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MATERIAL-HANDLING EQUIPMENT AS USED IN THE IRON AND STEEL INDUSTRY

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This paper describes the handling machinery and apparatus used in the manufacture of steel. From the time that the ore leaves the mines until the steel goes through the last process at the mill it is moved about exclusively by different types of heavy machinery designed especially for the purpose. The author expresses the hope that through his description, weak points in present-day practice will show themselves and means of improvement be suggested.

THE iron and steel industry probably requires a greater diversity of material-handling equipment than any other type of manufacturing, because of the enormous bulk and weight to be handled. From the time the material leaves the mines until it is turned out of the mills as finished product it is constantly being moved by heavy conveying machinery of all descriptions. It is the intention of the author to describe this equipment with the idea of bringing out weak points in present-day practice, and possibly open the way to strengthen the weakest links in conveying methods used.

2 As the principal object of this paper is to describe the machinery used about the industrial plant, just a brief description will be given of the handling methods before the material reaches the plant.

3 At the present time ore handling on the Great Lakes is carried on by a fleet of vessels unequalled anywhere in the world. Some of these vessels are capable of handling a cargo of 15,000 tons, and are over 600 ft. long. During the year 1916, 66,658,466 tons of ore were carried by the vessels from the upper Great Lakes to

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southeastern ports. The steamer *Homer D. Williams* carried 462,490 tons during the season of 1920.

4 Vessels equipped for self-unloading have been developed for handling stone and ore. The hold in such cases is divided into bins, which deliver the material by gravity to a belt conveyor running lengthwise of the vessel; this conveyor delivers the material to an elevator which hoists it to another belt conveyor suspended in a horizontal position from the masts of the vessel and capable of being moved radially and vertically like the boom of a derrick. This belt conveyor delivers to the storage pile on the dock, and it is

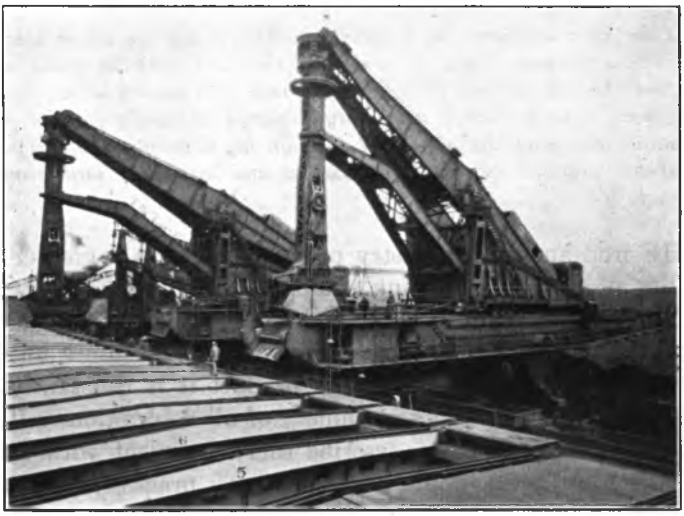

FIG. 1 HULETT ORE UNLOADER AT ASHTABULA HARBOR

possible to distribute the material onto the dock at any point or height desired within the scope of the boom conveyor.

5 Ore-unloading equipment has probably been developed to the highest point of efficiency at the ports on the Great Lakes. An example of this is Ashtabula Harbor on Lake Erie, where there are eight Hulett ore unloaders having a capacity of 15 tons each. They have a record of unloading seven boats of a total capacity of 70,000 tons in 22 hours actual time. Four 17-ton capacity machines of this type have unloaded a cargo of 13,000 tons in 3 hours and 25 minutes. Fig. 1 shows a view of these machines in operation.

6 These unloading machines remove the ore from the boat and dump it directly into railroad cars for shipment to inland plants, or they place it in a bin located at the rear of the machine where it may be picked up by a traveling ore bridge and placed in storage piles.

7 Ore shipped to inland plants in bottom-dumping cars may be unloaded directly into bins by gravity. However, the modern method is to use a traveling rotary car dumper as shown in Fig. 2 which can be spotted at any point in the length of the ore yard. The cars of ore are placed one at a time on the

Fig. 2 View of Rotary Car Dumper

dumper, turned upside down and the ore dumped into a concrete pocket that extends the full length of the ore yard. An ore bridge distributes the ore to the storage pile in the yard. Rotary car dumpers have been developed so that three men can unload about 20 cars per hour. Cars of 240,000 lb. capacity have been designed with a total dead weight of 78,800 lb., giving a ratio of revenue load to total weight of 75.4 per cent.

8 The traveling ore bridge is another valuable link in material-handling equipment and is used in many different ways in handling the ore at unloading docks. One of the largest bridges of this type ever built is 612 ft. long overall, and is used at the Western Pennsylvania Dock Company at Cleveland, Ohio. This

bridge handles a 15-ton bucket and covers an ore storage of over a million tons.

9 These bridges may also be used to place the ore and limestone in bins, preparatory to sending them to the blast furnace. Several different types of bins are used, although the principle is the same in each. The ore is placed in the bin either by the ore bridge, or by gondola-type hopper cars and it passes down through the bin by gravity as required, through a shut-off gate into a lorry car. From the bins an electrically driven

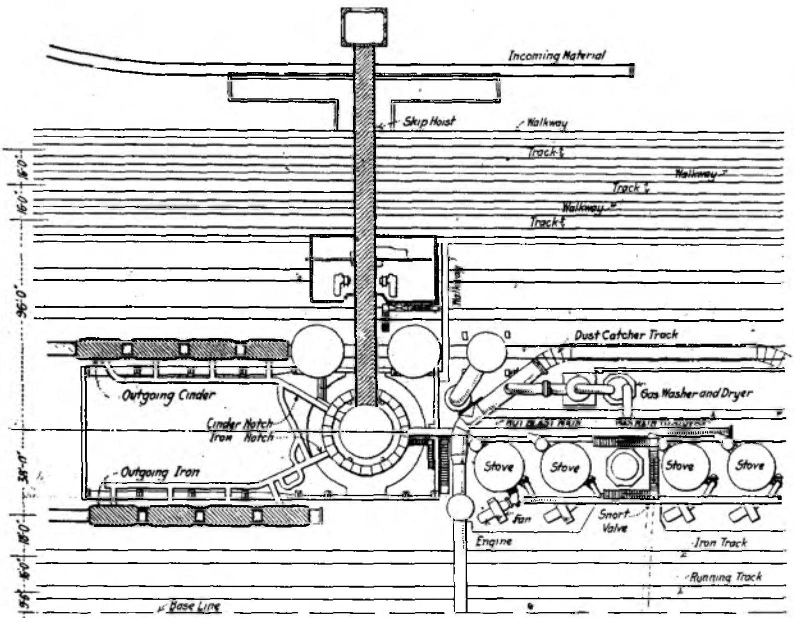

FIG. 3 GENERAL PLAN OF BLAST FURNACE AND STOVES

weighing lorry car is used to convey ore, limestone and coke to the blast-furnace skip hoist.

10 Fig. 3 shows how material is conveyed from the stock yard and bins to the top of the blast furnace, dumped into the bell hopper by the skip car, and finally deposited inside by the well-known double bell system. Two of the products of the blast furnace are pig iron and slag, which are drawn off at the base in a molten state. Both iron and slag were formerly allowed to run

from the furnace into sand molds and handled after cooling. Most plants today, however, run the molten iron and slag directly into ladles supported on special cars. In this way the iron is transported either to a pig-casting machine where it is cast into pigs, or to a mixer at the open hearth plant, where it is kept in the molten state, or further refined before it is placed in the bessemer converter, for the duplex process. The molten pig iron may also be conveyed direct to the open-hearth furnace for the straight open-hearth process.

11 The slag is disposed of in various ways, since it has become of considerable commercial value in the last few years. After

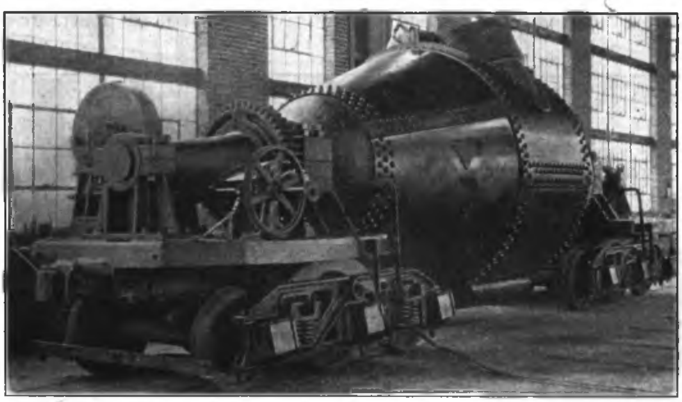

Fig. 4 Pugh Mixer-Type Hot-Metal Car

having been allowed to cool it is crushed to various sizes, and then used in the place of crushed stone.

12 A new design of car known as the Pugh mixer-type hot-metal car, shown in Fig. 4, has recently been developed for handling hot metal from the blast furnace. This car, built in capacities ranging from 70 to 150 tons, is claimed to have many advantages over the ordinary type, chief among these being the heat-saving feature which allows the hot metal to stand in the car for a period of 36 hours without " freezing." It is also a labor saver because, due to its large capacity, it requires less runners to distribute the metal from the furnace to the cars, thereby eliminating considerable scrap.

13 Fig. 5 shows a view of a typical slag car for conveying the molten slag away from the blast furnace. It is dumped pneumatically.

THE DUPLEX SYSTEM FOR MAKING STEEL

14 Fig. 6 shows the plan of a modern duplexing system for manufacturing steel. The machinery in this department of steel making must stand the most severe treatment of all, as the steel is handled at temperatures ranging as high as 2900 deg. fahr. It can therefore readily be understood how important it is to have such machinery and equipment designed as perfectly and as safely as possible.

15 The hot metal from the blast furnace is brought to the mixers by ladle cars. On Fig. 6 this car is shown in position before

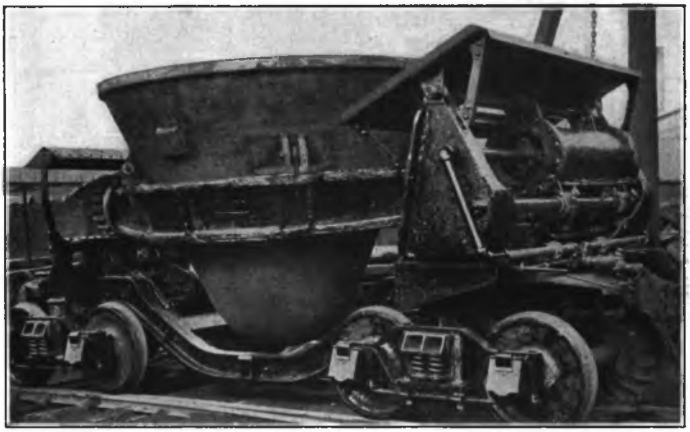

Fig. 5 Slag Car and Ladle

a 1300-ton-capacity mixer into which the content is poured by lifting the ladle free from the car with the aid of a 100-ton ladle crane.

16 The hot metal is removed from the mixer as required, by tipping it so that metal will run out of a spout opposite the receiving side. Another ladle supported on a ladle car is used to transfer the hot metal from the mixer to the bessemer converter. This ladle is tilted by a jib crane and the contents poured into the top of the converter already tilted to a receiving position.

17 The next step for the hot metal in the process of refine-

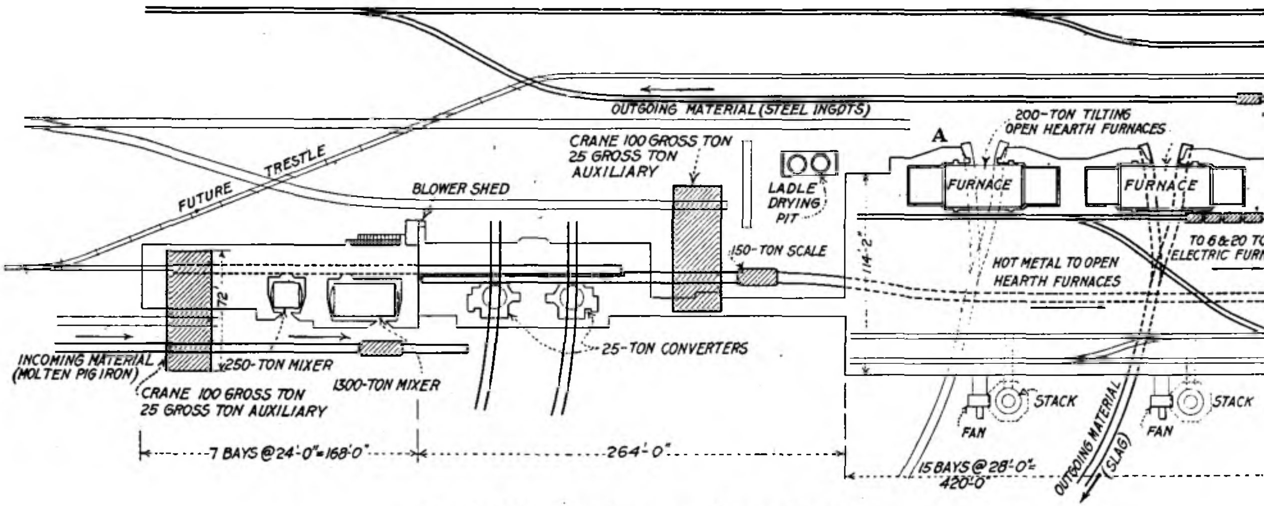

FIG. 6 GENERAL PLAN OF DUPLEX PLANT

ment is to convey it from the converter to the open-hearth furnace. This is done very much as was the previous operation except that the hot metal is poured from the converter into another ladle mounted on a ladle car and is transferred by steam or electric locomotive to a point before the open hearth furnace. Here, it is hoisted free of the car and poured into the furnace by means of an overhead crane. The track over which this car travels is indicated on Fig. 6 by the legend "Hot Metal to Open-Hearth Furnaces."

18 Fig. 7 shows a 65-ton ladle car that may be used for this transferring operation.

OPEN-HEARTH FURNACES

19 Scrap, ore and limestone are conveyed to the open-hearth furnace in cast-steel boxes called charging boxes, three or four of

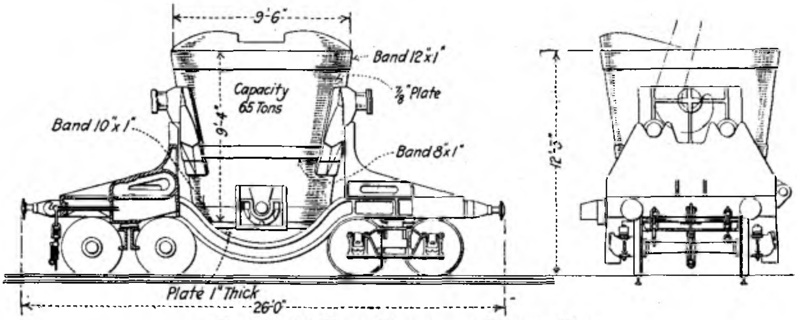

FIG. 7 65-TON TRANSFER LADLE CAR

which are moved on a specially built car. The scrap is placed in the boxes by means of the overhead crane and a magnet. The ore and limestone are handled either by the crane and a grab bucket in cases where it is necessary to move them from storage piles to the boxes, or they are placed in the boxes direct from bins by means of chutes, when the plant is so provided. The cars are then hauled in trains to the charging floor of the open hearth furnace building.

20 It occurs to the writer that the ore and limestone used in open-hearth practice could be handled more economically if it were either stored in bins under the approach trestle to the open hearth building and discharged by chutes into the charging box cars, or if it were stored in bins under the open-hearth floor and

removed by means of a grab bucket, or possibly by the application of mechanically operated proportioning devices used in conjunction with compartment bins discharging same to the charging floor of the open hearth.

21 In the methods now in vogue, the train of loaded charging boxes is transferred from the storage yard to the open-hearth charging floor in front of the furnaces by means of an electric or steam locomotive. The material in the charging boxes is then dumped into the furnace by an electric charging machine. This machine lifts the charging box into the furnace where it dumps its contents by turning the box through a complete revolution. The operator of one of these machines sometimes takes a loaded box and uses it as a means of leveling the charge within in the fire bed of his boiler.

22 The products of the open hearth are steel and slag. The steel is drawn off from the furnace and run into a ladle of a size consistent with the capacity of the furnace. In the Talbot system only half of the charge is drawn from the furnace at one time. After the ladle is filled it is transferred by an overhead crane to a position over the first mold of a train of ingot molds.

23 The slag which flows off at the time that the steel is tapped, is run into a slag ladle mounted on a special car by which the ladle is carried to a suitable point for dumping. The position of this car is indicated on Fig. 6 by reference (A). It is placed there to receive the slag during the tapping of the furnace and is hauled away afterwards on the track indicated by the note.

24 The molds in which the steel is cast are mounted on cars usally three or four molds to the car. These cars are heavily constructed as they must withstand having molten metal splash on all parts of them or the dropping of an ingot from a height of several feet when the mold is being stripped from it.

25 The direction of travel of these ingot cars is indicated by arrow heads and notes, as they travel from the open-hearth pit to the stripping yard.

26 The stripping process simply means removing the molds from the cast ingots after the metal has hardened sufficiently. Fig. 8 shows an ingot stripper, and indicates how the hooks of the stripper engage the ears of the mold lifting it clear of the ingot car and leaving the ingot on the car. When the mold has been used for a long time it may become slightly pitted, causing the ingot to stick

when it is being stripped from the mold. Under these circumstances it is necessary to drive the ram down into the opening at the top of the mold to force out the ingot.

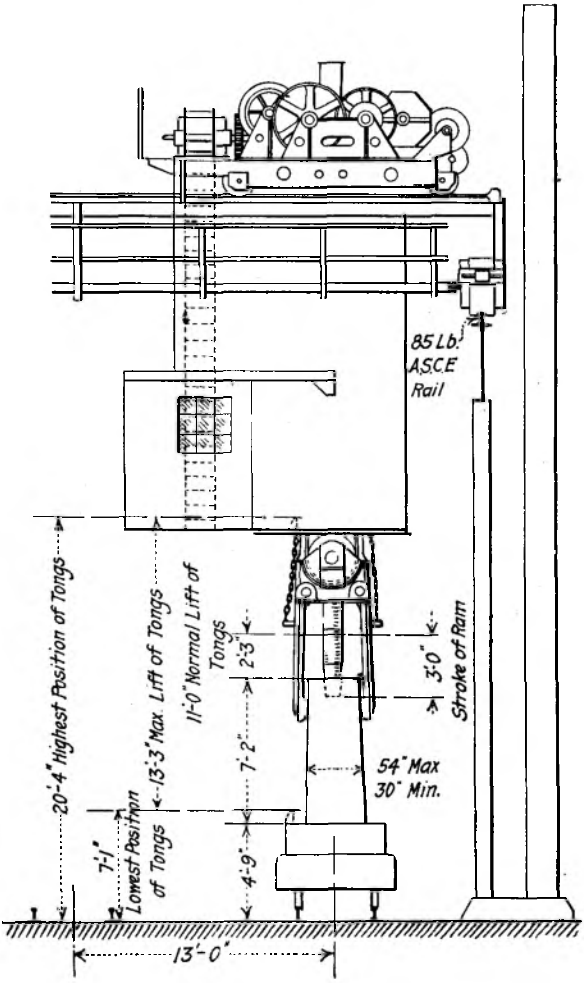

Fig. 8 200-Ton Ingot Stripper

27 The train of stripped ingots is now moved from the stripper yard to the soaking-pit furnaces, or to a suitable storage yard.

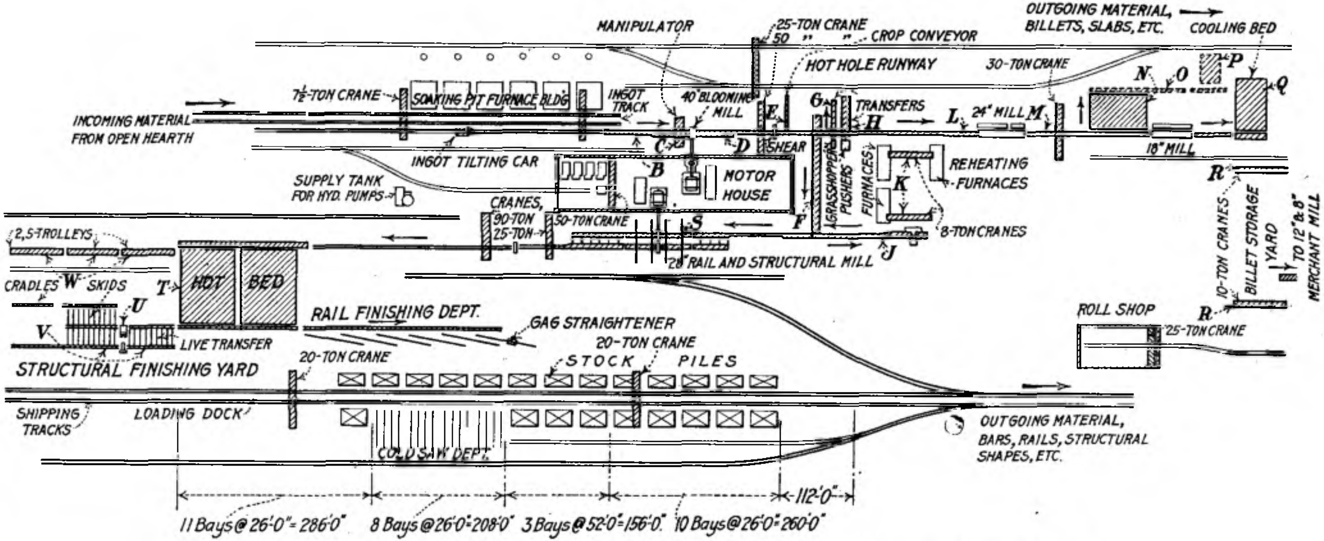

Fig. 9 General Plan of 40-in. Blooming Mill and Sheet Bar and Billet Mill

MODERN ROLLING MILL

28 Fig. 9 shows a plan of a modern rolling mill, in which nearly all the different types of material-handling machinery that have been developed to the present time for this industry are used.

29 This plant includes a 40-in. two-high reversing blooming mill, a 24-in. and 18-in. sheet bar and billet mill, and a 28-in. rail and structuarl mill. Provision has been made for serving a 12-in. and 8-in. merchant mill with billets from the sheet bar and billet mill. All mills are electrically driven. The different types of conveying machines are indicated by letters, in the order in which the material travels.

30 The blooming mill is served by six 4-hole soaking pits, in which the ingots are placed by an overhead electric tong crane. This crane handles the ingot on a principle similar to that of a pair of ice tongs. The operator's cage rides with and above the tongs, enabling him to place the ingots in the proper position in the pits.

31 The next step in moving the material is to serve the blooming mill with hot ingots from soaking pits. The soaking-pit crane delivers the ingot to a tilting buggy, places the ingot on roller table (B), and it is directed properly for entering the rolls of the blooming mill by manipulator (C).

32 Fig. 10 shows a general view of soaking-pit furnaces, and the end of a roller table, to which an ingot is being delivered by the traveling tilting buggy. This buggy travels back and forth in front of the soaking pits, operated either by a remote control switch which places the buggy at any desired position on the track, or motivated by an electric trailer — man-operated. In case of breakdown of the ingot tilting buggy the cranes can place the ingot directly on the table.

33 As previously stated, the manipulator is a machine used to place the ingot in the proper position for entering the rolls, and to turn or shift it for the next pass after passing back and forth through them. The modern manipulator is hydraulically operated. Its pushing arm has both a vertical and horizontal movement and is provided with a movable side guard on each side with tilting heads on one side for turning the section being rolled. This enables the operator to place the material at any desired position before the rolls.

34 Many mills are equipped with manipulators on both the entering and delivery sides of the mill, but when they are placed on delivery side the tilting heads are omitted.

35 After ingots have been reduced to blooms, slabs, or blanks by the blooming mill they are carried on to the shear by another electrically driven roller table indicated on Fig. 9 as table (D). The shear cuts the blooms to required lengths removing the fan-tail end or " crop end," as it is termed in the mill. This crop end is dropped down a chute at the shear to conveyor (E)

Fig. 10 General View of Soaking Pits, Ingot Tilter and Tong Crane

which conveys it to a bloom-butt car located on the track next to the mill building. This conveyor is usually very heavily constructed and due to the irregular shapes handled, it is built so that the billets are pushed along on a smooth surface of plates by a traveling scraper conveyor which will handle any size or shape liable to be produced by the mill.

36 In some plants open-hearth charging boxes are placed on charging car and the crop ends are loaded directly into the

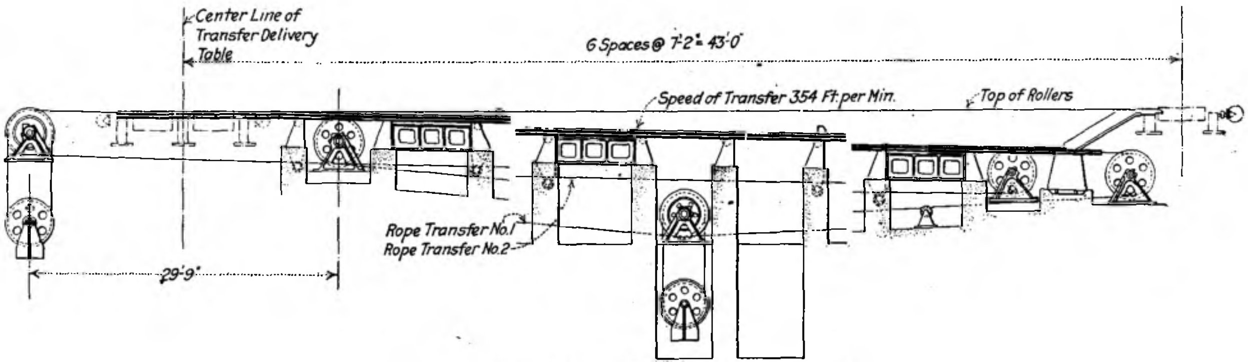

Fig. 11 145-ft. Bloom Transfer

boxes by the crop-end conveyor. This is desirable where the distance between the blooming mill and the open hearth is not far. If the distance is too far, too much money is tied up in charging boxes, due to the quantity necessary to provide for delays in transportation, etc.

37 The mill layout shown on Fig. 9 provides for distribution of blooms and blanks to the rail and structural mill by means of conveyor (F) and slabs and blooms to the hot-hole or shipping yard by means of conveyors (G) and (H). It also provides for distribution of blooms and blanks to reheating furnaces or to rail mill by means of conveyor (F), table (J) and charging cranes (K)

Fig. 12 Billet Conveyor and Grasshopper Pusher

when reheating for rail mill, or for blooms and slabs direct to the sheet bar and billet mill by table (L). Conveyor (F) shown in Fig. 11 is constructed with a surface of heavy tee rails on which the billets are skidded along by rapidly traveling dogs. The dogs run on tracks between the rails and are attached to wire ropes running around an idler pulley at one end of the bed and a driving drum at the other end. This conveyor must handle the blooms rapidly as they are sometimes passed from the blooming mill direct to the rail and structural mill without being reheated.

38 Fig. 12 shows another type of these conveyors and also the grasshopper type of pusher, a machine used for removing material from a roller table to a conveyor placed at right angles to it.

SPECIAL FEATURES OF GRASSHOPPER TYPE OF PUSHER

39 The feature of this machine is the peculiar path which the ram describes in passing through one cycle of operation. The levers are arranged to cause the ram to travel in practically a horizontal straight line in the forward stroke, while on the return stroke it describes an arc in an upward direction, clearing material that may be traveling out from the shear.

40 When it is desired to deliver material to the hot hole it is removed from the shear table by means of the grasshopper pusher, to either conveyor (G), Fig. 9, in the case of slabs, or to conveyor (H) in case of blooms or blanks.

41 When slabs are delivered to conveyor (G) it transfers them to a slab piler which arranges them in piles of four or five. They are then removed by the overhead crane to be stacked in the hot-hole yard and allowed to cool.

42 The same procedure takes place when blooms are delivered to conveyor (H), except that the blooms are delivered to a cradle from which they are removed to the hot-hole yard for cooling and storage.

43 The roller table indicated by reference (L) on Fig. 9 is the ordinary type of electric-driven table.

44 Many types of machines have been developed to replace the old-style hand methods of replacing heavy billets, bars, etc. in the furnace for reheating, preparatory to rerolling. Reference (K) on Fig. 9 indicates the location of two of these machines which travel on girders above the furnaces. They are designed so that the tongs may be placed in any position necessary to serve the furnaces on either side of the charging floor.

45 In the plant shown by Fig. 9 the charging crane (K), can pick up the material from the skids at the end of table (J) and place them in the furnace; store material at the end of the runway for future use; remove hot material from furnaces, and serve either the sheet bar and billet mill or rail and structural mill. This arrangement allows many methods of operation between the different mills.

SHEET BAR AND BILLET MILL

46 When it is desired to reduce the blooms to billets or flat bars they are conveyed direct from the blooming mill shear to the 24-in. mill by table (L) and rolled on the 24-in. mill without reheating. Some few sections, however, require reheating and the blooms for these are taken from table (L) by charging crane (K), placed in reheating furnaces, then returned to table (L), and to the 24-in. mill. After passing through the 24-in. mill they are delivered to the 18-in. mill by table (M) where the cross-sectional area of the bar is still further reduced. If it is not necessary to pass the bars through the 18-in. mill they are delivered to the stock yard or cars by means of a cooling-bed transfer conveyor (N), roller table (O) and transfer (P).

47 If it is necessary to pass the bars through the 18-in. mill they are conveyed to same by table (M). This table is designed with the axis of the rollers set at an angle of about 102 deg. with the center line of the table instead of 90 deg. (Fig. 15) for the purpose of throwing the bar off the table onto transfer conveyor (N). If it is desired to deliver the material to the 18-in. mill instead of placing it on transfer table (N) it is guided into a groove which is on the circumference of each roller, these grooves being in line on the table. Naturally this causes the material to follow a straight course to the 18-in. mill instead of being thrown off the table by the skewed arrangement of the rollers. After passing through the 18-in. mill the bars are cut to size by a rapidly operating shear, the knives of which move forward with the bar cutting it as it rolls along. This type of shear is called a flying shear. The bars are then conveyed to cooling bed (Q), where they are allowed to cool, and transferred by the cooling bed conveyor to a bar piler at the end of the conveyor. The bundles of steel bars or billets are then transferred to the billet storage yard, or to the merchant mill for further reduction to small shapes, or directly into cars for shipment by overhead crane (R).

28-INCH RAIL AND STRUCTURAL MILL

48 As previously mentioned it is possible to deliver blooms from the blooming mill direct to the rail and structural mill by means of conveyor (F), thereby continuing the reduction of the

bloom on the rail and structural mill without reheating. If it is desired to reheat the bloom, it is carried by means of conveyor (F) and roller table (J) to the end of table (J), where it is pushed onto the skid table, picked up by a charging machine (K), and charged into the reheating furnace. When properly heated it is returned to roller table (J) by charging machine (K).

49 Table (J) is designed with a double set of rollers so that blooms delivered to it may pass in either direction on both sides at once. The advantage of this can easily be understood; for example conveyor (F) may be delivering material to the furnace on one side of the table and at the same time material may be transferred from the furnace to the rail and structural mill on the other side. This arrangement is shown on Fig 11 by a light outline of the cross-conveyor at the delivery end of the conveyor.

50 If the bloom is to be rolled on the 28-in. mill it is carried to the mill by table (J) and a traveling tilting table (S). Two of these traveling tables are located on either side of the 28 in. mill and serve the purpose of catching the bloom as it travels back and forth through the mill. When the cross-sectional area of the bloom has been reduced to as small as is desired on the first stand, it is pushed over to the second stand by means of rope-propelled dogs which travel back and forth between the skid rails of a stationary rack transfer. The traveling tilting table (S), moves the material from pass to pass in either the top or bottom pass, as required. In event of either table breaking down, provision is made for removing the table beyond the face of the rolls where repairs can be made, and one table is used for both stands, which of course lessens production. When the roughing out is completed on the second stand of the 28-in. mill, the material is passed to the finishing stand of the 28-in. mill. Here it is given one finishing pass of either a rail or structural shape and passed on to the saws by another power-driven roller table.

51 If the finished material is a rail it is generally cut into three pieces of standard length simultaneously by four drop hot saws, the two end saws being used to remove the crop end of the rail. If a structural shape, it is cut by the sliding saw indicated to lengths desired. The material is then delivered to the cooling bed (T), on which it is drawn across by dogs attached to wire ropes or some other of the many methods of propulsion, that have been designed for this purpose.

52 Rails are delivered in one direction to a rail-finishing department and structural shapes in the opposite direction to a department for finishing I-beams, channels, angles, etc.

53 When finishing structural shapes they must be straightened and the ends cut true. Fig. 9 shows a modern arrangement for transferring shapes from the cooling bed to the straightener (U) and thence to the shears, by means of transfers (V). When shapes have passed through this last stage of finishing they are removed from the shear cradle by means of overhead cranes (W) and placed in piles for storage or directly in railroad cars for shipment.

54 Rails pass through a similar process of straightening and end finishing and are also drilled. They are conveyed from the cooling bed on roller tables, and transferred to the different finishing machines on idler rollers supported on individual stands.

55 The writer is of the opinion that the methods of handling rails in the finishing department can be materially improved and more of the manual labor eliminated by different plant arrangements than are used at the present time. Not enough power-driven machinery is used in this work. This problem could be studied with beneficial results.

56 The foregoing description gives a general idea of the type of material-handling machinery used in a steel mill, but of course does not cover all the variations that would naturally be required in manufacturing different forms of steel. For example, there are several types of mills which have not been mentioned, all of which require material handling equipment suited to the type of material handled.

57 The mill for manufacturing steel plates requires lighter but broader tables, and toward the finishing end chain conveyors are used to handle the plates. At the shears an arrangement of castors set up on spindles is used, allowing the plate to be placed at any desired relation with the shear. This arrangement is known as a castor bed.

58 The skelp and rod mill requires light tables and conveyors which will handle the rolled material rapidly, as the mills used for this work are small and run at a high rate of speed. They also require long cooling beds, that will handle the material in such a manner that it is straightened while cooling. The Edwards escapement bed is a good example of this type, and is

shown by Fig. 13. The rods are delivered to the top of the bed by a conveyor having a set of cone-shaped rolls. These throw the rod to the small end of the roll which retards the speed of the rod and allows a set of fingers to pick it up and place it on the first of a series of spurs on an inclined bed. As each rod passes out from the mill it is picked up and placed on this inclined bed, and as each is dropped on the bed the preceding rods are dropped down one spur at a time until they reach the bottom.

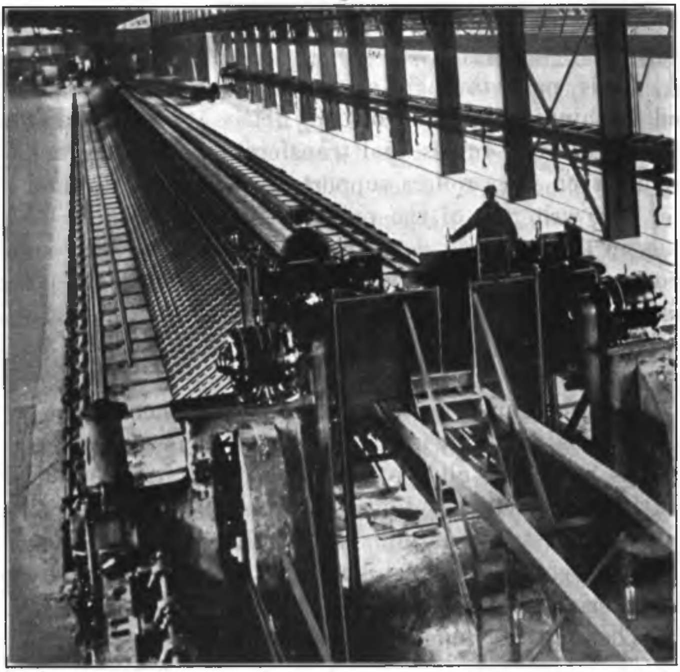

FIG. 13 EDWARDS DOUBLE-ESCAPEMENT-TYPE COOLING BED

This intermittent dropping from one spur to the other straightens the rapidly cooling rod so that when it reaches the bottom it is straight enough for ordinary purposes. The rod is then pushed out onto a roller table at the bottom of the cooling bed, and conveyed to the shear where it is reduced to the desired length. In some cases where the rods are small in diameter, for example $\frac{1}{4}$ in. and $\frac{5}{16}$ in., they are passed from the mill direct to coiling reels, where they are coiled into bundles and placed on a slow moving coil conveyor. This allows the bundles to cool before being placed in storage piles or on cars for shipment.

SHEET AND TUBE MILLS

59 Although material-handling equipment in sheet mills has improved considerably in the last few years, it is the opinion of the writer that there is greater chance for improvement in handling equipment in this type of mill than any other, as a vast amount of work is still done by hand.

60 Material is moved by hand to and from furnaces, to and from shears, and through the finishing processes of sheets, to an extent which should be eliminated by roller tables, chain conveyors, or even overhead monorail trolleys, any one of which properly installed would lighten the load now placed on human shoulders.

61 It might be said that the tube mill is a continuation of the plate or skelp mill, where tubes are made by bending up and lap welding the plate or drawing the smaller-sized skelp through a bell-shaped die to be butt-welded. Material-handling machinery for this type of work is well developed, and through the use of overhead cranes, conveyors, special pushers, etc., the manual handling of material is almost entirely avoided.

FORGINGS

62 Heavy forging is another branch of the steel industry that requires special handling machinery. It is a well-known fact that whenever steel is used to withstand heavy stresses, such as for battleship propeller shafts, heavy guns, etc., it is necessary to forge it. This is done under large hydraulic presses or steam hammers and it is necessary to handle the material rapidly after it is heated, to forge it as near as possible to the shape required before it cools. Fig. 14 shows a manipulator which when controlled by a skillful operator can handle a 3-ton forging with as great dexterity as a blacksmith handles a horseshoe. Such a machine may also be used to feed material into rolling mills of different types. Primarily, it is operated by three motors. The first controls the vertical travel of the end of the peel, the second rotates it on its own axis and the third moves it laterally by turning the car body on the truck. A handwheel controls the height of the rear or pivotal end of the ram so that it can be kept as nearly horizontal as possible. Two sets of springs are provided to give flexibility in both a vertical and horizontal direction and the tongs

are operated with compressed air furnished by a compressor mounted on the frame. The whole machine is moved on its track by two motors on the truck.

MISCELLANEOUS EQUIPMENT

63 Many types of conveyors are used in steel-plant auxiliary equipment, such as gas-producing plants, power plants, coal-pulverizing units, etc.

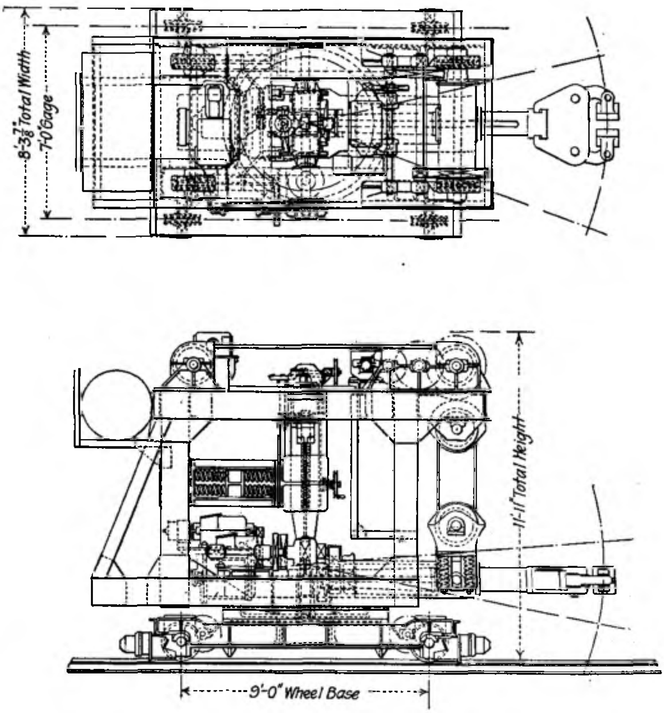

Fig. 14 Alliance Three-Ton Forging Manipulator

64 Among the most novel of these is one type of modern plant for pulverizing coal, in which the pulverized coal suspended in air is conveyed about the plant in pipes. This system has been successfully installed in several large steel plants where the pulverized coal has been used for open-hearth furnaces, reheating furnaces and boilers.

GENERAL

65 To summarize the problem of material handling in the iron and steel industry, it is quite apparent that there are many gaps in handling material from the ore mines to the finished steel which can be improved even with the present methods of manufacturing. Notably among these are the methods of conveying raw materials to the open-hearth furnace, and the many steps required from the blast furnace to the finished steel ingot. In other words they include the rehandling of material several times to obtain the desired refinement of steel, which is especially important where most of the material is handled in a molten condition with its consequent high cost. It is the writer's opinion that this refining process will change materially in the next few years through the medium of electricity, and as central power plants become more highly developed and more of our natural resources are put into use to obtain cheap electrical power, furnaces will be developed that will operate by a continuous process. They should be able to take the ore at one end of the furnaces, and with the addition of material at different points obtain the alloy desired at the pouring end thereby eliminating the handling now required from one furnace to the other by miscellaneous containers, ladles, etc.

66 In reducing ingots to the finished steel product, improvements should be made which will increase the safety of working conditions and eliminate as much as possible by proper ventilation at the mills and well-ventilated operating pulpits located at a distance from hot work, the disagreeable conditions arising from heat. Machinery should also be developed, wherever possible, to eliminate the necessity of handling hot steel with tongs around bar mills, rod mills, sheet mills, etc.

67 There is without a doubt a vast field of research, and improvement in this industry, as there is in all others, and it is for us, as engineers, to continue our endeavors and bring out these improvements.

DISCUSSION

In answering questions raised in the discussion, F. L. Estep, who presented the paper, said that he doubted if a machine could be invented to open the packs, since this is a problem of 75 per cent rolling and 25 per cent heat and the human element was needed. In a steel plant, he said, the wages were on a tonnage basis and therefore all equipment should be designed and constructed to meet the practical requirements of the workers and not to meet theoretical conditions. Handling and moving was a large item in the cost of manufacturing steel and steps were being taken to reduce it.

Stafford Montgomery asked about economical methods for conveying and storing large quantities of many sizes of light tubes in the finished condition between drawing operations, also whether steam locomotives could be economically eliminated from the yard proper of a steel company and electrical power used. In reply Mr. Estep stated that three or four methods could be applied in the handling of tubes between departments and storage between operations. A tube mill, as a rule, did not have overhead cranes in a big building but monorails could be installed which would quickly carry a good tonnage of hot or cold material. Or if it was cold tonnage, it could be handled with a magnet and a monorail. In regard to the question of steam against electricity, he said that the overhead-trolley system, nine times out of ten, would be too expensive. Difficulties in the way of maintaining and safeguarding would offset the saving in operating economies.

E. L. Shaner was of the opinion that the handling equipment in iron and steel plants could be divided into two classes, the largest of which was comprised of heavy and intricate machinery that required the attention of engineers who specialized in that equipment. On the other hand, there were many operations which required simple mechanisms and hand labor, and the reduction of handling costs on these operations was of great interest to iron, steel, electrical and metallurgical engineers.