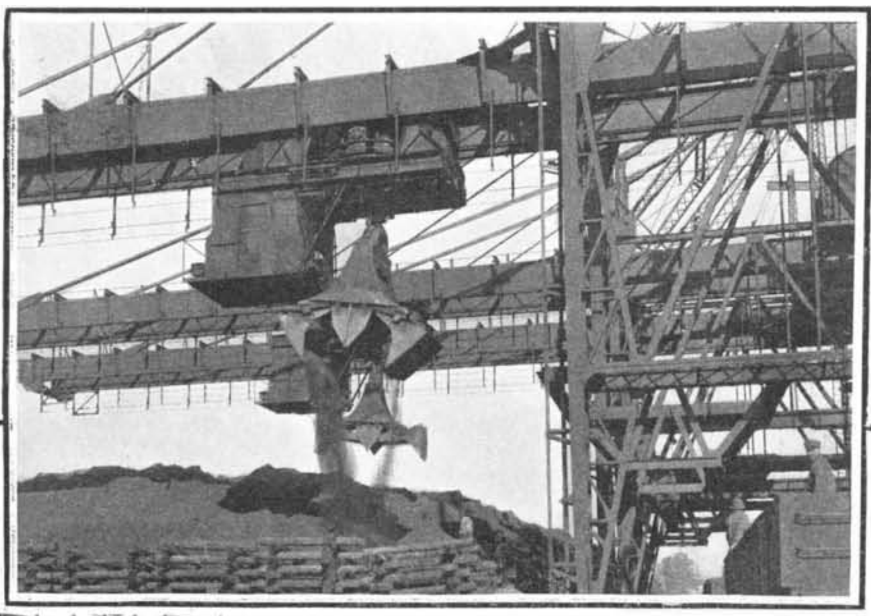
The Wonderful Iron Mines of Lake Superior—How the Ore is Mined and Carried in Bulk.

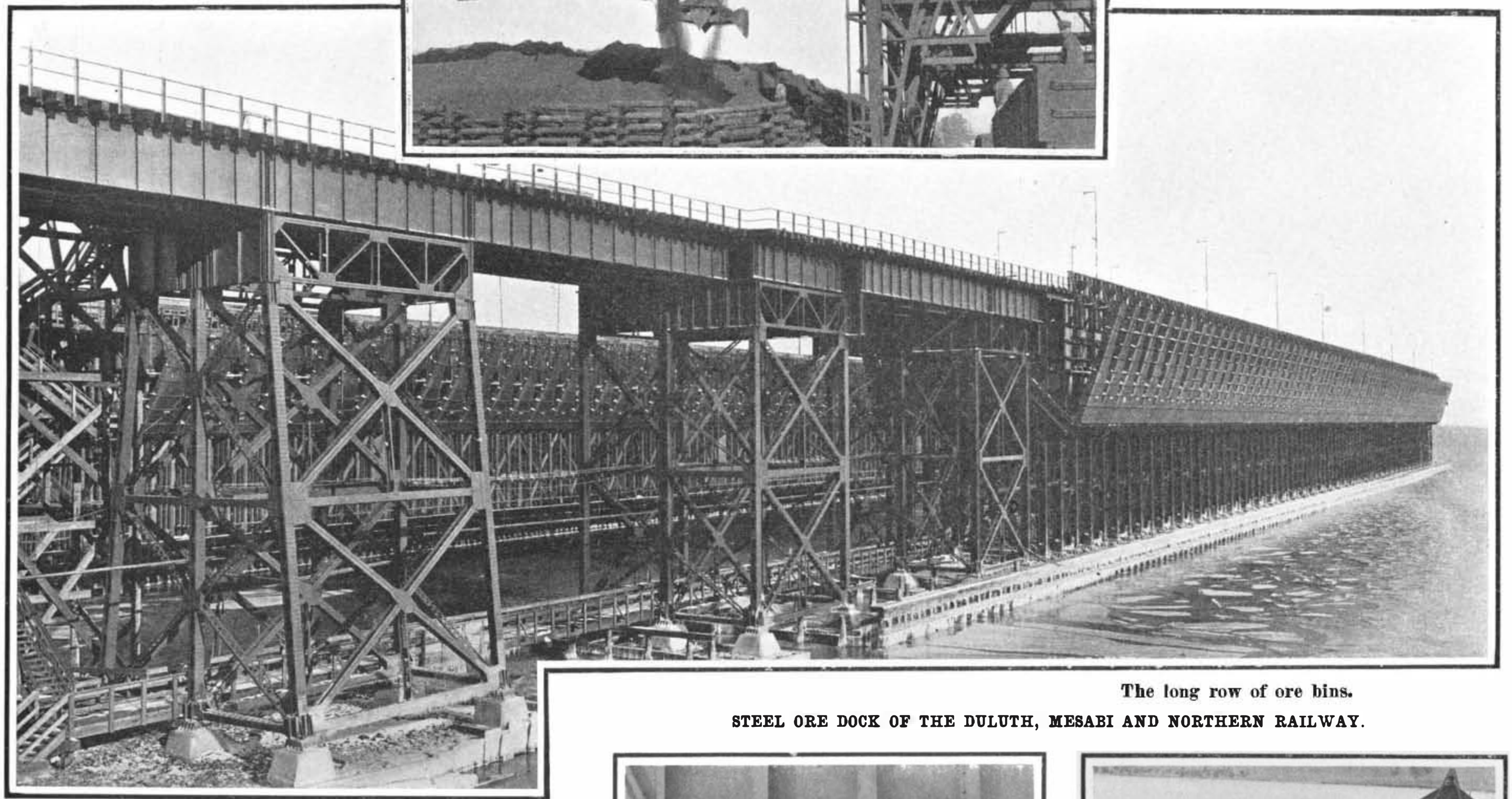
It usually happens that the attainment by a particular people of great distinction in some special branch of the industrial arts is due to the natural characteristics of the country in which they live. This is certainly true of our own country, whose wide extent and rich natural resources have impelled us to the construction of ingenious appliances for the handling and transportation of material in great bulk, which have made the name of the American mechanical engineer known throughout the civilized world. Particularly is this true with regard to the mining and transportation of minerals, the most bulky and less costly of which (coal and iron ore) are produced and shipped on a scale of magnitude not equaled in any other country of the world.

In a Special Number, devoted to the Great Middle West, a conspicuous position must necessarily be taken by the steel industry. Elsewhere we have dealt with Gary, where the largest and most up-to-date steel works in the world has lately been put in operation. The present chapter describes the vast deposits of rich iron ore which lie near the shores of Lake Superior, and those methods of mining, transportation, loading and unloading, by which the enormous bulk of ore, which is necessary to keep the blast furnaces of our steel works in continuous operation, is brought from mine to furnace at a cost so low as to enable this country to manufacture steel far more cheaply than any other country in the world.

The Lake Superior Iron Mines.—If Nature had set out with the determination to assure for the United States the premier position in the steel industry of the world, she could scarcely have done so more effectively than by spreading out around the western and southern shores of Lake Superior those huge deposits of iron ore above referred to. Not only do the ore formations cover vast areas, but in the wonderful Mesabi mines the ore lies practically at the surface of the ground, and frequently, after a few feet of overlying material have been stripped off, the cars can be run right into the mine and loaded directly by steam shovels. Furthermore, the Lake Superior ore is of unusual richness, much of it running over sixty per cent iron. The principal mines are located in ranges, of which the most famous are the Menominee, Marquette, and Gogebic ranges in Michigan, and the Vermillion and Mesabi ranges in Minnesota. The mines are located from twenty-five to seventy-five miles from the shores of Lake Superior. Eight separate railroads carry the ore to as many shipping ports on the lake, where it is unloaded into twenty-six docks having a total storage capacity of 1,326,616 tons. The total hauling capacity in a single day

Five-ton buckets unloading material at the stock pile.

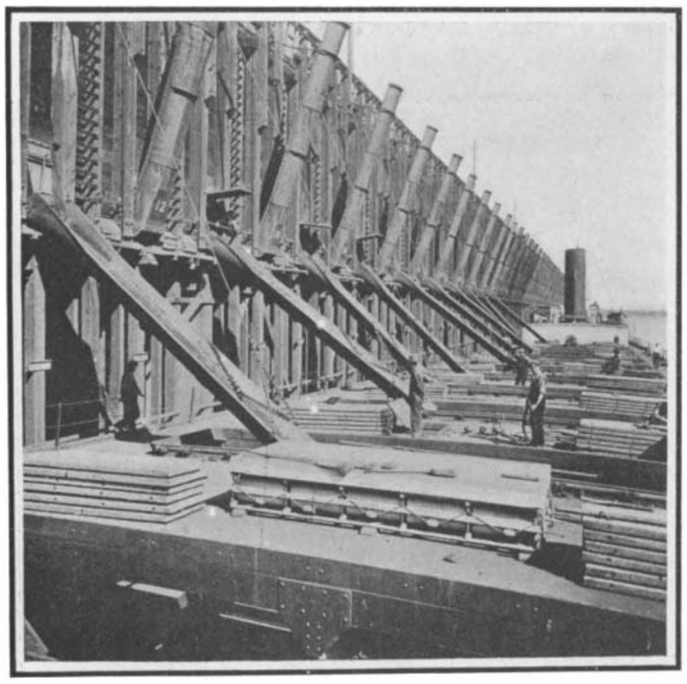




The long row of ore bins.

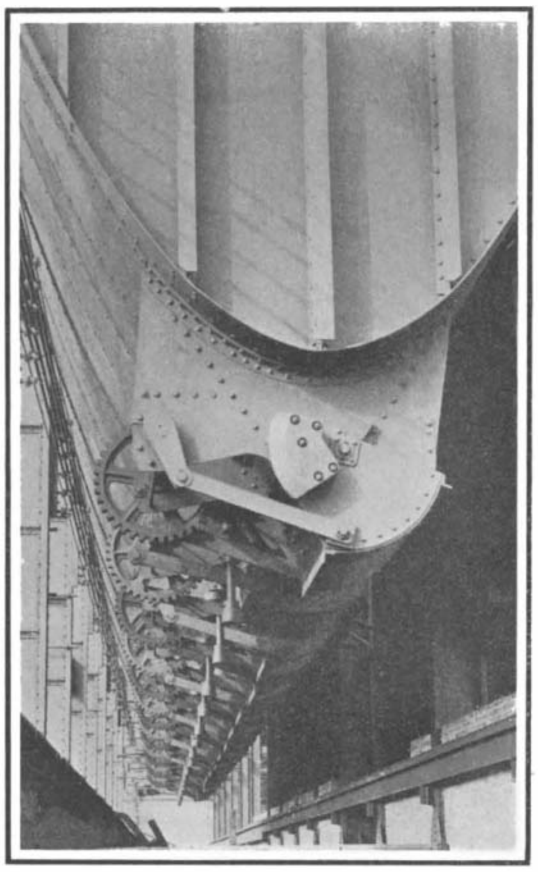
Steel viaduct approach over which trains run to the ore bins.

STEEL ORE DOCK OF THE DULUTH, MESABI AND NORTHERN RAILWAY.



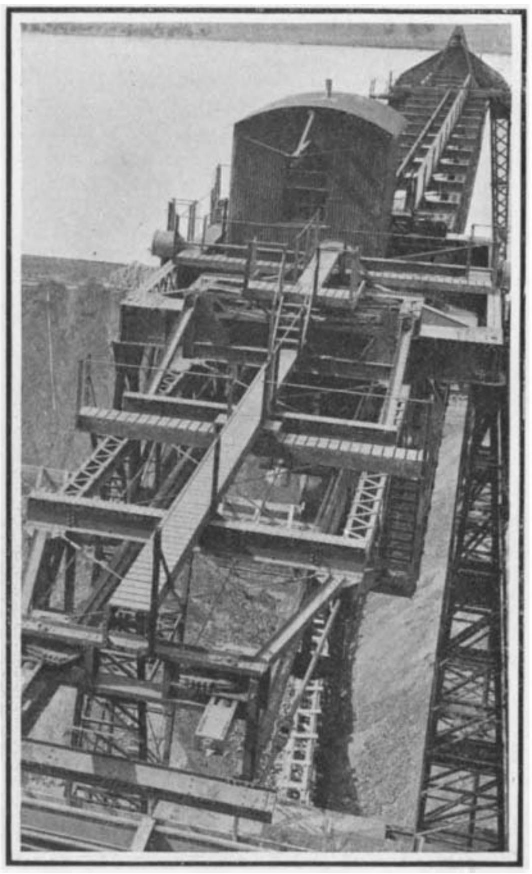
The ore discharges through spouts by gravity into the holds of the steamers.

VIEW OF STEEL ORE DOCK AT DULUTH, MINN., TAKEN FROM DECK OF STEAMER.



The ore is delivered to these bins from the steamer or stock pile.

ORE, LIME, AND COKE BINS AT FEDERAL FURNACE STEEL PLANT.



Shows details of Brown hoisting machinery. Length, 354 ft. 8 in.; bucket lifts 7½ tons.

TOP VIEW OF ELEVATED BRIDGE TRAMWAY AT BUFFALO, NEW YORK.

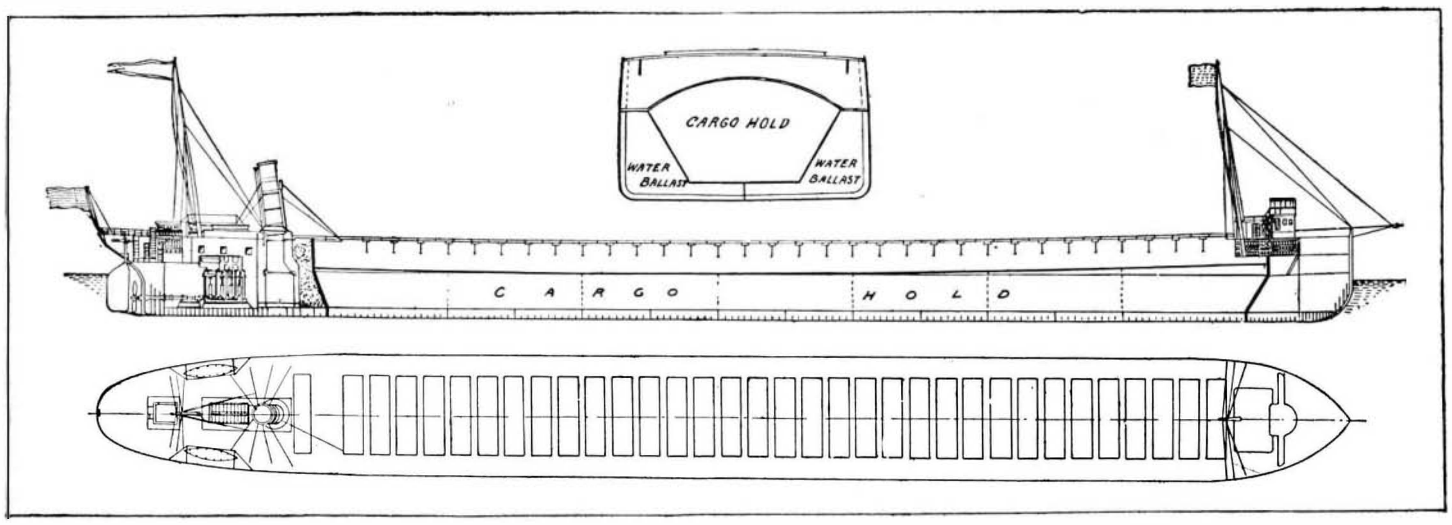
of these eight railroads combined is 250,000 tons. The greatest record for unloading is that of the Duluth, Mesabi & Northern, which in a single day has loaded 165,000 tons into sixteen steamships.

In the course of an interesting and illuminating address dealing with the history of the Lake Superior mines, given last summer by William J. Olcott, president of the Oliver Mining Company, Duluth, the speaker drew attention to the fact that in 1844, while William A. Burt was surveying township lines and making geological observations in Marquette County, Michigan, he noticed a deflection of eighty-seven degrees from the normal of the solar compass, and thereupon sought for and found at several points outcrops containing iron ore. In 1847 a forge was started about three miles from these outcrops, and on February 10th, 1848, the first iron to be made in the Lake Superior region was produced by Ariel N. Barney, the daily output of the forge being about six tons. The early development of these mines was little more than crude exploration. In the winter of 1850, the first ore was hauled to Marquette on the shores of Lake Michigan. In 1852, Congress granted to the State of Michigan 750,000 acres of land for the construction of a small canal around the Rapids of St. Mary's River, connecting Lake Superior and Lake Huron. The canal was completed in 1855, and the first shipment of iron ore consisted of 132 tons, which passed through the canal on August 17th of that year. In those early days mining was done by open-pit-work methods, the ore being hauled out in carts and dumped into railroad cars. The Marquette range furnished all the iron ore from Lake Superior until 1876, when shipments began to be made from Menominee range, from which the total output to date has been 63,641,213 tons. In 1885, shipments began to be made from the Gogebic in Michigan and Wisconsin, and from the Vermillion mines in Minnesota. Up to date from Vermillion alone over 28,000,000 tons of high-grade ore have been shipped.

The most famous of the Lake Superior mines, however, are those of the great Mesabi range in Minnesota, which extends for an unbroken distance of eighty miles and includes no less than eighty-six mines. The geological formation is peculiarly favorable for mining. The greater part of the ore bodies lie horizontally, and are covered by a shallow bed of glacial drift. To get at the ore, it is merely necessary to remove the surface covering, and then excavate the ore with the steam shovel, loading it directly into the cars, trains of which are run into the mines for this purpose. Furthermore, the ore beds are as rich as they are extensive, for analysis shows them to consist of from 47.50 per cent to 61.26 per cent of pure iron, with an average for the whole district of probably about 57 per cent of iron. Although the first mine in the Mesabi range was discovered as late as 1890, in the year 1907 over 27,000,000 tons were shipped from this range alone. "It is the low cost and capacity for enormous production of the Mesabi range," says Mr. Olcott, "that is the guarantee of the continued supremacy of the United States in the manufacture of iron and steel."

We are accustomed to look upon the excavation of

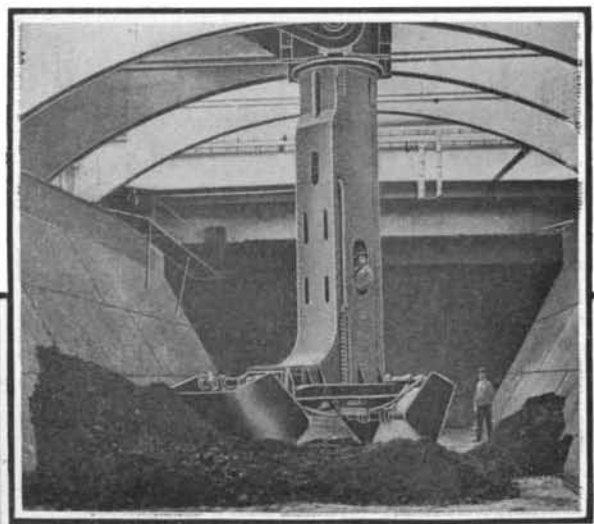
(Continued on page 449.)

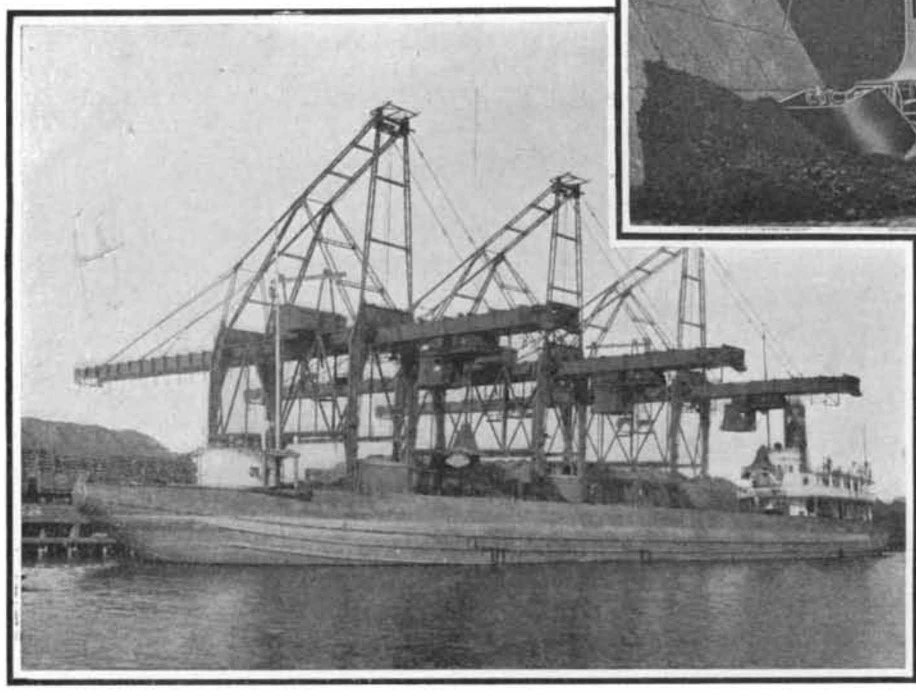


Transverse section, inboard profile, and plan, showing the one great hopper hold 409 feet long with its 33 hatches.

THE "WOLVIN," A TYPICAL LAKE STEAMER FOR THE TRANSPORTATION OF ORE. CAPACITY 11,536 TONS.

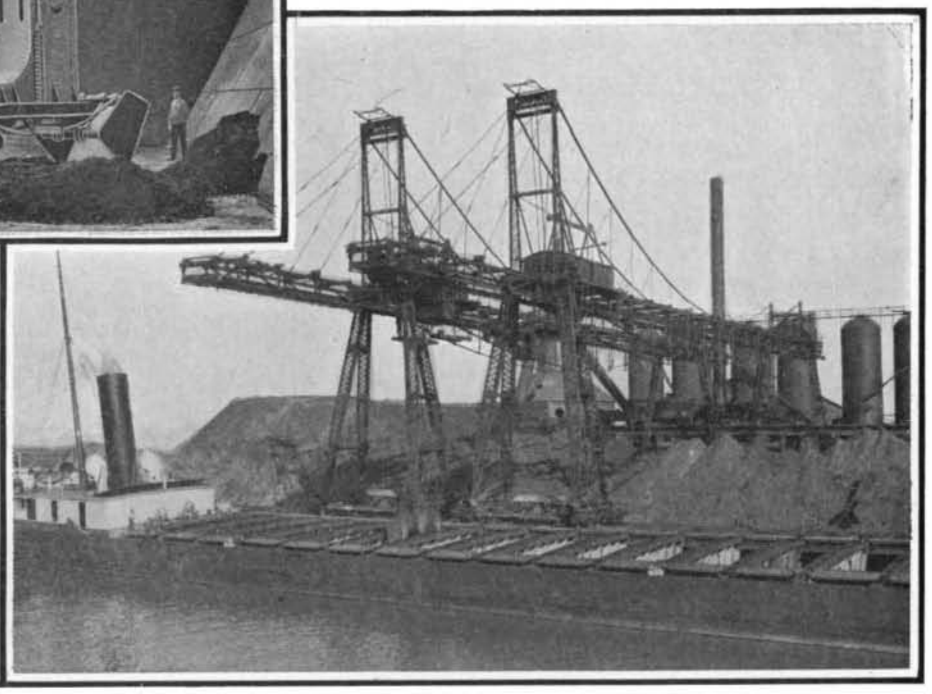
Ten-ton bucket of unloader in hold of the "Wolvin."





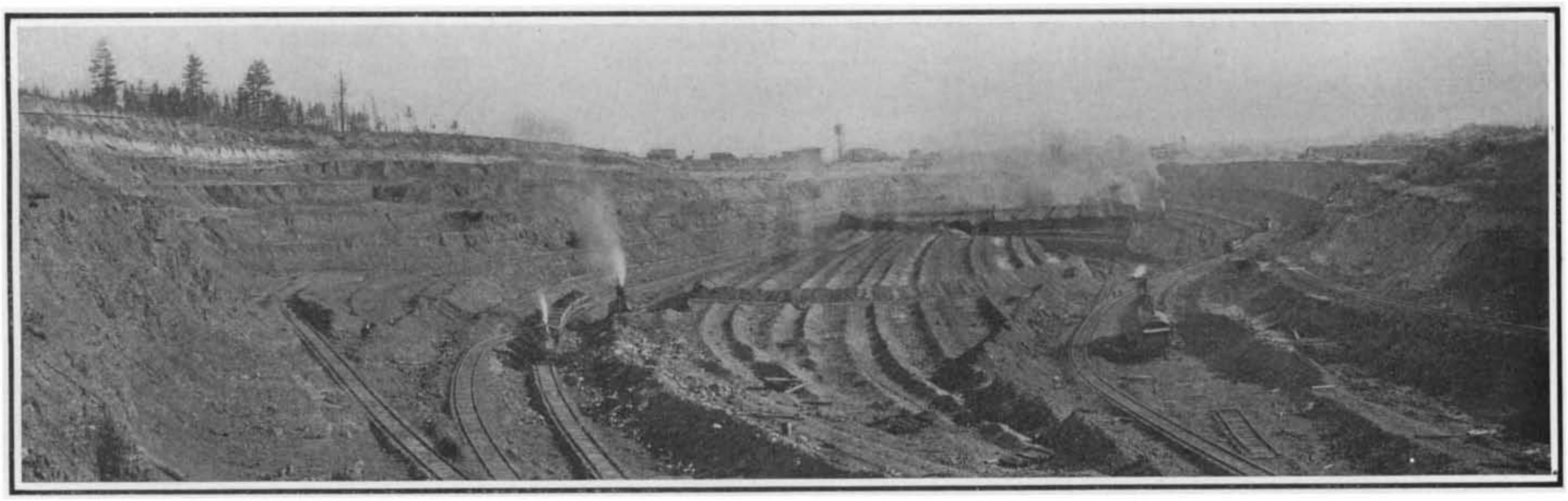
Length of bridge, 222 feet 8 inches. Bucket lifts 5 tons.

THREE FAST PLANTS UNLOADING WHALEBACK STEAMER.



Length of tramway, 360 feet. Bucket capacity, 5 tons.

TWO BROWN TRAMWAYS UNLOADING A TYPICAL LAKE STEAMER.



The iron ore lies so near the surface that after stripping the glacial surface material a vast horizontal bed of rich ore (60 per cent iron) is exposed. The ore is dug by steam shovels and loaded directly into the cars. Over 1,000,000 tons are shipped out every year.

THE FAMOUS IRON MOUNTAIN MINE OF THE MESABI RANGE.

THE WONDERFUL IRON MINES OF LAKE SUPERIOR.

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the Panama Canal as the greatest task of its kind ever undertaken; yet it is a fact that at the close of the present year the stripping of the surface material and the excavation of the ore from the Mesabi range alone during the seventeen years that mining has been carried on will represent a total of excavation equal to that required for the Panama Canal.

TRANSPORTATION OF THE ORE.—Apart from the easy accessibility of the ores, particularly in the Mesabi range, the low cost at which the iron ore is delivered to the railroad cars or on the stock pile at the Lake Erie ports is due in a large measure to the present system of mechanical handling and transportation which enables a huge tonnage to be moved in a minimum of time and for a minimum of cost. From the time the ore is lifted by the shovel in the "open-pit" mine, or is loaded into the skip of the deep underground mine, it is handled entirely by mechanical means and no human hand comes in contact with it. The trains of ore cars, as they arrive at the Lake Superior ports, are run out directly above long elevated docks, consisting of continuous rows of ore bins. The hinged bottoms of the cars are released and the loads dropped into the ore pockets, where the material remains until the ship steam alongside for loading. Hinged to the bottom of the ore pockets are long rows of metal chutes, and as a chute is lowered into position over the hatch of the steamship, the gate at the bottom of the ore pocket is opened, and the ore slides by gravity into the hold. The ore-shipping piers of the Great Northern Railway at Superior are capable of receiving and loading from five to six million tons of ore in a season, and they have a record of loading a ship of 5,250 gross tons in 30½ minutes. An even greater feat was the loading of the steamer "H. E. Corey," of 10,000 tons capacity, at Duluth and Iron Range steel ore dock at Two Harbors, Minn., this season, in 39 minutes. One of the piers of the Great Northern Railway Company is 73 feet above water level, 62½ feet wide, nearly half a mile in length, and has a storage capacity for 87,500 tons. The construction of a special type of ship of large tonnage for the ore trade, coupled with the invention of unloading machinery of great capacity at the terminal ports, has brought the cost of transportation down to a very low figure. Thus, a ton of ore is now hauled one hundred miles by rail from the most distant mines in the Lake Superior range to a Lake Superior port, is loaded into the ship, is carried one thousand miles by water, and unloaded into cars or onto the stock pile at a Lake Erie port, at a cost of less than $1.80 per ton.

The iron-ore steamer of the Great Lakes has been designed with a strict reference to the economical loading, transportation, and unloading of iron ore in bulk. Its characteristics are great length, moderate draft, and a huge cargo hold which extends continuously for nearly the whole length of the vessel, and is provided with a continuous row of hatches extending the full length of the hold. We present an inboard profile and a cross section of the "Wolvin," one of the largest of the typical ore steamers. This vessel is 560 feet in length, 56 feet beam, and 32 feet deep. The cargo hold is built in the form of a long hopper, whose sides slope from the main deck to the top of the ballast tank. The hopper is 43 feet wide at the top, 24 feet wide at the bottom, and extends continuously for a length of 409 feet. The space between the hopper and the outside of the vessel forms two series of water-ballast tanks, the ballast space being divided into compartments by athwartship bulkheads built in at intervals of 60 feet. The tanks have a maximum capacity of 8,000 tons of water. Transverse stiffness is afforded to the sides of the vessel by a system of arched girders, which also serve to support the upper deck and the hatch covers. Between the girders are 33 hatches, each of which measures 9 feet by 33 feet in the clear. The largest single cargo of ore carried by the "Wolvin" was 11,536 tons, a feat which she performed in 1904. The pilot house, bridge, and captain's quarters are forward at the bow. Aft of the cargo space are the coal bunkers, boiler room, engine room, and the quarters for the crew.

Great as are the dimensions of the "Wolvin," they have been exceeded regularly in each succeeding year. The "E. H. Gary" in 1905 carried a single cargo of 12,368 tons; in 1906 the "J. P. Morgan" carried a single cargo of 13,272 tons of ore, and in 1907 she carried 13,800 tons. Equally remarkable for size are some of the sailing cargo ships, the most notable of which is the "John Smith," which in 1907 carried a single cargo of 9,408 tons.

It is the magnitude of the ore trade which has made the Sault Ste. Marie canal the most important artificial waterway in the world, at least in respect of the bulk of tonnage passed through. According to figures given at the thirteenth annual meeting of the Lake Superior Mining Institute, the maximum freight traffic through the canals for a single day was on August 26th, 1907, when 487,000 tons were passed through in 121 vessels. The total traffic into and out of Lake Superior for that year was 58,217,214 tons, on which $38,458,345 were paid as freight charges. Of this total tonnage, 68 per cent was iron ore.

UNLOADING AND HANDLING MACHINERY.—In order to keep pace with the low cost and speed with which the huge bulk of iron ore is mined, loaded into special steamers, and carried to its destination at the various Lake Erie ports, it was necessary to design special unloading machinery, capable of lifting the ore from vessels and loading it, either into the stock pile or into railroad cars, with proportionate speed and at a relatively small cost per ton. The design and construction of this class of machinery has grown to such importance, that there are several large industrial concerns which are occupied almost entirely with this class of work. In one of our views illustrating the interior of the hold of the "Wolvin," and also in the general panoramic view of the water front of the Gary Steel Works, we show what is known as a Hulett automatic ore unloader. Four of these machines, located at the docks at Conneaut, Ohio, are credited with having taken out of the "Wolvin" 7,257 gross tons of ore in four and one-half hours. At present there are five of the Hulett unloaders at Gary, and when the plant is completed there will be ten. The plant consists of a massive walking beam, to the outer end of which is pivoted a vertical arm. At the bottom of the arm is a bucket capable of lifting ten tons at each operation. As the bucket descends into the hold of the vessel, the two halves open, and are automatically moved apart in a horizontal direction, so as to make a wide "grab" of the ore. The machines at Gary are carried on two tracks 62 feet apart, and span two railroad tracks laid parallel to the edge of the dock. They are operated by electricity, and each weighs about 450 tons and requires only three men for its operation. They are showing a capacity for unloading ore at an average rate of 300 tons per hour for each machine. As each bucket-load is lifted, it delivers the ore to a conveyer car, which travels back to the rear of the machine, and discharges its load into suitable hoppers at the rear.

By the courtesy of the Brown Hoisting Machinery Company, we are enabled to present photographic views of several types of unloading machinery as installed for the unloading of iron ore, coal, and other heavy materials in bulk at various ports on the Great Lakes. During the recent meeting in New York of the Society of Naval Architects and Marine Engineers, a paper was read on Material Handling Equipments for Lake Vessels which traced the development of this type of machinery from the year 1880. At that time dock managers were looking for some mechanical means for lifting the ore from the ship and depositing it at some distance from the face of the dock; and this was first accomplished by a cableway machine, built and erected at Cleveland in 1880 under Mr. Alex. E. Brown's supervision. From that first device have been developed the mammoth machines of the Brown hoist type. They consist essentially of a long overhead bridge extending at right angles with the dock and supported on two towers, one at the dock, the other 200 to 300 feet inshore. Upon the bridge are rails, on which travels a self-propelled trolley. Upon the trolley are motors for hoisting the load and for moving the trolley to and fro upon the bridge. In unloading, the trolley runs out over the hold; the grab bucket descends and grabs its 5 to 7 tons of ore; raises it, and then the trolley travels back to the stock pile, where the load is dropped.

GARY: THE LARGEST AND MOST MODERN STEEL WORKS IN EXISTENCE.

(*Continued from page 441.*)

purified has an average heat value of 95 British thermal units per cubic foot.

It is estimated that 2½ times as much power can be derived from a given quantity of gas with gas engines as with boilers and steam engines.

THE OPEN-HEARTH FURNACES.

The hot metal is tapped from the bottom of the furnaces into 40-ton ladles, mounted on massive eight-wheeled trucks, which are hauled successively beneath the pouring spout. When a train of ladles is made up it is hauled to the mixer building, which contains two huge receptacles, each of 300 tons capacity. Into these the ladles discharge the hot metal, and the mixing of the product of the different furnaces insures a uniform average of composition of the metal. From the mixers, which are arranged so that they can be rocked or tilted, the molten metal is poured into 60-ton charging ladles which are conveyed to the charging side of the open-hearth furnaces on electric transfer cars. From these cars the ladles are picked up by a 75-ton traveling crane and the metal is poured into the open-hearth furnaces through a runner.

The whole of the output of the Gary plant consists of open-hearth steel, and the open-hearth furnace plant is by far the largest of its kind in the world. It is housed in large steel-frame buildings, 193 feet in width and 1,190 feet long. Ultimately there will be six of these buildings, each containing fourteen 60-ton furnaces, or eighty-four furnaces in all. To the molten metal with which each furnace is charged there is added a certain amount of steel scrap; and the charge is then subjected to the fierce heat of burning gases which enter at one end of the furnace, pass over the charge, and leave through flues at the other end. From time to time samples are taken from the furnace and tested. The object of this treatment is the same as that of the air blast in the Bessemer converter, and though the operation consumes more time the product is very much more reliable. The impurities are burned out of the metal until the proper percentage of carbon, etc., for the particular grade of steel which is being made has been reached. The metal is now ready for pouring.

Down each side of the long line of open-hearth furnaces is a set of railroad tracks on which the metal is brought to or removed from the furnaces, and handled thereat. On the tapping side on which the treated metal is withdrawn from the furnaces is a line of massive standards in which are placed the ladles of 80 to 100 tons capacity into which the metal is poured. When they are full, the proper amount of ferro-manganese is added to the metal in each ladle, and they are then picked up by 125-ton traveling cranes and carried to platforms, from which, by opening a plug in the bottom, the molten steel is poured into the ingot-molds, large cast-iron molds 65 inches in height, tapering from 20 by 24 inches at the bottom to 18¾ by 22¾ inches at the top. Here the metal cools to the point of solidification. The mold is then lifted off the ingots which, by the way, are carried on four-wheeled cars, each car carrying four molds, and after having been heated to a uniform heat throughout in the "soaking pits" the product is ready for rolling in the billet mill or the rail mill.

It should be mentioned that in order to take care of the product of the blast furnaces on Sundays and holidays, when the open-hearth furnaces are not at work, the hot metal is brought in ladles to the casting machine, where it is poured into an endless chain of traveling molds which passes continuously below the mouth of the ladle. There will be eleven of these machines for the service of the complete plant.

BILLET MILL.

Standing parallel with the rail mill is an electrically operated billet mill, in which a portion of the ingots are rolled down to suitable size for further manipulation throughout the plant. Here are four 40-inch blooming mill stands, each pair driven by a 2,000-horse-power electric motor, and a five-stand continuous 32-inch mill driven by a 6,000-horse-power motor. Beyond this are two blooming shears, 12 x 12 inches and 10 x 10 inches. Next, the blooms go to a 24-inch 6-stand continuous mill, driven by a 6,000-horse-power motor, or to a pair of cooling beds for shipment. If further reduction is desired the billet is sent to a 6-stand 18-inch continuous mill and rolled down to sizes varying from 3½ inches square to 1¾ inches square.

LARGEST RAIL MILL IN THE WORLD.

The Gary plant contains the largest rail mill in existence. It is also the only electrically driven mill which rolls rails direct from the ingot without reheating. The proportions are immense, the main building being 990 feet long by 76 feet wide, with another building containing the soaking pits, for both rail mill and billet mill, which is 1,350 feet long by 84 feet wide. The soaking pits are square chambers with hydraulically-operated sliding doors in the roof, capable each of holding four 4-ton ingots. They are heated by gas and in them the ingot is brought up to the proper temperature for rolling. The roll trains are driven by six 6,600-volt induction motors, three of 6,000-horse-power and three of 2,000-horse-power. The finished rails are taken to inspection beds in a finishing department and are then loaded on the cars. This rail mill can turn out 4,000 tons of 80-pound rails in twenty-four hours.

GAS-ENGINE-OPERATED BLOWER PLANT.

Air blast for the furnaces is produced in two buildings, 550 and 600 feet long and 104 feet wide, which are among the most interesting features of the Gary plant. The blowers, of which are are twenty in all, are driven by sixteen gas engines and four steam engines. These blowing engines are of great size and power. The gas and blowing cylinders are placed in tandem. The gas cylinders are 42 inches in diameter and the blowing cylinder 72 inches, and they have a common stroke of 54 inches. Each en-