

## IRON.

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In view of the extraordinary developments of the iron mining and manufacturing industries in the United States since the beginning of the war in Europe, and in view of the inevitable further increase in demand for iron and steel as a consequence of the entrance of the United States into the war, it is of interest to review these developments briefly and to consider how fully it may be possible to meet these increased demands.

### CONDITIONS IN 1914 AND LATER.

Prior to the beginning of the war—indeed, during nearly the whole of the year 1914—the iron industry was in a state of stagnation. Prices were low, there was but little domestic or foreign demand for iron and steel, and that little demand was easily met by the operation of mines and furnaces at a greatly reduced rate of output compared with that of the two preceding years. In fact, many companies that could have saved money by closing their mines and furnaces generously kept them in operation to an extent sufficient to support part of the army of people dependent on the wages earned in normal times.

The first effect of the European war on the financial situation in the United States was such as still further to discourage the buying of iron and steel products and to depress prices. This condition, of course, could not well be other than temporary, for, as was pointed out by the Director of the Geological Survey in Bulletin 599, published in the autumn of 1914, the interference of war with industries in the belligerent countries could not fail to reduce the output of their mines and furnaces and to enlarge the demand for American iron and steel. It also seemed probable that domestic markets on the Pacific coast, formerly supplied in large part by manufacturers in England, Belgium, and Germany, would become open to American manufacturers, as well as markets in Canada, South America, and Japan.

Such trade revivals and readjustments require time for their accomplishment, even under the impetus of war conditions, and it was not

until the middle of 1915, or until the war had been in progress nearly a year, that the demand for iron ores and metals had become general throughout the United States. Not until June or July, 1915, did the price of pig iron begin to rise, and although the year closed with prices \$1 to \$1.25 a ton higher than at the beginning of the year, the average price at blast furnaces of all grades of pig iron for 1915 was 21 cents lower than the average for 1914.

As soon as the demand for iron ore became heavy, about the middle of 1915, it met with a ready response, particularly in the Lake Superior district, where there was an increase in shipments of nearly 45 per cent in 1915, compared with an aggregate increase of about 12 per cent in the other iron-mining districts of the United States. In 1916 the heavy movement of ore began as soon as navigation opened, with the result that more than 66,500,000 gross tons was shipped from the Lake district, an increase of nearly 41 per cent. The total shipments for the United States in 1916 amounted to 77,870,553 tons, an increase for the whole country of about 40 per cent. The increase in districts other than Lake Superior was about 41 per cent. The quantities mined, which are given in the table on page 4, differ slightly from the shipments just mentioned.

At the beginning of 1916 extraordinary activity prevailed in the iron and steel industries, and this activity was maintained with comparatively little variation throughout the year, as is indicated by the record of pig-iron production by months, which ranged between 3,000,000 tons and slightly over 3,500,000 tons. The total production in 1916 amounted to 39,434,797 gross tons, compared with 29,916,213 tons in 1915,<sup>1</sup> an increase of 32 per cent, following a 28 per cent increase in 1915. In the first six months of 1917 the output of coke and anthracite pig iron<sup>2</sup> was 19,069,892 gross tons, compared with 19,410,453 tons in the corresponding period of 1916, a decrease of about 1.7 per cent.

The general average prices of iron ore per ton at the mines for the whole United States were \$1.81 in 1914, \$1.83 in 1915, and \$2.34 in 1916. At lower Lake ports ore prices were advanced 70 to 75 cents a ton for the season of 1916, after having remained stationary since 1914. For the season of 1917 there was a general advance of \$1.50 a ton, or 2.7 to 2.9 cents a unit of iron. The 1916 and 1917 advances range between 15 and 21 per cent and 25 and 30 per cent respectively. Compared with these modest advances prices of pig iron rose greatly during 1916. Southern foundry No. 2, at Birmingham, rose from \$13 to \$22 a ton, an increase of 69 per cent. Southern Ohio No. 2, at Ironton, seems to hold the record with an increase from \$14 to \$30, or 114 per cent, and the higher grades of iron also held up well, as indicated by the rise in Bessemer iron at Pittsburgh

<sup>1</sup> Iron and Steel Institute.

<sup>2</sup> Iron Age, July 5, 1917, p. 35.

from \$20 to \$36, or 80 per cent. In the middle of July, 1917, the price of basic pig iron at western Pennsylvania valley furnaces and of Bessemer pig iron at Pittsburgh reached \$53 and \$57.95 a ton, respectively,<sup>1</sup> the highest points since the Civil War.

With regard to the iron-ore situation, which is, of course, of fundamental importance, it was stated by the Geological Survey at the beginning of the war that the iron-ore reserves in the United States are so huge that mining operations (so far as the available ore is concerned) can readily respond to an increased demand for ore. The great increase in ore output during 1915 and 1916 and the fact that there was only a very moderate rise in the price of ore compared with the extraordinary rise in the price of pig iron indicate the accuracy of the prediction. At present the chief limitations to output of iron ore in the Lake Superior region are those imposed by shortage of labor and of transportation facilities. Notwithstanding the great drain on the iron-ore reserves new discoveries of ore have practically kept pace with production, so that there is as much ore known to be available as at the beginning of the war. This enlargement of known reserves is due largely to exploration work on the Cuyuna range, in Minnesota. In the summer of 1916, when the season for open-pit mining and shipping of iron ore was at its height, strikes among mine and dock laborers threatened seriously to curtail output and shipments, but a firm hold on the situation by the mining companies, coupled with a disposition to share profits with employees, averted serious or protracted trouble and made possible a record output of iron ore. The Lake transportation situation was further aided by high water and generally favorable weather, and there was good team work between the Lake fleet and the railroads at both ends of the chain. It has been freely predicted, however, that the present railway equipment and vessel tonnage can not greatly increase the movement of Lake Superior ore.

In other iron-ore districts, such as the Adirondack region, southeastern New York and northern New Jersey, and the Birmingham district, there was also much activity. These districts are relatively small, and their output could not have been increased in so large a proportion from existing mines, which are largely underground, had not the output of 1915 been only about normal or less than normal. In these and other small districts many long inactive mines were reopened; in fact, almost every mine that contained available ore of present commercial grade was drawn upon, and if an iron-ore mine can not be made to pay under present conditions there seems little hope for its immediate future.

Blast furnaces on the Atlantic seaboard, when possible, draw their supplies of ore, in part, from Cuba, Sweden, Spain, Canada, and

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<sup>1</sup> Iron Age, July 19, 1917, p. 149.

Chile. The resumption of traffic through the Panama Canal made possible the importation of Chilean ore and also the transportation of iron and steel products to the Pacific coast of North and South America, to the Hawaiian and Philippine islands, and to Japan. The shortage of vessels, however, has seriously handicapped this trade.

#### IRON MINING BY DISTRICTS.

The bulk of the iron ore mined in the United States is produced in certain well-defined districts, and statistics of production by these units are of interest in showing how each has responded to the quickened demand for ore since 1914. The Lake Superior district mined nearly 85 per cent of the total ore in 1916, and the Birmingham district about 7.9 per cent, or less than one-tenth as much as the Lake district. The Adirondack is the only other individual district that mined as much as 1,000,000 tons. The increase in production in the Lake Superior district approximated 40 per cent in 1915 and 36 per cent in 1916; the other districts showed increases angling between 6 and 55 per cent in 1916.

*Iron ore mined in the United States, 1913-1916, in gross tons.*

	1913	1914		1915			
		Quantity.	Increase or decrease (percent).	Quantity.	Increase or decrease (percent).	Quantity.	Increase (percent).
Lake Superior (Minn., Mich., Wis.).....	52,377,362	33,540,403	-36	46,944,254	+40	63,735,088	36
Birmingham, Ala.....	4,602,573	4,282,556	-7	4,748,929	+11	5,976,018	26
Chattanooga (Tenn., Ala., Ga., N. C.).....	708,619	432,006	-39	539,024	+25	836,623	55
Adirondack, N. Y.....	1,214,704	544,724	-55	699,213	+28	1,077,638	54
Northern New Jersey and southeastern New York.....	451,453	541,084	+20	644,493	+19	683,150	6
Other districts (south, central, and western).	2,625,726	2,098,988	-20	1,950,577	-7	2,859,155	47
	61,980,437	41,439,761	-33	55,526,490	+34	75,167,672	35

#### FOREIGN TRADE.

Comparatively little iron ore is imported into the United States—only 1,000,000 to 2,000,000 tons a year, or about 2 to 3 per cent of the quantity annually mined. Moreover, the exports of iron ore nearly offset the imports, so that the United States is at present self-sufficient so far as the supply of iron ore is concerned. Such ore as has been imported in recent normal years has come mainly from Cuba, Newfoundland, Canada, Spain, and Chile. Supplies from the United Kingdom, Germany, the Netherlands, and Belgium were almost wholly interrupted in 1915 and 1916, and it is probable that

the imports from Newfoundland, which diminished greatly in 1914 and ceased altogether in 1915, have been diverted to England or used at home. Supplies from Canada, however, arrived in increased volume in 1915 and 1916, largely from the Canadian ranges in the Lake Superior district.

It is possible to import high-grade iron ores such as are received from foreign countries for use along the Atlantic seaboard, if there is no interference with shipping and when ocean freights are low and there is no tariff on the ore. Even under these favorable conditions, however, foreign ore rarely gets beyond the tidewater furnaces. Although the United States possesses supplies of iron ore sufficient for normal demands and for many years of war needs, both European and American, present economic conditions render it practicable to import ore, especially from Cuba and South America. Iron ore forms the basis of the largest manufacturing industry in the United States. The profits to both capital and labor are derived from the manufacture and sale of iron and steel products rather than from iron-ore mining; therefore, so long as the United States can utilize cheap ores from Latin America and export to those countries, as well as to Europe and the Orient, fabricated iron and steel goods, there is reason to favor continued importing of iron ore. Moreover, as little good coal is known to occur near the largest deposits of iron ore in South America it may never be feasible to establish the manufacture of iron on a large scale on that continent. South American iron ore will thus find a market either in Europe or in the United States, and whatever part of it is commercially available to the United States should serve two important purposes if sold here, namely, in increasing trade between the United States and South America and in conserving the ore supplies of the United States.

The quantity of iron ore exported from the United States in recent years has only slightly exceeded 1,000,000 tons in any year, and the largest imports have been only a little over 2,500,000 tons.

A comparison between the quantities of iron ore mined in the United States and those imported and exported in the last five years is given in the following table:

*Iron ore mined, imported, and exported in the United States, 1912-1916, in gross tons.*

Year.	Mined.	Imports.	Exports.
1912.....	55,150,147	2,104,576	1,195,742
1913.....	61,980,437	2,594,770	1,042,151
1914.....	41,439,761	1,350,588	551,618
1915.....	55,526,490	1,341,281	707,641
1916.....	75,167,672	1,325,736	1,183,952

The imports of manufactured iron and steel (not including ferro-alloys) into the United States in the last three years have not varied greatly and are small in comparison with the exports, which have increased enormously, as shown in the following table:

*Value of iron and steel products imported and exported in 1914, 1915, and 1916.<sup>a</sup>*

	Imports.	Exports.
1914.....	\$11,703,491	\$65,988,280
1915.....	9,122,108	153,626,753
1916.....	11,098,607	362,524,715

<sup>a</sup> Compiled from records of Bureau of Foreign and Domestic Commerce, Department of Commerce.

A graphic comparison of domestic production and consumption of both iron ore and pig iron is shown in figure 4.

#### GEOGRAPHIC DISTRIBUTION OF IRON-ORE DEPOSITS.

The major features of the distribution of iron-ore deposits in the United States are now well known, and most of the ore-bearing districts that are advantageously situated with respect to transportation facilities, fuel supplies, manufacturing centers, and markets have been studied in more or less detail by the United States Geological Survey or by State organizations, including tax commissions, so that estimates of ore tonnage are available. Future general work in the less well-known areas and more detailed work in the better-known areas by both public and private agencies will probably increase rather than decrease the tonnage apparently available.

The locations of the principal deposits of iron ore in the United States are too well known to need extended description here. Twenty-eight States are regular producers of iron ore, and several others contain deposits of value. The States in which commercially important deposits of iron ore occur may conveniently be grouped into six geographic divisions, as shown in the following list, in which the varieties of ore found in each are also indicated:

1. Northeastern States: Massachusetts, Connecticut, New York, New Jersey, and Pennsylvania. Magnetite, hematite, and limonite.
2. Southeastern States: Maryland, the Virginias, Tennessee, North Carolina, Georgia, and Alabama. Hematite, limonite, and magnetite.
3. Lake Superior States: Michigan, Wisconsin, and Minnesota. Hematite, limonite, and magnetite.
4. Mississippi Valley States: Ohio, Kentucky, Iowa, Missouri, Arkansas, and eastern Texas. Limonite, hematite, and siderite.
5. Rocky Mountain States: Idaho, Montana, Wyoming, Colorado, New Mexico, Utah, and Nevada. Hematite and magnetite.
6. Pacific States: Washington and California. Magnetite and hematite.

The Lake Superior region is by far the most productive of these divisions and is followed in order by the southeastern and north-

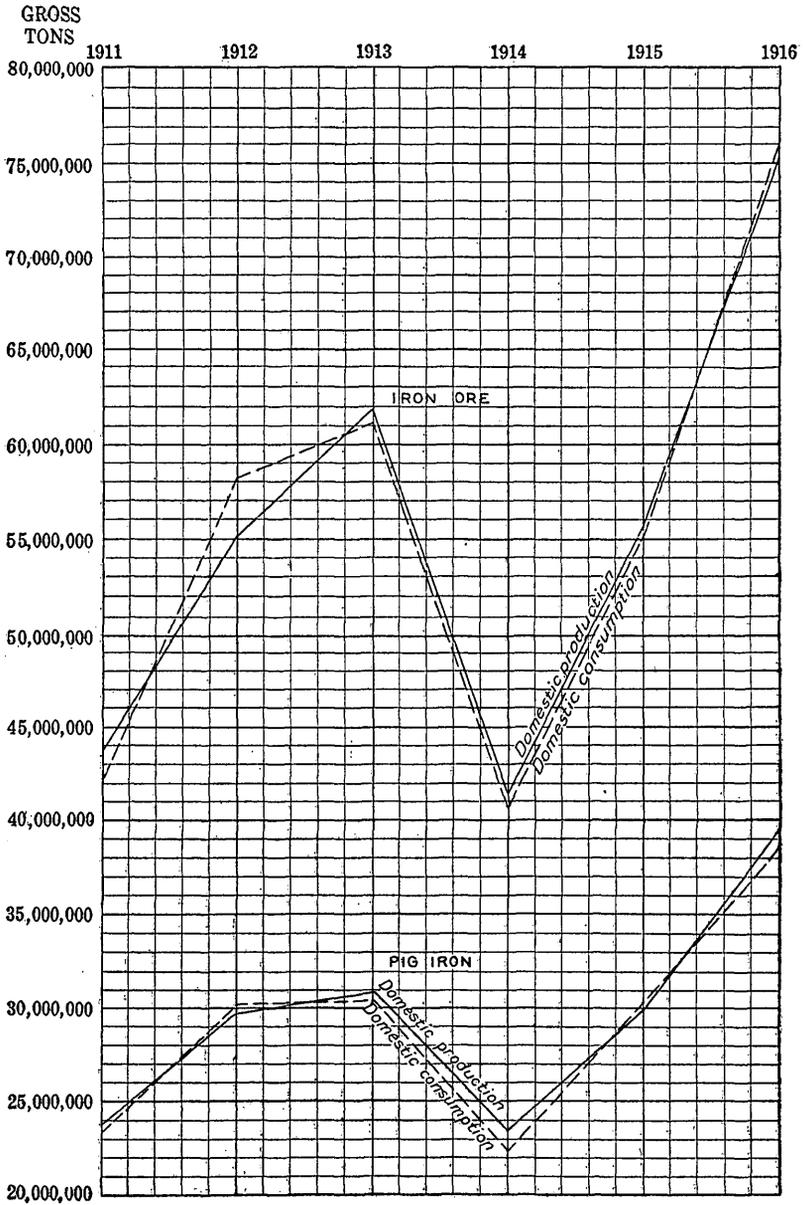


FIGURE 4.—Domestic production and consumption of iron ore and pig iron, 1911-1916.

eastern divisions; the Mississippi Valley and western divisions are at present of minor importance, although it is probable that Texas, California, and Utah are destined to become large producers of iron ore.

## IRON-ORE RESERVES.

The following data on estimated tonnages of iron ore in the United States and in other countries bordering the Atlantic Ocean have for the most part been published by Eckel,<sup>1</sup> although arranged somewhat differently here:

*Estimated tonnages of iron ore.*

	Minimum.	Maximum.
UNITED STATES.		
Northeastern States.....	300,000,000	600,000,000
Southeastern States.....	2,000,000,000	2,750,000,000
Lake Superior States.....	2,000,000,000	2,500,000,000
Mississippi Valley States.....	600,000,000	1,000,000,000
Rocky Mountain States.....	300,000,000	700,000,000
Pacific States.....		
	5,200,000,000	7,550,000,000
FOREIGN COUNTRIES.		
Newfoundland, Canada, Mexico, and Cuba.....		7,000,000,000
South America.....		8,000,000,000
Europe.....		12,000,000,000
Total tonnage on three continents bordering Atlantic Ocean.....		34,550,000,000

These recent estimates credit to the United States between 5,000,000,000 and 7,500,000,000 tons of iron ore of present-day commercial grade, of which about one-third is in the Lake Superior district. It thus appears that the United States possesses more than one-fifth of the available supply on three continents bordering the Atlantic Ocean.

Immense as this quantity may seem at first glance, it is not sufficient to prolong production for many decades if the rate of increase in consumption of ore that has prevailed thus far is maintained. The draft on the ore reserves of the Lake Superior district is relatively much heavier than on those of the other districts, on account of the possibility of open-pit mining on the Mesabi and Cuyuna ranges and the low cost of transporting the ore to coal fields. The Lake district normally produces over four-fifths of the iron ore mined in the United States, and it has been estimated that if this proportion and present rate of increase are both maintained the known ore reserves of present commercial grade in the United States portion of the Lake Superior district can not last much beyond the year 1930.<sup>2</sup> There are certain factors, however, that indicate the possibility of a considerable prolongation of the life of the Lake Superior iron-ore supplies, as well as of those of the whole United States. If ore consumption should continue at the present rate, with no further increase, the estimated reserves of present commercial grade in the United States would probably be sufficient for 150 years.

<sup>1</sup> Eckel, E. C., Iron ores, pp. 381-397, McGraw-Hill Book Co., 1914.

<sup>2</sup> Idem, p. 355.

## IMPORTANCE OF CONSERVING IRON ORE.

The conservation of the iron-ore supplies of the United States, the discovery of new supplies, and the development of methods for rendering supplies of low-grade ore available are vital to the maintenance of the industrial independence and supremacy of this country, notwithstanding the apparent abundance of the supplies at present available, for, as has been pointed out, the reserves of high-grade iron ore now convenient of access are rapidly becoming depleted.

Certain important factors that will aid in prolonging the life of the iron-ore reserves of the United States may be summarized as follows:

1. The steady accretion to the permanent supply of metal and the consequent reduction in rate of increase of production (waste of war not taken into consideration).

2. The adoption of methods of conservation of ore and metal.

3. The increase in imports of ore from Cuba and South America, whose deposits must logically be regarded as a portion of the immediately available reserve, as such ores can be used most profitably and economically in the United States.

4. The further discovery of iron-ore deposits in the Western Hemisphere.

5. The possibility of metallurgic improvements that may enable pig iron to be derived economically from low-grade ores, and the solution of metallurgic problems, including that involving the utilization of titaniferous iron ores, of which there are large deposits not now available

6. The increase in the price of pig iron, which will bring lower grades of iron ore into the market, thus vastly increasing the tonnage of reserves available.

## IRON AND STEEL MANUFACTURE.

Any discussion of the ability of the United States to continue to furnish iron and steel to her allies in Europe at the same or a greater rate than was maintained in 1916 and at the same time to meet the superimposed demands of war on the part of this Nation itself must take into consideration many factors bearing on the iron and steel making capacity of the country. At the outbreak of the war the iron and steel industry was operating on a subnormal scale, and consequently the manufacturing capacity was in excess of requirements. Some of this excess capacity was, of course, represented by antiquated equipment that could not be put into shape for resumption of operations on short notice. The excess capacity at the opening of the war was greater in blast furnaces than in steel furnaces, so that one of the first effects of the war was to stimulate the building of

new steel furnaces. According to the Iron Trade Review,<sup>1</sup> the steel-making capacity at the beginning of 1915 was estimated at 37,500,000 tons, at the beginning of 1916 at 39,000,000 tons, and on January 1, 1917, at 43,000,000 tons, and it is expected that by January 1, 1918, it will amount to 48,000,000 tons. Thus there will have been an increase in three years of 10,500,000 tons, or 28 per cent, in steel-making capacity. The increase in capacity for basic-process steel is estimated to be about one-third greater than that for the acid process. The pig-iron capacity is estimated to have been more than 39,000,000 tons at the beginning of 1916 and to have been brought up to 40,000,000 tons at the beginning of 1917, but the prospective increase in blast-furnace capacity for 1917 is larger than for several years and will tend to close the gap between steel-making and pig-iron producing capacity, which has been becoming too wide.

The iron and steel making capacity at the end of 1917 will be none too large, judged by present and prospective demands, and probably it will not be large enough to fill orders promptly. The present excessively high prices are sufficient indication that the manufacturing capacity of the country is wholly absorbed. As to still further expansion there are of course limitations other than the demands for iron and steel. The capital involved in the iron and steel industry is so vast that ordinarily the future has to be taken seriously into consideration in planning new plants or additions to old plants. Wartime demands and prices, however, have upset many precedents and have encouraged many increases in plant capacity irrespective of the consideration whether or not they might prove excessive after the war. This has been particularly true of concerns whose profits have been great enough to pay off back indebtedness and pay for the additions to their plants within a year or two of their construction. In looking to the future the optimist has seen a demand heavier than normal after the war. Several factors in the domestic situation have appeared encouraging, such as the needs of the railways, of building construction, of the automobile industry, and of shipbuilding. Railway and general building and improvement work, except where urgently needed, is usually postponed in times of high prices and uncertain deliveries, but the longer these industries are deprived of supplies through such conditions the greater the flood of orders that will be released when conditions once more approach normal. Foreign trade with South America and the Orient is expected to grow, and European trade in the necessities of peace is expected to be augmented after the end of the war. The entry of the United States into the war and the

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<sup>1</sup> Have we too many steel furnaces? Iron Trade Rev., Jan. 4, 1917, p. 47.

demands of this Government for iron and steel of course once more raise the question whether further increases in capacity will be absolutely needed on that account. Certain large steel makers have patriotically assured the United States Government that they would furnish the steel needed for the war at prices very much below those current in the spring of 1917. This fact in itself may deter further increase in capacity, inasmuch as profits from such work sufficient to pay for the increase within a few months will not be in sight. It is probable also that the Government orders will be placed slowly and will not exert a sudden strain on manufacturing capacity.

There are also certain factors which will affect the manufacturing capacity just as vitally as insufficient equipment. Among these are limitation of supplies of coke and other fuel and of ore, due to insufficiency of transportation facilities and of labor, as well as shortage of labor at the steel mills. Some observers of the situation feel that the capacity for making crude metals will probably prove sufficient, but that the real problem lies in the ability to fabricate the special articles used in warfare, as well as in the industries expanded by war demands.

#### ESSENTIAL GEOLOGIC AND METALLURGIC STUDIES.

Interest in the question of the duration of iron-ore reserves has already been awakened. Estimates of such reserves based upon incomplete field work of the United States Geological Survey show that, though relatively great, the reserves are not unlimited, and statistical canvasses extending back for many decades show the immense increases in consumption of ore, so that data are available from which calculations may be made with reference to the probable life of the deposits. Much may yet be done to further the work of iron-ore conservation and efficient utilization. The United States Geological Survey should continue both reconnaissance and detailed geologic work on the deposits of iron ore and manganiferous iron ore within the country and also keep more closely in touch with commercial developments, both prospecting and mining, so that at any time up to date information may be readily available concerning the status of the iron-ore reserves. Statistical data should be gathered from year to year that will show accurately the variation in the metallic content of the ore as mined, the quantities of ore of different grades that are mined, and thus the general trend during a series of years. Technologic studies should be made, both under Government auspices and by mining companies, bearing upon the decrease of wastage in iron-ore mining, upon the possibility of increasing the percentage of extraction in mining, and upon the problems of beneficiating iron ore, through processes by which enormous

supplies of ore of grades too low to be utilized under present conditions may be made available. Here also is an opportunity for the invention or improvement of metallurgic processes by which pig iron may be made commercially from ores of lower grade than at present used and from titaniferous ores, and by which ores may be smelted electrically in regions where cheap water power is available but good coal is scarce.