezuela and Sweden to secure proper grades of ore for open hearth use.

That use of oxygen, however, presents a problem. To produce the quantity of oxygen contemplated in the present state of the art, an average of 7,200 cubic feet per open hearth heat,<sup>1/</sup> would require the use of about 15 Kwh of electricity,<sup>2/</sup> for every 1,000 cubic feet of oxygen, or 54 million Kwh assuming open hearth heats of 200 tons each. If oxygen were used generally in electric furnaces in the production of stainless and alloy steels there would be required 164 cubic feet per ton<sup>3/</sup> of electric furnace steels, and, assuming 60 ton electric heats, power requirements for oxygen would be 0.22 million Kwh.

Therefore, total power requirements for oxygen would be 54.22 million Kwh.

It may, therefore, be a rather tight decision as to whether oxygen is to be secured from iron ore, provided suitable grades for open hearth use can be found, or from electrical energy, because of possible local excess loads on power generating facilities.

Next to iron, manganese is the most important element which is found in all grades of steel. As a deoxidizing agent and as a checkmate to the harmful effects of sulphur it has no substitute. Unfortunately, its nature is such that there is no important quantity returnable from scrap to assist

- 1/ Some Practical Aspects of Direct Oxidation in the Basic Open Hearth Process. Frank G. Norris and Edward B. Hughes. Yearbook, American Iron and Steel Institute, New York. 1948.
- 2/ Tonnage Oxygen for Increased Iron and Steel Production. Julius H. Strassburger, Ibid.
- 3/ Use of Oxygen for Decarburization and Melting in Electric Furnaces. J. H. Biseman, Ibid.

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in relieving shortages and even the most effective conservation measures can do little to extend the life of stocks on hand because its proper and adequate use is essential to maintain steel quality.

About 92 percent of all manganese is used in steelmaking; about 5 percent in chemical uses, chiefly dry battery manufacture; and the remaining 3 percent is used in nonferrous metal manufacture and for miscellaneous uses in the glass and ceramic industries.

In order to produce 96 million tons of ingots and steel for castings, to provide for the foundry industry, and to maintain safe working inventories, it will be necessary to provide about 750,000 tons of standard 80 percent blast furnace ferromanganese, 183,000 tons of spiegeleisen and 300,000 tons of blast furnace ferrosilicon. In addition there would be required 33,000 tons of electric furnace ferromanganese of low and medium carbon grades, 510,000 tons of electric furnace ferrosilicon and between 200,000 and 225,000 tons of other ferroalloys which are produced outside the steel industry.<sup>1/</sup>

The quantity of manganese ore necessary for all metallurgical purposes including the foregoing as related to production of ingots and steel for castings would be 0.0161 ton (32.2 lb.). Therefore, production of 96 million tons of ingots and steel for castings reflects a requirement of about 1,550,000 tons of ore, 90 percent of which must come from foreign sources.<sup>2/</sup>

As you know, such a high degree of dependency on foreign sources has been a matter of concern for many years. (See Appendix B). The threat to the nation's stockpile of manganese ore which occurred during World War I led to experiments with the use of electrolytic manganese.

Manganese was used to secure required hardenability characteristics in constructional alloy steels by replacing part of the nickel and chromium contents. In this use, a form of manganese lower in carbon content than standard 80 percent ferromanganese (which contains up to 7.50 percent carbon and lower in phosphorus content than low carbon ferromanganese (which contains 0.35 percent phosphorus and up to 0.75 percent carbon) was necessary.

<sup>1/</sup> Foregoing data derived from Minerals Yearbook, U.S. Department of the Interior, Bureau of Mines, Government Printing Office, 1942, 1943, 1944, Washington, D. C. Average production for consumption 1942-4 incl. in tons per ton of ingots and steel castings; blast furnace ferromanganese 0.0078; spiegeleisen 0.0019; blast furnace ferrosilicon 0.0031; electric furnace ferrosilicon 0.0053; electric furnace ferromanganese 0.00034; silicomanganese 0.00063; all other 0.00214.

<sup>2/</sup> Ibid.

The same condition prevailed in the production of low carbon stainless steels. Electrolytic manganese of the following typical composition served the purpose: manganese 99.68 percent, carbon 0.02 per cent.

Electrolytic manganese was used principally in electric furnaces by adding it to the bath after the reducing slag was on; recovery was about 90 percent as compared with a recovery of 70 percent from low carbon ferromanganese.

If only standard 80 percent ferromanganese of all the manganese alloys were to be replaced by metallic manganese it would be necessary to produce 625,000 of metallic manganese to satisfy the assumed production rate. To produce that quantity of electrolytic manganese would require the mining and treatment of 3.6 million tons of ore and the consumption of 5.6 billion Kwh of electricity and 250,000 tons of sulphuric acid.<sup>1/</sup>

Consumption of sulphuric acid in the steel industry averaged 554,000 tons per year for the years 1942-4 inclusive. It seems reasonable to conclude that a pyrochemical means of treating low grade manganese ores will have to be found.

Problems involving the use of chromium and nickel call first for an estimate as to the amount of alloy steel which might be produced if total steel production were 96 million tons of ingots and steel for castings.

The highest percentage ever reached was 14.8 percent in 1943 and that total resulted in unused surpluses and contained tonnages which were exported, some of which never reached their destinations because of enemy action. Once again, it is very difficult to estimate without knowing what our problems of overseas supplies might be, probable theaters of operation, types of weapons and materiel and style of combat.

It would appear that a perfectly safe figure is 15 percent or 14.4 million tons of alloy steel, both open hearth and electric furnace. That figure assumes technological advances in weapons and materiel which require larger quantities of alloy steels than have been used heretofore. It also assumes rigid controls of strategic elements - and economical use of them.

In that connection, it is my opinion that specifications for implements and materiel which contain strategic alloys should be reviewed critically with most effective use of alloys in mind. And by that I do not mean "chipmunk" saving - that way lies defeat. I mean conservation for maximum essential utility.

<sup>1/</sup> Utilization of Three Kids manganese Ore in the Production of Electrolytic Manganese. U.S. Department of Interior, RI 3815. June 1945.

It might well be that such a "conservation" review will indicate an increase in over-all consumption, in the present state of the art, based on necessary mechanical and physical properties of required materiel. If that be true the metallurgists of industry will have to meet it and outdo the ingenuity shown from 1941 to 1945, and again prematurely advance the state of the art of effectively using alloying elements.

Nickel is probably the most versatile alloying element known; and metallic nickel has more varied uses than any other metal. About 61 percent of all nickel is used in making alloy steels and irons, 27 percent is used in nonferrous metallurgy; 10 percent is used for plating other metals; and 2 percent goes to the chemical and dye industries.

Nickel is commonly referred to in steelmaking terms as a "non-oxidizable" element, that is, no substantial quantity of it is lost in normal steelmaking operations and recovery from scrap is 95 percent or more. For that reason nickel is easily stockpiled in steel in use, in coins, medals and trophies and in many other forms.

During the period 1942-4 inclusive, world production of nickel averaged 178,000 tons. In 1943 International Nickel Company alone furnished nearly 75 percent of the world total.<sup>1/</sup>

"Deliveries of nickel in all forms (by International Nickel Company in 1943) amounted to 265,000,000 pounds, which was 55 million pounds greater than the amount reported for 1939. In order to obtain this nickel it was necessary to mine 12,100,000 tons of ore in 1943 (34,400 tons per average working day) as compared with 7,300,000 tons (21,700 tons per average working day) in 1939."<sup>2/</sup>

It is apparent that the nickel content of ore has declined some 30 percent in 5 years, a fact further attested to in the recent announcement that "increased metal requirements of the world since prewar placed such a drain on the ore reserves of base metal producers that they were forced to mine lower grade ore."<sup>3/</sup>

- <sup>1/</sup> Mineral Yearbook. U.S. Department of the Interior. Bureau of Mines. Government Printing Office. 1944. Washington, D. C.
- <sup>2/</sup> Address to Shareholders of the International Nickel Company of Canada, Limited, by Robert C. Stanley, Chairman and President, Annual Meeting, April 26, 1944, Toronto, Canada.
- <sup>3/</sup> Robert C. Stanley in The New York Times, July 24, 1948.

During 1946 and 1947 the steel industry consumed a total of 134.7 million pounds of virgin nickel in the manufacture of 13.5 million tons of alloy and stainless steel.

ii In 1946, 36 million pounds of virgin nickel were used in making 550,000 tons of stainless steel or about 65 pounds per ton; 31 million pounds were used in making 5.4 million tons of other alloy steels or about 6 pounds per ton.<sup>1/</sup> In 1946, the foundry industry used 6 million pounds of nickel<sup>2/</sup> and in 1947 it used 11 million pounds, ample proof of an expanding technology.<sup>3/</sup>

In 1943, the steel industry used 250 million pounds of nickel in making 13.1 million tons of alloy and stainless steels or an average of nearly 20 pounds per ton.<sup>4/</sup> The over-all average for 1946 was about 11 pounds of nickel per ton of alloy and stainless steel.

Assuming at least as efficient use of nickel as in the past, and assuming the same rate of use as for the year 1943, the quantity of nickel necessary to produce 14.2 million tons of alloy steel would be 288 million pounds or 80 percent of the average world total for the years 1942-4 inclusive.

Peak production of the Canadian mines was only 92 percent of that projected requirement and ores are leaner now than they were in 1943. Aid would have to be sought from other sources, probably Cuba from which supplies in the form of nickel oxide were secured in the latter years of the war. Nickel oxide and nickel oxide sinter are acceptable substitutes for metallic nickel in the manufacture of most grades of steel. (See Appendix C).

The importance of chromium as an alloying element in steel has increased greatly in recent years because of the rising importance of stainless steels and heat-resistant steels. In the manufacture of steels of this nature there is no presently known substitute for chromium.

Some chromium can be recovered from steel scrap particularly if the scrap is melted in electric furnaces, but large quantities are irretrievably lost in manufacturing operations because chromium is an oxidizable element. Recovery of chromium from scrap in low carbon steels averages about 40 percent in open hearth furnaces and 60 percent

<sup>1/</sup> Mineral Industry Surveys. Mineral Market Reports. M.I.S. No. 1518 U.S. Bureau of Mines, May 21, 1947.

<sup>2/</sup> Ibid.

<sup>3/</sup> Robert C. Stanley in American Metal Market, April 29, 1948.

<sup>4/</sup> Strategic Minerals. John B. Demille. McGraw-Hill Book Co. New York 1947.

in electric furnaces; recovery from high carbon steels averages about 60 percent in open hearths and 80 percent in electrics. Recovery of virgin chromium from ferroalloys average 90 percent in both kinds of furnaces.

About 45 percent of all the chromium is used as an alloying element in steel, 40 percent is used as a refractory material and 15 percent is used in the leather tanning and dye industries and for plating. The steel industry is only one of many consumers of refractory chromite.

During the period 1942-4 inclusive consumption of chromite, the only known ore of chromium, averaged 902,000 tons for all purposes. In 1943 U.S. production reached a peak of 160,000 tons or about 18 percent of consumption.<sup>1/</sup>

During 1946 and 1947 the steel industry consumed a total of 342 million pounds of virgin chromium in the manufacture of 13.5 million tons of alloy and stainless steel or an average of a little more than 25 pounds of chromium per ton.

The average content of chromium per ton of alloy and stainless steel for the years 1942-5 inclusive was 20 pounds.

Assuming as we did for nickel, equal efficiency and wartime rate of use, the production of 14.4 million tons of alloy steel would require 288 million pounds of chromium or 490,000 tons of chrome ore.

Refractory grade chromite is used in both run-of-the-mine and ground conditions, and it is also manufactured into bricks. It is used to line and repair basic open hearth furnaces below the slag line, and soaking pits. About 3 pounds are consumed for each ton of steel produced; therefore, a production of 96 million tons of steel would require 144,000 tons of refractory chromite.

Total steel industry requirements for chromite would be, then, 634,000 tons or about 70 percent of the average total U. S. consumption for the years 1942-4 inclusive.

Let us now assemble some of the more important figures, just as the steel industry has physically to assemble materials. To produce 96 million tons of ingots and steel for castings will require on a conventional basis

<sup>1/</sup> Op. cit. GPO. 1944. Wash., D. C.

Iron ore	125,400,000
Coal	111,500,000
Coal Equivalent in other fuels	16,000,000
Scrap, purchased	18,000,000
Limestone	36,000,000
Manganese ore	1,546,000
Chrome ore	634,000
Nickel, metallic	144,000

No such quantity of raw materials has ever been assembled by the steel industry. And the foregoing figures represent materials for only one year of capacity production. It is not difficult to visualize some of the obstacles which would have to be surmounted to sustain any such program over a period of several years.

Given freedom from industrial strife, and unhindered by theorists and demagogues, the steel industry could do the job. Individually and collectively the men of the industry from cinder snappers to board chairmen know how to do it better than any other group of men on earth.

## APPENDIX A

IRON ORE

Two outstanding recent discussions of future iron ore supply have been the address of C. M. White, President of Republic Steel Corporation, before the American Institute of Mining and Metallurgical Engineers<sup>1/</sup> in March of 1947, and the paper read by George W. Hewitt, Assistant Vice President of Wheeling Steel Corporation, before the American Iron and Steel Institute's General Meeting<sup>2/</sup> in May of 1947. Both of these men arrive at the same broad general conclusions, with minor differences in approach.

The most recent and probably most accurate estimate of world reserves of iron ore is that of Harry Mikami, published in "Economic Geology" in 1944, and used largely in White's discussion. Mikami estimates world actual ore reserves at 40 billion net tons and potential reserves at 185.2 billion tons. Of the actual reserves he credits the U. S. with 4.3 billion tons, distributed as follows: Lake Superior, 1.46 billion; Alabama, 1.59 billion; Northeastern, 0.79 billion; all other, 0.46 billion.

The U. S. thus possesses at best only a small fraction of actual world iron ore reserves, although her proportion of the world's steel production has been, and will undoubtedly continue to be, a much larger one. As White points out, this means that the actual known ore supply is being exhausted much more rapidly in the U. S. than in the rest of the world. Although foreign reserves, including possible increases from new explorations such as the recent Labrador discoveries, are so large as to indicate an ample over-all world supply for a long time to come, Hewitt emphasizes that dependence upon outside sources is not only un-American but definitely dangerous, particularly in time of war. White states that even in peacetime the economic use of imported ores has been limited to those steel plants located on or near the seacoast. However, Hewitt declares that South American ore delivered inland is likely to be more and more of a competitive factor as Lake Superior costs rise with a lessening proportion of direct shipments from open-pit operations and an increasing ratio of beneficiated product.

The problem, then, is one which the U. S. should for the most part work out and solve within its own borders, although White hints that a complete solution may involve a partial relocation of the iron and steel industry. However, it is apparently an inescapable fact that in a comparatively short period of years the open-pit ores of Minnesota will not be available in sufficient quantity, even adding the production of the

- <sup>1/</sup> Iron Ore and the Steel Industry. C. M. White. Transactions, A.I.M.E. New York. 1947.
- <sup>2/</sup> Iron Ore Supply for the Future. George W. Hewitt. Yearbook. American Iron and Steel Institute. New York. 1947.

other Lake Superior mines, to meet the needs of the present Lake-supplied steel industry. White calculates our future ore requirements to be at least 112 million tons annually, of which the Lake Superior region would be called on for 84 million. (Hewitt estimates these needs at 100 million, and 67 to 78 million, respectively.) Of the Lake Superior total, White figures the demand on the open-pits to be at least 62 million tons a year. With an estimated open-pit ore reserve of 6.5 million tons (Minnesota Tax Commission, 1946), this reserve would, arithmetically, last a little over ten years. White states, however, that ore cannot be produced on the basis of mathematical averages, and believes that open-pit production will begin to decline after about half of that period.

Hewitt makes his estimate on the life of high-grade Lake Superior ores as a whole. Dividing estimates taxable reserves of 1.304 billion tons (as of the end of 1945) by 78.4 million tons, he gets 16.3 years (16.6 seems to be the correct figure); and by 67.2 million, 19.4 years. He feels, however, that present first-grade reserve estimates are rather conservative and that an additional 35 to 50 percent can be mined from these districts, making a total of theoretically 20 to 25 years' supply. Such a view would seem to be strongly supported by the history of past production records and reserve estimates. However, White cautions us that the record of the past is not an acceptable guide to the future, and that the nearer an ore-producing district approaches exhaustion, the more accurately can its remaining tonnage be estimated; or, as Hewitt puts it, "It would appear that we are approaching the lower part of the barrel where the apples are more easily counted."

Three main domestic sources of ore to meet the threatened shortage are listed by White: (1) the Northeastern magnetites; (2) the Mesabi underground reserves; and (3) Mesabi taconites. Characterizing the first two of these as inadequate to replace present open-pit production, he concludes that the chief source of our possible future ore supply lies in the magnetic taconites of the Mesabi. In this opinion he is apparently joined by Hewitt.

That this has also been the trend of thought among many other members of the ore and steel industries is evidenced by the number of projects for study and development of beneficiation processes sponsored by such members in recent years. One of the oldest of these is the research project at Battelle Memorial Institute, backed by a dozen ore and steel companies. Laboratories, pilot plants, etc., have also been maintained by several other groups. Bethlehem and Youngstown, working through Pickands, Mather and the latter's Erie Mining Co.; Armco, Wheeling and Cleveland-Cliffs, with Oglebay Norton and its Montreal Mining Co.; Oliver; Butler Bros.; and M. A. Hanna are among the names associated with such enterprises.

Taconite is a generic term for a very hard rock, occurring in large mass formations, containing from 20 to 30 percent of iron, with silica

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as the chief impurity. According to some geologists, there are approximately 60 billion tons of taconite lying along and under the Mesabi range. In its magnetic form, found close to the surface near the eastern end of the Mesabi, it can be treated to produce a concentrate containing 62 to 65 percent iron. The concentration of the hematitic (non-magnetic) taconites of the central and western Mesabi, however, is technically more difficult, since they are not susceptible to magnetic treatment. In view of all the resources, mental, physical and financial, which are being brought to bear on the dual problems of separation and agglomeration, it may be expected that a commercially satisfactory solution will not be too long in the future. Even at present the cost of magnetite taconite concentrate is said to be no higher than that of ore from deep underground mines.

A recent development has been the so-called "fusion piercing" method of sinking drill holes for blasting, by which the speed of rock penetration has been increased approximately ten times.

Still another facet of the problem is the question of vulnerability of the Lake ore supply to enemy attack in war time. In World War II the Soo locks were the most heavily guarded inland area in the U. S. In that conflict no enemy action was attempted against the iron ore industry, but that is no guaranty that none would be attempted, perhaps successfully, in the future. In the event of partial or complete interruption of the Lake supply, the fact that the subsidiary problem of taconite beneficiation had been solved would be small consolation. In such an emergency the iron and steel industry might be able to draw on ores, perhaps beneficiated, from other sections of the country.

APPENDIX B

MANGANESE

The iron and steel industry uses over 90 percent of all the manganese consumed in the United States, and more than 90 percent of this country's total requirements are normally imported from foreign--mostly very distant--sources. This is, therefore, one of those cases where the industry is heavily dependent upon supplies from abroad which are, of course, subject to drastic dislocations of transportation and otherwise, in the event of war.

The United States is, for practical purposes, a "have-not" nation with regard to manganese, for the reason that, while extensive deposits of manganese ore do exist in at least 17 states in various sections of the country, these are of such low grade as to render their use for standard ferromanganese so far unprofitable. Strenuous attempts have been made to develop an important domestic manganese industry, but these have hitherto all been failures from the viewpoint of the steel industry, due to the above-mentioned low quality of the ores. (The deposits in Maine are the latest disappointment in this respect.) Domestic production received considerable impetus from Government purchases during the war, but fell off again in 1945.

As shown in the attached table of imports of manganese ore for 1944-46 inclusive, our chief sources of supply are: Russia, India, Cuba, South Africa, the Gold Coast, Brazil and Chile. The last names has rapidly become a major source of manganese ore imports. Shipments from Russia temporarily ceased during the war, but reentered the trade in April 1945.

In addition to the countries listed in the preceding paragraph, manganese is produced in commercial quantities by about 30 other countries, notably Czechoslovakia and Egypt. It is not produced in significant amounts in the major industrial countries, Russia being the only industrialized nation which is self-sufficient. However, any great expansion of the Russian steel industry might eliminate her as an exporter, to say nothing of the obvious results of a possible direct conflict between Russia and the U. S. (In view of recent developments India must also be classed as a highly undependable source.)

There would not appear to be any real question of exhaustion of world supplies in the relatively near future. (A tabulation of world resources is also attached; however, the figures do not check readily with other information at hand and are therefore open to some question.) Our own minimum wartime requirements were estimated by the OPM at about 1,200,000

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tons of ore per annum, although imports for 1945 and 1946 ran considerably higher, and it is stated that in 1944 we consumed about 900,000 tons of metallic manganese, of which about 250,000 tons apparently came from ore stockpiles. In the past, the U. S. has used a little over 22 percent of total world production; which, taken in conjunction with our share of world steel production, amounting to 35 percent or more, would indicate superior efficiency on the part of U.S. industry.

Of the world's manganese supply, American capital controls 20 percent; British 25 percent; and Russian 35 percent.

Although we experienced a serious shortage of manganese in World War I, such a condition was averted in the recent conflict by industrial stockpiles built up before Pearl Harbor. (As a consequence, this highly strategic material was never placed under allocation.) Government stockpiling later took place under the Metals Reserve Company and its successor, the Office of Metals Reserve, the ore being stored both in the U.S. and outside, in Brazil, Chile and Cuba.

It is felt in mining circles that the stockpiling process should now be repeated against a possible future emergency, and that this should be supplemented by a program of research on methods of upgrading domestic ores; such program possibly to embrace the construction of several standby processing plants at a cost of approximately \$20,000,000 apiece.

As for the comparatively recent development of electrolytic manganese from domestic ores, present production by this process is approximately 200 tons per month, or less than 1/2 of one percent of our minimum requirements.

General Imports of Manganese Ore (35% or more Mn), 1944-46 incl.

Country	Net Tons					
	Gross Weight			Mn Content		
	1944	1945	1946	1944	1945	1946
Australia	-	-	-	-	-	-
Belgian Congo	9,053	-	-	4,526	-	-
Brazil	170,025	282,036	160,171	71,873	119,500	66,386
Canada	-	-	17	-	-	6
Chile	4,289	91,334	149,452	2,101	42,699	68,014
Cuba	467,059	293,572	158,734	223,392	140,325	77,469
French Morocco	1,348	-	1	786	-	1
French W. Africa	-	-	2,868	-	-	1,434
Gold Coast	170,857	273,479	303,643	88,811	141,809	150,790
India & depend.	222,962	199,122	365,044	111,000	99,589	182,194
Mexico	83,122	46,377	29,873	36,633	20,638	13,451
New Zealand	539	-	-	240	-	-
Union of S. Africa	28,656	124,630	281,861	13,153	57,448	133,580
U.S.S.R.	-	151,345	205,001	-	70,802	102,243
United Kingdom	22	-	-	20	-	-
<b>Total</b>	<b>1,157,932</b>	<b>1,461,945</b>	<b>1,656,465</b>	<b>552,535</b>	<b>692,810</b>	<b>795,579</b>

less than 1 ton.

Present import duty - 1/2¢ per lb. of contained manganese.

Percent of World Production Normally Used by U.S., 32%.

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MANGANESE ORE: WORLD LOCATION AND USABLE CONCENTRATES  
(In Gross Tons)

<u>Location</u>	<u>Average Percent Manganese Content</u>	<u>Usable Concentrates</u>
<u>United States 1/</u>		
Crude Ore	20	4,000,000
Crude Ore	12	20,000,000
Crude Ore	2	3,750,000,000
<u>Other Western Hemisphere 2/</u>		
Cuba	45+	18,800,000
Brazil		3,000,000
Chile		15,000,000
Mexico		250,000
Other		300,000
		250,000
<u>Africa</u>		
Belgian Congo	40+	22,000,000
French Morocco		1,000,000
Gold Coast 3/	50+	1,000,000
Union of South Africa	30-51	10,000,000
		10,000,000
<u>Asia</u>		
USSR 4/	40+	372,300,000
India		300,000,000
China	50+	50,000,000
Turkey		20,000,000
Malaya		1,000,000
Palestine		500,000
Philippines		500,000
		300,000
<u>Europe 5/</u>		
Italy		200,000
		200,000

1/ Total known usable concentrates in the United States are not large and amount to approximately two million gross tons. There are large tonnages of low-grade ore from which usable concentrates could be produced at high cost.

2/ Revised by U.S. Geological Survey, 19 August 1946.

3/ Ibid.

4/ Ibid.

5/ Roumania, Poland Czechoslovakia have extensive deposits of low-grade manganese which would aggregate 10-20 million tons and which could be used for very limited purposes. It is probable that they are being used at present.

Source: U. S. Geological Survey.

APPENDIX C.

NICKEL OXIDE

In the early months of World War II it became apparent that a serious shortage of nickel was imminent and that in addition to conservation measures, new sources of nickel would have to be developed if even only the most essential demands were to be met. Conservation measures were applied by the Office of Production Management on March 7, 1941 in a general priority control order which was superseded on May 15, 1941 by a general preference order which provided for formal allocation. That was the order which led directly to the development by the Technical Committees of American Iron and Steel Institute of the National Emergency (NE) chromium-nickel-molybdenum series of constructional alloy steels.

New sources of nickel were sought and it was early recognized that the nickeliferous iron ores of Cuba could be successfully utilized to produce a nickel oxide of adequate purity. These ores of the following typical composition: iron 38 percent, nickel 1.47 percent, magnesia 8.0 percent, and silica 15.7 percent, were processed by the Nicaro Nickel Company to an oxide product of the following typical composition:

Nickel oxide	97.29 percent (Ni 76.50%)
Cobalt oxide	0.60 " "
Silicon	0.45 " "
Carbon	0.04 " "
Sulphur	0.03 " "

Production on a commercial scale was started in December, 1943.

That product was used as a substitute for metallic nickel in the manufacture of stainless and alloy steels in both electric furnaces and open hearth furnaces up to the following percentages: stainless steels and electric furnace alloy steels, 50 percent; open hearth alloy steels, 30 percent.

The nickel oxide was added to furnace charges with scrap and the nickel oxide was reduced by iron thus precipitating nickel into the molten metal. The oxide was added in paper packages containing the equivalent of 50 pounds of nickel, and the quantity so added to furnace charges frequently comprised 4 percent of the metallic charge. Larger additions caused difficulty in electric furnaces during melting because of interference with electric currents.

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Nickel oxide could not be used successfully for late additions in electric furnaces because it changed the characteristics of the reducing slag. In general, the recovery of nickel from nickel oxide in the manufacture of stainless steel was 97 percent as compared with 98 percent recovery from metallic nickel.

In open hearth furnaces difficulty was experienced because the oxide was so fine that large quantities were lost as dust and carried away with the furnace gases. Late additions were not too successful either, because the bags of oxide would not satisfactorily go through the slag into the molten metal. Recovery of nickel from the oxide in open hearth practice was about 80 percent as compared with a recovery of 95 percent from metallic nickel.

The quality of the steel produced in both electric furnaces and open hearth furnaces using nickel oxide as a source of nickel was in no way inferior to like products made with metallic nickel.

Lately, a nickel oxide sinter of the following typical composition has been produced by International Nickel Company: nickel 73.88 percent, copper 1.25 percent, iron 1.32 percent, cobalt 0.63 percent, silicon 0.48 percent and sulphur 0.02 percent. That sinter is heavier than the nickel oxide previously discussed and can be handled in bulk.

In electric furnace practice in the manufacture of stainless steels it is added with scrap and recovery of nickel averages 95 percent. In open hearth practice, the sinter penetrates the slag and recovery is high. The time of addition must, however, be carefully calculated because if added too late in the heat the nickel oxide would change the characteristics of the slag and precipitate carbon into the molten metal. For that reason, too, the sinter cannot be used as a late addition in electric furnace practice.

QUESTION: Is there any possibility of getting significant amounts of scrap out of Germany?

MR. PARKER: I really don't know the answer to that one. I have not interested myself in it for the simple reason that we have a committee which works in conjunction with the Department of Commerce, we have a paid staff that has been to Germany, and so on. I thought that they could spend a great deal more time on it than I could. They should know the answers.

I don't see how we can do very much until the legal problem of who owns the scrap is solved. From what I have read and heard, that problem is not on its way to solution. I don't pretend to even begin to understand what the problem is, I have been told that if there is a wrecked American tank on Joe Doaks' farm in France, there is a problem as to who owns that tank. To me, it doesn't make sense. I think the United States of America owns that tank and can pick it up and bring it home, but the legal gentlemen say "no," that they may be the farmer's property.

It would appear that that is the major problem, at least from all that I have read about it. I have not seen any real difficulty in collection or assembly or transportation.

QUESTION: Sir, what is the trend of the electric-furnace production of steel--up, down, or static?

MR. PARKER: The electric-furnace process is definitely on a long-time upward trend. But, for normal peacetime uses, there is just so much electric-furnace steel that an economy can absorb at the price which electric-furnace steel commands, largely because of the cost of electric power. In other words, we cannot make efficient use of very much electric-furnace steel. Therefore, the rate of increase is a small one.

QUESTIONER: Is it tied to the source of power or is it a difficulty in the steel industry?

MR. PARKER: There is electric-furnace capacity right now that is not being used.

QUESTIONER: Would a large increase in power result in a prompt increase in electric-furnace steel?

MR. PARKER: No. I don't see why it should. We couldn't make use of the steel; it's too good. It would be uneconomical to put steel of that quality, at the price that has to be paid for it, into an ordinary job. Some of that is being done today. That is why electric-furnace production is up a little from normal. There are grades of carbon steel being produced because people that make some other object for sale are willing to pay for any kind of steel so long as they get it, and they are using electrics.

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QUESTION: Is question has to do with the transportation requirements for steel, particularly with regard to rail. Do you think that there is adequate rail transportation available to the steel industry now? Do you think conditions will improve within the next five years?

MR. PARKER: As I understand it, the only difficulty we have had has been with cars. If plenty of cars were available, we would not have had any transportation difficulties. In other words, there is adequate trackage. I cannot think of any spot in the industry that is not or at least does not seem to be very adequately served if the cars are available. Our difficulties have been more in outgoing than in incoming shipments. Incoming shipments, you see, are very largely in open gondola cars, whereas the outgoing shipments--tin plate, wire, full finished sheets, and many other products--require superior equipment. We didn't have it, and that backed up on the finishing lines and, in a few spots, slowed down production for a few days. But it wasn't anything serious.

QUESTION: Do you have any information as to whether or not the rail industry will be able to provide the additional cars that are required?

MR. PARKER: No, sir; I don't have that information. That is precisely why I put two lines in my little opus to the effect that these particular things, if they come to pass, will impose a burden on the transportation industry. I am not equipped with facts and figures to say either yes or no. I realize that a warning flag is thrown up by the type of analysis that I made.

QUESTION: Could you tell us something of the trend toward the development of top pressures and the use of oxygen in smelting and what it might mean to us in the saving of coke?

MR. PARKER: Of course, the pressure top, within limits, is now an accomplished fact. I believe Republic Steel has three at Cleveland and is installing pressure tops on five more of its furnaces. I think Youngstown Sheet and Tube Company is installing two pressure tops. With the way production is now, of course, no company will shut a furnace down just to put a pressure top on it. It waits until it goes down for relining; and if the company goes along with the theory of high top pressure, it will put it on. There are those who don't agree with that theory and believe that there are other means of increasing production.

As far as oxygen is concerned, I don't believe that anybody in this country has put oxygen on a full-scale blast furnace yet. The Bethlehem Steel Company is building an oxygen plant at Johnstown. When that plant is completed, it will go on to the blast furnace. But it will be first used when the furnace is running on manganese ore, because that shows more promise of increasing production and reducing the coke factor than does the operation of the furnace on iron.

Small-scale operations on a 15-ton blast furnace in Germany are controversial. One group of metallurgists will take the data and see something in it. Another group will take exactly the same data and say they can do it better another way.

The information that we have out of Russia, principally by Peter Kapitza, doesn't add up. He claims to have run a full-scale blast furnace with oxygen. I don't know of any top-flight blast furnace man in this country who believes it. Once again, all the data are not there, so that we cannot calculate as to whether he did what he said he did or he didn't.

So right at the moment, we don't know the answer.

The Bethlechem plant was supposed to have been finished three weeks ago. It isn't finished yet. It probably won't be finished before February. They have indicated that just as soon as they get any results at all they will make known immediately what they get.

MR. BUTTS: I believe there are no other questions.

We are very grateful to you, Mr. Parker, for this morning's entertainment. I call it "entertainment" rightfully, because we can't take these things too seriously; otherwise we would really be knocked out. We have enjoyed it, and we thank you very much. We look forward to seeing you again this afternoon.

(23 Sept. 48-450) Not edited.

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