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MATERIALS FOR THE PRODUCTION OF STEEL

7 November 1955

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MATERIALS FOR THE PRODUCTION OF STEEL

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COLONEL NYQUIST: As you are aware, this is our first lecture on the Natural Resources Unit. Because of its importance to both a peacetime and a wartime economy, we have selected steel as our subject this morning. Now since steel comes under the category of a manufactured product, the industry is almost totally dependent upon a continuous flow of such natural resources as iron ore, coal, limestone, manganese, and many other alloying elements. Therefore, we feel it quite appropriate that the subject for our lecture this morning be "Materials for the Production of Steel."

To bring us the story, we are very fortunate in having Mr. Norwood Melcher, Chief, Division of Mineral Industries, Region V, Bureau of Mines. Mr. Melcher.

MR. MELCHER: Thank you, Colonel. Good morning, gentlemen. Colonel Nyquist pointed out, and you have no doubt heard on numerous occasions, that the basic raw materials for steelmaking are coal, iron ore, and limestone. While this statement is true in the sense that steel can be made with these ingredients--plus the use of oxygen in air--it is a tremendous oversimplification. Modern steelmaking practice is not only based on a wide variety of these mineral raw materials but requires the use of many additive elements to purify the metal and to impart essential properties to steel for many applications, the number of which is increasing almost daily. Moreover, the quality of the basic iron ore and coal as mineral is deteriorating, while the requirements for steel continue to increase at a very rapid rate. Thus, the mining engineer and metallurgist are hard-pressed to provide raw materials of satisfactory grade and in sufficient tonnages to meet these growing demands.

Probably the most important and often the most critical raw material among the great steel producing nations is coking coal. In fact, several potentially large steel producers, notably some South American and African countries, from a standpoint of metallic resources are almost completely stymied because of lack of available coal.

The United States is blessed with large resources of coal, but in the matter of grades for producing high-quality coke, many problems exist.

Coke is a manufactured product, and in spite of the frequent use of the term "coking coal," there is relatively little coal that is used as mined to produce high-quality metallurgical coke. Most coal is subjected to washing or blending or both preparatory to coking. Generally 15 to 30 percent low-volatile bituminous coal is used with high-volatile that alone would produce only an inferior coke. The expansion of the low-volatile coal and the contraction of the high-volatile coal are offset by this blending. Low-volatile coal, alone, would ruin the walls of a slot-type coke oven.

Of the 83 million net tons of coking coal delivered to oven-coke plants in 1954, 66 percent was high volatile, 11 percent was medium, and 23 percent was low volatile.

The strength of a weak coking coal is sometimes improved by adding a small amount of such noncoking ingredients as anthracite fines, petroleum coke, or low-temperature char. In addition to the above, the ash and sulfur content must be considered, as coke is the main source of sulfur in pig iron.

Most of the reserves of high-rank and high-quality coal best suited for the production of coke and coal chemicals are found in the Appalachian Region, principally in West Virginia, Pennsylvania, Kentucky, Alabama, and Virginia. In a few areas in the West, principally in Colorado, Utah, Oklahoma, and Arkansas, coal is produced that is satisfactory for the manufacture of coke when used in blends. The most important areas in the West are the Raton Mesa region, Colorado-New Mexico; the Sunnyside field, Utah; and the Crested Butte field, Colorado.

The Bureau of Mines is on record that there is ample medium- and high-volatile coal for the next 100 to 185 years. However, there is still some question about low-volatile coals. The remaining known reserves of low-volatile coal as of January 1, 1953, which constitutes less than 1 percent of the total reserve of all ranks, are estimated at nearly 17 billion tons. Of this tonnage, however, only 4 billion is usable--assuming 50 percent to be in beds that can be mined and a 50 percent mining loss with present-day mining practices. At the 1953 production rate of 53 million tons, there would be an 80-year supply. However, if we assume a 60 percent and 200 percent increase by 1975, as with the high- and medium-volatile coal, the consumption by 1975 would be 85 and 160 million tons. Under these production requirements, the low-volatile coal reserves would last only about 25 to 50 years.

Considering the reserves and uses of medium- and high-volatile bituminous coals in both the eastern and interior areas and the reserves and uses of the low-volatile coals, it appears that the low-volatile coal reserves will be exhausted before those of the medium- and high-volatile bituminous coals. This is unfortunate in view of the present practice of improving the quality of coke of high-volatile coals by the addition of low-volatile. As the low-volatile supply diminishes, either other blending agents and new coking techniques must be found and developed or the noncoking uses of these coals must be restricted.

The coke industry of the United States is composed of 15,000 beehive ovens and 16,000 slot-type ovens, with an annual coke capacity of 89 million net tons. About 95 percent of our annual production is consumed by the iron and steel industry--90 percent to blast furnaces and 5 percent to foundries. The remainder is used for gas; chemical, heating, etc.

Coke ovens are probably the most vulnerable part of a steel plant. They cannot be shut down in the manner that blast furnaces and open hearths are and their rebuild time is much greater. The Bureau of Mines, in looking to the future in this respect, has recently--June 1955--conducted experiments to find a substitute for coke in blast furnaces and cupolas. In the Bureau's experimental blast furnace at Pittsburgh a fuel burden consisting of 40 percent anthracite and 60 percent coke was successfully used for pig iron production. In a metallurgical blast cupola, with a daily capacity of 400 net tons, 30 percent anthracite and 60 percent coke was successfully used.

The steel industry is also aiding this problem by reducing the coke consumption per ton of pig produced. A few of the things that have been done are: (1) ore beneficiation, including improved sintering methods; (2) improving coke through blending coals and mechanical cleaning; (3) charging uniform sizes of coke in the blast furnace; and (4) the use of high top-pressure in blast furnaces. Additional ore preparation and possibly recycling part of the gas furnace are ideas which may reduce fuel requirements in the future.

Another major problem in the coke industry is commercial consumption of coke oven gas, which has a low B. T. U. value--550 per cubic foot--and is often high in sulfur. This gas has been replaced in many steel plant and commercial outlets by natural gas, which has a B. T. U. value of 1000 per cubic foot and is low in sulfur. A plant has

recently been constructed at Birmingham, Alabama, which produces ammonia from coke oven gas and at the same time increases the B. T. U. value of the remaining gas to 1000. Another plant of this type is now under construction at Geneva, Utah. This will make the gas competitive and approximately equal to natural gas in B. T. U. value.

The basic metallic raw material for the production of steel is iron ore. Approximately 94 percent of all iron ore consumed in the United States is used in the blast furnace for making pig iron. A total of five percent is of premium grade and is used in the basic open hearth furnace in the production of steel, and the remaining one percent is used for miscellaneous purposes, such as ferroalloys, cement, paint, and other uses.

Domestic iron ore supplies are obtained from four geographical areas of the United States: The Lake Superior region; Southeastern States, around the Birmingham area; Northeastern States; and the Western States. The Lake Superior district, which includes Minnesota, Michigan, and Wisconsin, is by far the largest producer, providing 82 percent of the domestic supplies; Southeastern States--Alabama, Georgia, Tennessee, and Virginia--produce seven percent; Northeastern States--New Jersey, New York, and Pennsylvania--produce four percent; and Western States, which includes all the area west of the Mississippi River, except Minnesota, produce seven percent of the total required.

The demand for steel through two world wars and the currently unprecedented high level civilian demand for steel products has resulted in the United States outgrowing its domestic supplies of iron ore. In 1945, the United States imported only 1.2 million gross tons of iron ore, or two percent of the total consumed. This year, only ten years later, nine million gross tons were imported in the first six months, and the total for the year is expected to reach 22.5 million tons. This will amount to 20 percent of all iron ores consumed in the United States in 1955.

If the high level demand continues, imports by 1960 will probably total 30 percent of the ores consumed in the United States.

This increasing pattern of dependence on foreign iron ores has now been well established. Each year we can expect the dependence to increase. Currently, steel capacity of the United States exceeds 124 million net tons of steel a year. This requires about 140 million gross

tons of iron ore for full operation. By 1960, with a steel capacity of around 130 million net tons, the industry will require 150 million gross tons of iron ore, assuming adequate scrap supply is available.

Currently, iron ore is being imported from 12 countries. The principal sources in order of their importance are as follows: Canada, supplying 36 percent of the total; Venezuela, 36 percent--incidentally, Venezuela, which is very new in this trade, has grown at a fantastic rate; Peru, Brazil, and Chile, 18 percent; and 10 percent from Sweden, Liberia, Mexico, the Dominican Republic, Cuba, British West Africa, and the United Kingdom. The distance the ores have to be shipped and the location of the deposits is a matter of some concern to the steel industry. Canadian sources are the largest and most strategically located. The bulk of Canadian imports will be imported via the Great Lakes and connecting rail lines as soon as the St. Lawrence Seaway is completed.

The currently known largest Canadian deposits are in the Knob Lake area, 350 miles north of tidewater at Seven Isles, Quebec, the shipping port on the Gulf of St. Lawrence. These deposits are situated in the Labrador Trough straddling the Quebec-Newfoundland interprovincial boundary. Other deposits are located at Steep Rock, Marmora, and Michipicoten, Ontario. Development of currently known Canadian deposits and further successful exploration in Ontario, in the Ungava Bay area of New Quebec, along the Labrador Trough in New Quebec and Labrador, and on the west coast of British Columbia will, within a decade, place Canada as one of the major iron ore producers of the world.

Venezuelan deposits are the next in importance. Although not as favorably strategically located as those of Canada with respect to ocean shipping, nevertheless, imports from Venezuela are expected to total eight million gross tons in 1955 and possibly 13 million tons by 1960. Other foreign sources are expected to continue importing about the same as their imports for the year 1955.

Canadian deposits fill a direct need in the United States iron ore picture by providing a source of quick expansibility of ore tonnage during periods of emergency requirements. Heretofore, the expansion feature has been a characteristic only of the great open pit mines of the Lake Superior district situated in Minnesota. The gradual depletion of the high-grade direct shipping ores of this district have reduced the flexibility of the district to expand its tonnage. It is possible to produce

100 million tons per year from the Lake Superior district for several more years, but each year mining difficulties continue to increase. Production will be maintained through increased production by ore concentration and underground mining.

Basically, long term planning for adequate domestic iron ore production is aimed towards decreasing the dependence upon foreign sources rather than at a reduction of iron ore imports. This is being done through both industry and Government research programs directed towards establishing methods of mining and concentrating low-grade ores to develop adequate alternative domestic supplies that can decrease dependence upon foreign sources.

Low-grade materials are associated with all of the major domestic deposits. In the Lake Superior district, it is the so-called magnetic and nonmagnetic taconites of Minnesota, and the Jaspers of Michigan and Wisconsin. In the Southeastern and Western States, they are finely divided siliceous, hematitic, and limonitic ores containing excessive amounts of silica, and in the Northeastern States the material resembles magnetic taconite.

Technical processes to treat these low-grade materials vary with the characteristic of the material. In Michigan the jaspilite is ground to a minus 200 mesh, and the separation of iron and deleterious materials is accomplished by a process known as flotation. The final product must be agglomerated into at least three-eighths-inch pieces before it is suitable for a blast furnace charge.

Magnetic taconites of Minnesota are ground to a minus 300 mesh, magnetically separated, and the resulting product agglomerated either by sintering or pelletizing into three-eighths to one-half inch pieces for charging into the blast furnace. The low-grade ores of the Northeastern States can be treated in much the same manner.

The finely divided ores of the Southeastern and Western States and nonmagnetic taconites of the Lake Superior district usually require primary crushing and magnetic roasting prior to fine grinding and magnetic separation.

I might say that the great tonnage of ore in the Lake Superior region from the long range is the nonmagnetic type and will probably exceed 60 billion tons. Whereas the magnetic type, which is the basis of the industry now being introduced there, is a relatively small part of that.

The magnetic roast serves to change the nonmagnetic minerals hematite and limonite to magnetic magnetite, which can then be separated magnetically from the deleterious materials associated with the ores.

As I have indicated iron ore is only one form of ore and, while it is the bulk of the industry, a large number of metallic elements other than iron ore are consumed by the steel industry in the manufacture of steel. Among these elements are aluminum, boron, chromium, cobalt, manganese, molybdenum, nickel, silicon, and tungsten. Of these, all steels contain carbon, manganese, phosphorous, silicon, and sulphur.

The alloying elements may be roughly divided into two main groups: (1) Those used principally for cleansing the molten steel of unwanted impurities; and (2) those used for their specific alloying effect. Aluminum, manganese, and silicon are effective deoxidizers and scavengers and may be considered as belonging to the first group even though most of them are also used in certain steels for their specific alloying effect. The second group consisting of such elements as boron, carbon, chromium, cobalt, molybdenum, nickel, tungsten, and vanadium, are added for their effect in securing a combination of strength, hardness, ductility, and deeper penetration of heat treatment reaction through their solid solution with iron, or through the formation of carbides.

The forms in which the elements are added to iron and steel depends largely on the process and qualities to be added. Ferroalloys are adaptable for all processes, but economy is responsible for the use of the lower priced compounds. The present trend is toward greater use of the ores and concentrates as such and the use of chemical compounds. Future production of ferroalloys, particularly ferromanganese and ferrochromium, may be lower in grade, in part because high-grade ore is becoming less abundant, and in part because of the economic advantage of using less costly materials.

By far the largest use of manganese is in the manufacture of carbon steels. Constructional and engineering alloy steels that normally contain a low percentage of alloying elements account for the largest use of most of the other alloy metals. In recent years more than one-half of the total chromium and nickel (excluding scrap) consumed by the ferrous industry has been in the manufacture of stainless steels. The largest use of tungsten and vanadium is in the manufacture of tool steels, but in recent years molybdenum has replaced tungsten to a large degree in high-speed steels.

Unfortunately, the United States is not self-sufficient in many of the elements used by the iron and steel industry. Chromium is derived largely from imported ore that comes in over long sea lanes. Domestic commercial reserves are very small and if the country could satisfy its chromium needs from these reserves, they would be exhausted in a very short time. The role of chromium in stainless and heat-resisting alloys, and in high-speed tool steel is unique. In many constructional and engineering alloy steels chromium is replaceable only with difficulty.

Manganese is among the cheapest alloying elements and is used in the largest amounts. Although there is a large supply of low-grade domestic ores, economic utilization of them is still lacking. Consequently, high-grade ores are imported over long sea lanes. Long-range research is designed to make available the nation's large resources of low-grade ores. Domestic commercial reserves of molybdenum are estimated at more than two billion pounds of molybdenum content, about 90 percent of the total estimated world reserves. The metal is widely used in alloy steels and can readily be substituted for some of the scarcer metals for many applications.

Nickel, next to manganese, is the most widely used alloy. The United States is almost wholly dependent upon imports from Canada and Cuba. Domestic deposits are low-grade, but some ferronickel is being produced from the deposit in Oregon, and nickel salts are recovered from some copper refineries.

Tungsten.--Although the United States is the free world's largest producer of tungsten, domestic reserves are limited and production is inadequate to meet emergency needs. About 64 percent of our 1954 supply was imported, mostly through long sea lanes.

Vanadium byproduct recovery from uranium mining operations is greatly in excess of industry requirements. The large surplus has become a growing problem of the vanadium industry. Although the metal can be used in place of chromium, nickel, and molybdenum for some applications, efforts are not directed to its maximum use because of its higher cost.

Cobalt, as compared with some other alloy metals, is not used in large tonnages. It is essential in the manufacture of some products produced by the steel industry. Belgian Congo has supplied most of the United States requirements.

Columbium-tantalum requirements are met almost entirely through imports from the Eastern Hemisphere and Brazil. These metals are essential in some types of stainless steels to prevent intergranular corrosion.

In recent years the Government has taken measures designed to alleviate to a large degree the dependency of the United States on foreign sources for these highly strategic metals during an all-out emergency. Among these measures are: (1) the National Stockpile whereby the estimated deficit between supply and demand is purchased, to the fullest extent practicable, and held in reserve for possible emergencies; (2) exploration and development of domestic reserves; (3) price incentive programs; and (4) research on the beneficiation of submarginal ores.

As a result of these and other Government actions, the United States supply of all of these strategic metals has been increased substantially. However, domestic production of chromium, columbite-tantalite, manganese and nickel is still very small as compared with domestic needs and, due to limited commercial ore reserves, no substantial increase in the production of these metals can be foreseen for the next few years.

Part of the assignment here is on technological developments which bear on this subject. A number of technological developments in the production of alloying metals have taken place in recent years, among which are: (1) new ways of extracting some of the metals from the ores by chemical methods rather than by the usual method of smelting and refining; (2) upgrading of heretofore noncommercial ores; (3) production of very pure metals by electrolytic deposition. Processes developed by the Bureau of Mines for the production of electrolytic manganese and chromium have been adopted to commercial production and research on the production of high purity molybdenum by electrodeposition is being conducted.

Similarly, there have been several important innovations in steelmaking practice which will have pronounced effect upon the types and quantities of raw materials needed for future operations. Some of these highlights in steel technology are: (1) the concept that the electric furnace could replace the open-hearth to a substantial degree; (2) high-top pressure blast furnaces; (3) the low-shaft blast furnace, which would, to a degree, do away with coke ovens and use low grade fuels--this probably has application in communities with relatively small

requirements; (4) a process known as induction stirring in the electric furnace, which I will mention in a moment; (5) lance injection of gases and solids other than oxygen to remove and add elements to the furnace bath; (6) continuous casting of steel slabs and billets; (7) vacuum-melting for the production of steel with superior quality, free from inclusions; (8) another innovation is the use of rare earths to conserve manganese and nickel and improve the quality of steel; (9) the so-called Linz-Donawitz process, a new oxygen-blow process for faster production rates, increases use of pig iron and decreases use of scrap as compared with open-hearths; (10) hot extrusion.

1. Some of the advantages of the electric furnace over the open-hearth for the production of low-carbon steel are: (a) its capital cost is 40 percent less; (b) its lower cost in producing steel from cold metals; (c) even with a 50-50 percent molten pig iron-scrap charge, annual return of the invested capital is equal to or greater than the open-hearth, particularly on below-capacity operations. The electric furnace is more flexible and may be put into operation or withdrawn at will. The open-hearth, on the other hand, takes up to one week to bring it to temperature when starting up and the brick-work frequently fails when it is shut down. The annual rebuild time of the electric furnace is 15 days compared with 30 days for an open-hearth. The electric furnace gives a two percent greater metallic yield, better temperature control and greater control of sulfur, which is important in the production of high quality steel.

2. The use of high top-pressure blast furnaces received further recognition during the past year when additional firms announced plans to use this process. Some 13 pressurized furnaces were operating in the United States during 1954. Previous results of this type of operation have shown that up to a 15-percent increase in pig iron production, 70 pounds less coke per ton of pig iron produced, and a 30 percent lower flue-dust rate are possible.

3. The low-shaft blast furnace has been talked about quite a bit in this country but one has never been used commercially. This type of furnace is designed to utilize low-grade fuels. The Bureau of Mines is experimenting with one type at Pittsburgh.

4. An interesting innovation was the development of the induction stirrer which was started in Sweden in 1936, when the Swedish Electric Company was asked by a steel company whether the bath in a hot-metal mixer could be stirred by some electrical method. Dr. Ludwig

Dreyfus, the engineer of the Company, suggested a method and demonstrated in the laboratory that this principle would work. The first full-scale electric stirrer was tested in 1939 on a 15-ton steel arc furnace. This principle makes the electric furnace an electric motor. The molten bath is caused to move by a magnetic force which is produced by passing an electrical current through a stator mounted underneath the furnace. The Steel and Tube Division of Timken Roller Bearing Company at Canton, Ohio, has used this method since October 9, 1952. Some of the advantages of this operation are: (a) uniform temperature throughout the bath; (b) constant composition throughout the bath; (c) faster metal-slag reactions; and (d) quicker solution of added alloys.

During 1954 the field of vacuum melting was extended to the production of high-temperature alloys and constructional alloy steels on a commercial scale. Larger units are now under construction that will operate continuously without breaking the vacuum. While one charge is being melted and poured in a vacuum chamber, another charge is introduced through an air lock. Vacuum-melting on a commercial scale is done in high-frequency induction furnaces under vacuums of one to ten microns. During the melting process, gases and high vapor pressure elements are distilled off. Nonmetallic compounds and oxides are decomposed. Due to the absence of reactive gases, the normal alloy losses from this cause do not take place. This prevents the formation of nonmetallic compounds which appear in steel as inclusions. Superior quality steels are currently being made by this process. This steel has a superior surface finish, free of inclusions, with fatigue properties many times greater than conventional bearing material.

During the past few years a number of experiments have been conducted concerning the addition of rare earths--metals and oxides--to iron and steel. The rare earths are the elements of atomic numbers 57 to 71, beginning with lanthanum and cerium and ending with lutetium. Morrogh--Research Manager, British Cast Iron Research Association--has shown that small additions of cerium--0.005 percent--are capable of neutralizing the harmful effects of titanium, lead, bismuth, antimony, aluminum, and copper in the production of nodular irons by the magnesium process, thus permitting the use of a much wider range of raw materials. In the United States it has been demonstrated that rare earths--one to two pounds per ton of steel--improve the hot-working characteristics and corrosion resistance of certain stainless steels and the surface qualities and mechanical properties of carbon steels.

One ferroalloy manufacturer claims that the use of rare earths in steel could result in a saving of 100,000 tons of manganese per year in the United States. There are sufficient deposits of rare earths minerals in the United States to supply any foreseeable demand. It is a well known fact that the surface quality of killed low-carbon steel depends on the manganese-sulfur ratio--the higher the ratio, the better the quality. The rare earth metals form relatively stable sulfides in liquid steel which rise through the molten metal to form a slag, thereby eliminating sulfur. Normally, almost all of the sulfur stays in the metal as iron and manganese sulfide. Of particular interest is the improved hot-working properties of Cr-Mn austenitic stainless steel which is normally difficult to hot roll. A project covering the use of rare earths in carbon steels is being conducted by the Bureau of Mines.

The first oxygen steelmaking process in the United States to employ the Austrian Linz-Donawitz technique was placed in operation by McLouth Steel Corporation at Trenton, Michigan, on December 23, 1954. The oxygen process installation includes three 40-ton solid-bottom converters with a capacity of 1500 tons of steel a day. Molten pig iron from the blast furnace is poured into the vessels and high-purity oxygen is introduced at supersonic speed through a lance lowered to about 10 inches above the melt. Up to 25 percent scrap may be added for cooling compared with 6 to 10 percent for air-blown converters. The time required to make steel by this process varies with the grade produced. Actual blowing time may take from 8 to 18 minutes, the latter being for low carbon grades. Higher carbon grades may also be made by recarburizing the low carbon steel of the long blow with molten pig iron which is poured through the slag removing Si, S, and P. The low phosphorus, sulfur, and nitrogen steels produced by this method are comparable with open-hearth steel.

The world's largest blast furnace--hearth diameter 30 feet, 3 inches--built for Great Lakes Steel Corporation at Ecorse, Michigan, was blown in in June 1955.

Electrostatic precipitators for dust removal in steel plants has been extended to sintering plants, open-hearth furnaces, and rolling mills. At one eastern plant they are employed on hot scarfing machines in the blooming and slab mills. A southern plant has installed three units for iron ore sintering machines. Units have also been installed at western plants for various installations.

This is the end of the regular presentation. I understand there will be a considerable question period here so that is all at this time.

QUESTION: Have there been any interesting developments in geological prospecting of any of these materials by aerial photography?

MR. MELCHER: Of course, geologists and mining engineers are working on that problem all the time. There hasn't been anything too startling in the ferroalloy field here in quite a number of years. Most of the progress in that field has been the development and extension of deposits which were known to exist for quite a number of years but without too much known about them. Of course in the area of atomic energy we have done amazing things, but that is in the field of production, in which there were formerly very little market and people more or less paid no attention to it. But in ferroalloys--I imagine you are talking about this country--there has not been anything too encouraging.

QUESTION: Two of the recent technological advances that appear to cut down the time schedule of getting out steel seems to be the so-called turbo hearth and the electric furnace. What incentive does Government give to increase the amount or the number of these kinds of plants?

MR. MELCHER: Incentive by the Government?

QUESTION: Yes.

MR. MELCHER: Very little in the way of direct incentives. Of course, the Government is engaged in a wide range of cooperative research. Some of the standby companies propose to the Government to do research in that connection and obtain research grants from the Government, but most of it is done by cooperative work where the Government is using its facilities wherever possible and contributing public funds to the construction. There may be some indirect assistance in taxation, but there is no formal program of that type.

QUESTION: Birmingham is the only place that has three basic materials all in one spot. In your opinion, what is the most strategic place to put a new steel mill? Would it be near iron ore, coal, or halfway between them, or near the market?

MR. MELCHER: Historically, the cheapest way of doing it is by putting the steel mill near the fuel. However, in recent years there

have been changes and the market conditions have taken on a greater importance than before. In general, the fuel and the market are the governing factors. Rarely does a steel plant develop near the ore supply. That is not only not an economic way of doing it, but the fuel is such a tremendous transportation problem, and, as I say, the market has become a more important factor. Labor supply also is very important.

QUESTION: Has any work been done in the application of nuclear energy as a substitute for coal as a heat source in the manufacture of steel?

MR. MELCHER: There has been quite a bit said about that but very little research. I would say there has been no direct research to any extent, but the area does hold quite a bit of promise as a method of manufacturing steel at reduced cost. Of course, it could be done readily as merely a means of obtaining power, but the process will have to go a lot further than that to make it really attractive.

Probably the most promising area there is through a combination of atomic energy reactors and the possible use of hydrogen as a reducing agent. That is something a lot of steel people are doing a lot of thinking on, but there has really been no direct research in that field.

QUESTION: You stated that 64 percent of the tungsten that we utilize is imported, I believe it was. In Korea we put a considerable effort into reopening tungsten mines. I was wondering if that has been a good investment or if we have reaped any benefits for our stockpiles or what have you?

MR. MELCHER: Yes, we have. Probably my statement was misleading because a large part of the domestic production--virtually all of it--has gone into stockpiling. So the pattern, as far as industry is concerned, has followed the preassistance era, and the stimulated production by Government assistance has gone into the stockpile. You are quite right, there has been a large increase in production in tungsten due to these assistance programs.

QUESTION: Could you give me some idea of the availability of limestone of the proper grades?

MR. MELCHER: I didn't go into that particularly. The country has very large reserves of limestone and it is not a particularly severe

problem strategically. But in the better grades of limestone, they don't happen to occur as a rule where you want them and the problem is almost entirely one of transportation, not of available resources. There is quite a latitude of stone that can be used, such as magnesium bearing limestone, but it does pose problems in transportation.

QUESTION: Assuming that technological advances do not overcome this deteriorating situation with regard to the ores and the coal, and so forth, is it economically feasible for the United States to maintain its leadership in the production of steel as an import nation?

MR. MELCHER: Is it economically feasible?

QUESTION: I mean could we continue to use our plant capacity and import it and be competitive?

MR. MELCHER: Yes. Again the problem is transportation, and modern transportation methods have brought the cost down so low that it is possible, so far as I can see, to import materials on a competitive basis. Of course raw material cost is increasing and will continue to increase and brings in more foreign ore on a competitive basis, which was maybe a negative answer. But the diminishing reserves here has raised the cost to a point where it would continue to be economic on the shipping basis.

QUESTION: I understand that steelmaking is an around-the-clock operation. We have heard one of the union leaders indicate that he would like to put industry on a five-day week. What impact would that have on the industry?

MR. MELCHER: Well, to think of operating the steel industry on a five-day week I think is not a feasible thing to do. Of course, the workers have been on five days for a long time, but to think of closing down or slowing down anything as complicated as a blast furnace for two days and then start up two days later, I think is completely impractical. It would take most of the next five days to get on a smooth operation. I just can't see that it could possibly work.

QUESTION: Getting back again to this problem of transporting fuel to the iron ore or vice versa, or both of them to the market area for the manufacturing process, it would seem that it might be feasible to transmit the coal into electricity in the mining area and move it nearer to the market or to the ore. Is this feasible and is it being done?

MR. MELCHER: Well, it is not being done to any great extent, the reason being that the large use of fuel in the steel industry is not for power but for a reducing agent to reduce iron ores. So if you think in terms of changing the power into electric power, it would mean a revolutionary change in the process for making iron, and I don't see that in the foreseeable future.

QUESTION: You mentioned the use of rare earths to give steel special properties, and specifically you mentioned cerium. Since rare earths are no doubt grouped together because they have certain fusing and chemical properties, do you feel that cerium is specific enough in itself to give steel certain properties or would other rare earths be combined with it?

MR. MELCHER: No, it is not unique. It is just one element. But the material as used probably will be a rather complex compound of all the rare earths, and will probably be a compound because of the cost. The metals are too expensive to use as such.

QUESTION: With the reducing sources of primary ores, I am wondering if scrap is being used to the fullest extent and are there any particular problems in the use of scrap to make it not feasible to use the available stuff?

MR. MELCHER: Yes, there is a very serious problem in scrap for the long-range point of view. Copper is an element which is being introduced in steel at a rather alarming rate. Once copper gets into the steel circuit, no one has ever discovered a means of getting it out. So we are either going to have to find out some way of removing it from other elements similar to it or it will restrict the use of a large part of our scrap. Also some of the poorer grades of scrap bundles are becoming so high in impurity content that it is no longer in demand on the market.

I would say, however, that the scrap resource is being used about as much as it could be. There is some room for argument on that but it is a matter of price and what you can afford to do with scrap. Outside of impurities, the supply of scrap will pretty much follow the production of steel and will be available when used to the maximum extent.

QUESTION: When they talk about steel operating at 90 percent, 95 percent or 105 percent of capacity, what are they talking about?

MR. MELCHER: Rate of capacity is supposed to be the rate at which facilities can make steel, assuming normal time for shutdown periods. That varies slightly in blast furnaces but is about 10 percent. In steel furnaces, it varies maybe from 10 to 15 percent. Assume that a furnace can operate about 90 percent of the time and is down for repairs 10 percent of the time, if they actually operated all facilities for a week, theoretically you could reach 110 percent of capacity. It sounds rather ridiculous, but that explains why you frequently have 101 and 102 percent capacity operation for short periods.

QUESTION: You didn't say anything about refractories in your remarks, yet I remember we spent quite a lot of time trying to get refractory chrome for the stockpile. Are we going more toward magnesite or silica or are we depending on importing refractory chrome?

MR. MELCHER: We are still depending on imports for chrome refractories. The chrome use pattern is rather peculiar because actually the industry has tried for years to use the maximum amount of chromite in making refractories because of economics. It has been the cheapest thing to make refractories out of and still have a good refractory. So much of the use of chrome refractories could be substituted by magnesite and as a practical trend more and more mixtures of the two are being used. Chrome makes a very desirable refractory because of its high melting point and because it is neutral to all slag action. It is affected by neither acid slags nor basic slags.

QUESTION: On the direct casting, how big ingot do they draw on a regular sized run?

MR. MELCHER: I don't know what the size is. I can say this, that none of them are of the large commercial ingot size.

QUESTION: The reason I asked was that I was curious as to why it took so long. They were drawing up to four-inch copper.

COLONEL NYQUIST: Mr. Melcher, on behalf of the College, I want to thank you for coming down here and giving us a very interesting and educational discussion. Thank you.

MR. MELCHER: Thank you, Colonel.

(4 Jan 1956--250)K/en