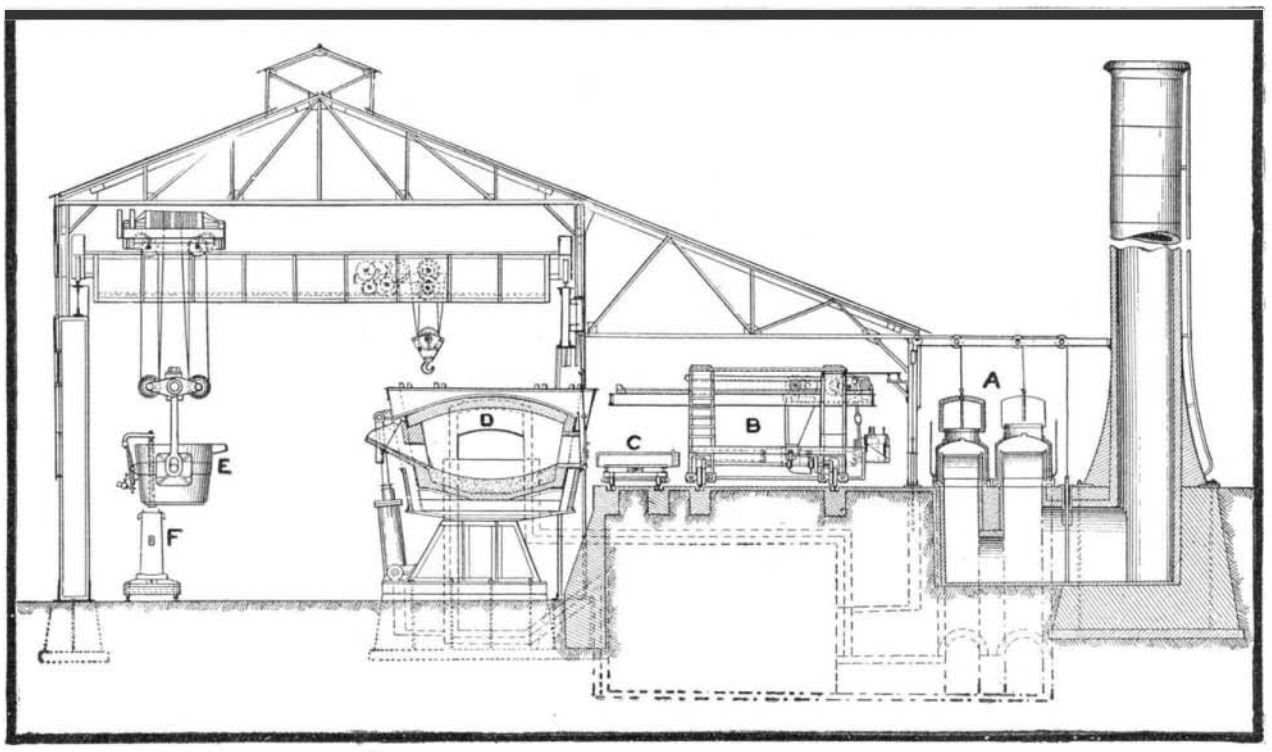
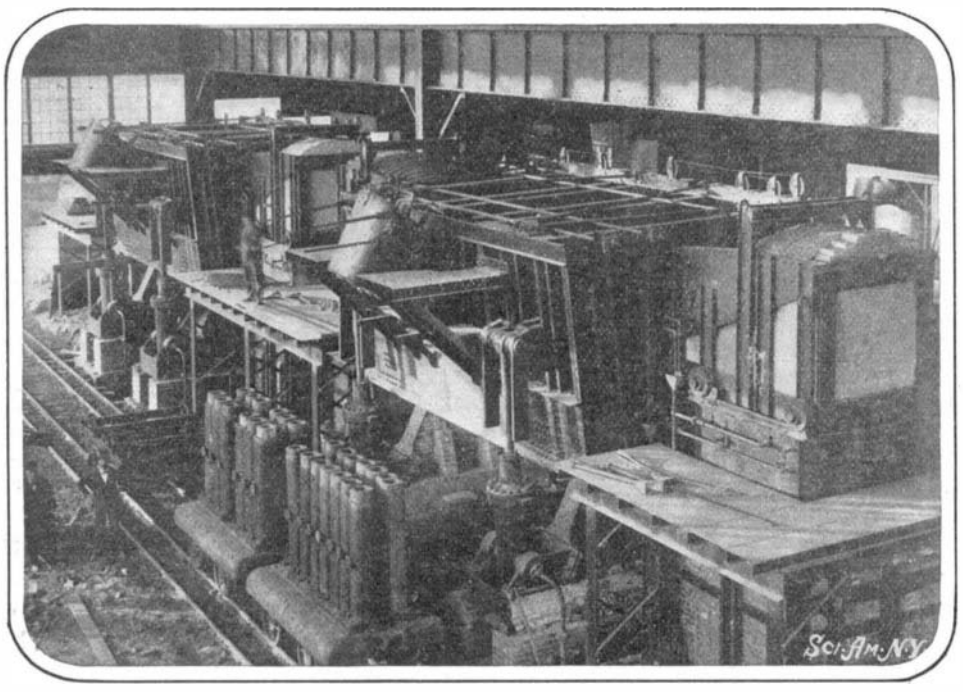
MANUFACTURE OF BRIDGE AND BUILDING STRUCTURAL SHAPES.

It was a wise choice which selected the term "structural shapes" to designate the wide variety of angle-irons, T-irons, I-beams, Z-bars, channel irons and built-up posts, beams, and girders which are used in modern iron and steel construction, for it would be scarcely possible to find any term that would so descriptively apply to every single member of an extremely numerous class of manufactured articles. There is no other branch of the iron and steel industry, perhaps, in which the American citizen has more reason to take pride than this, for upon no other have we stamped our national individuality so deeply. The American bridge and the American composite steel-and-masonry building are two forms of construction that are recognized the world over as having received their most marked development in this country. Of bridge building particularly it may be said that it is to the improved methods of manufacture and of shop management, coupled with a system of design that has an eye always to expeditious and economical work in the construction shop, that the great rapidity and cheapness of construction and erection of American bridges is due. From among the many great "structural" works of the country that make bridge building a specialty, we have selected for the present description the Pencoyd Iron Works, of Pencoyd, Pa. The choice was made for the double reason that these works are among the largest and most representative in this country, and that they are particularly familiar to the American public because of their successful and widely-advertised competition with foreign builders, in which they secured the contract for the construction of the Atbara Bridge in the Soudan.

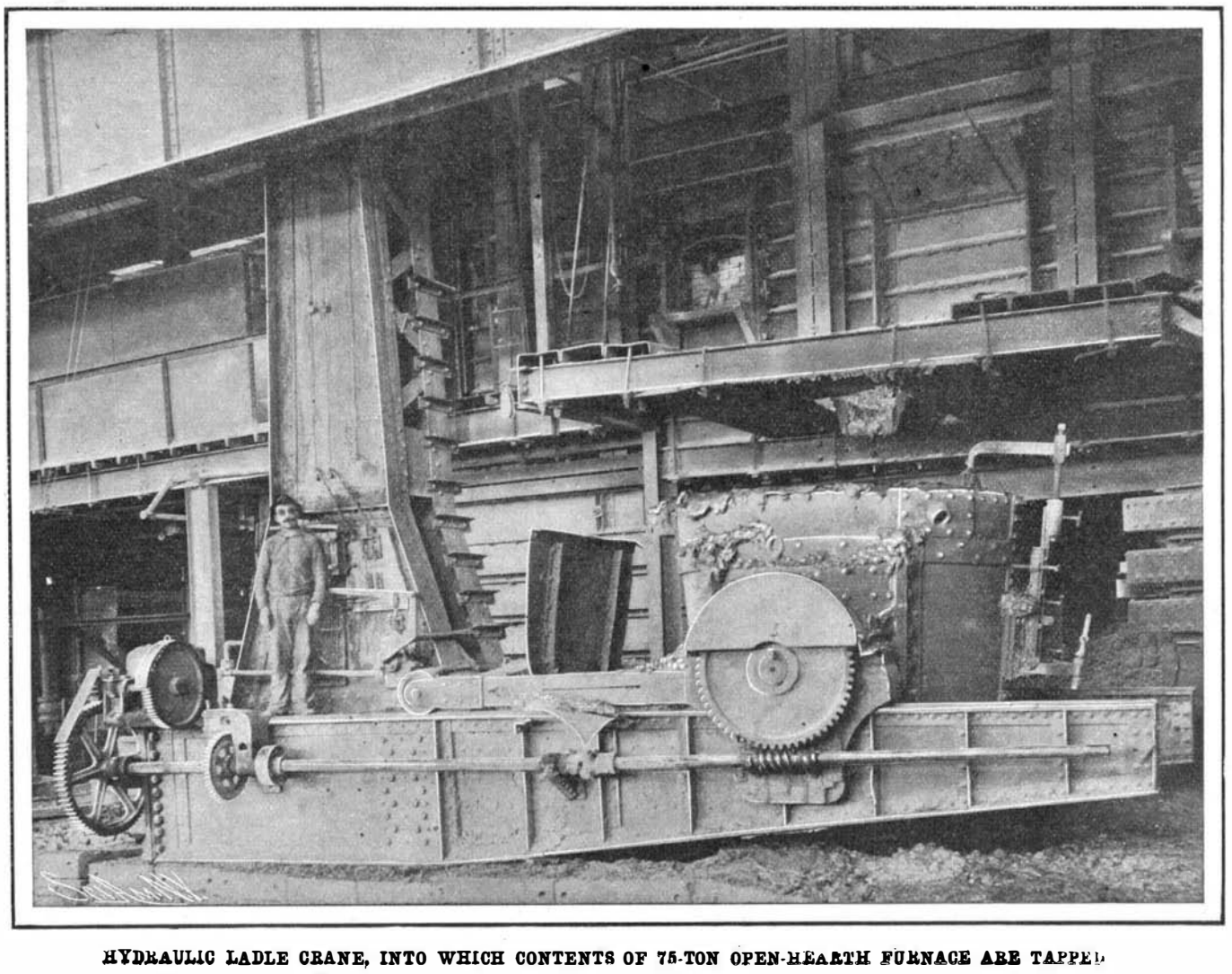


To extreme right is the chimney; then follow: A, air and gas reversing valves; B, charging machine; C, buggies from which charger picks up boxes of "mixture," thrusts them into furnace and empties them; D, Wellman rolling furnace, showing charging door, pouring spout, and hydraulic cylinder for pulling over; E, ladle crane, with its crane in position over a mold for pouring an ingot.

SECTIONAL VIEW, SHOWING RELATIVE POSITIONS OF PARTS OF A WELLMAN OPEN-HEARTH PLANT.



POURING SIDE OF 20-TON OPEN-HEARTH FURNACES, WITH FORE HEARTH IN POSITION.



HYDRAULIC LADLE CRANE, INTO WHICH CONTENTS OF 75-TON OPEN-HEARTH FURNACE ARE TAPPED.

THE OPEN-HEARTH PLANT.—The shapes are rolled entirely from basic open-hearth steel, three grades being produced — "rivet," "soft," and "medium." The rivet steel has an ultimate strength of from 48,000 to 58,000 pounds; soft steel, of from 52,000 to 62,000 pounds; and the medium of from 60,000 to 70,000 pounds. In each case the required elastic limit is not less than half the ultimate strength, and the test pieces of steel must be capable of being bent over upon themselves to an angle of 180 degrees without fracture, while the eye-bars used in bridge construction must show a tensile strength of not more than 10,000 pounds below the test specimen of the grade of steel from which they are rolled. They must also show not less than 10 per cent elongation in the body of the bar, and they must break in the body and not in the eye. The open-hearth plant (no Bessemer steel is made at these works) consists of ten furnaces, each of about 30 tons capacity, and one tilting furnace of 75 tons capacity, the total output of which is 4,600 tons of ingots per week. In the stock yard the raw materials consist of ore, scrap steel (such as junk, crop ends, punchings, and general scrap from the construction shop), and pig iron. The pig is melted in cupolas and run into the open-hearth furnaces, where an equal proportion of cold scrap is added. One of our engravings shows a hydraulic ladle crane into which the contents of the 75-ton furnace are poured, the crane with its burden being then swung around over the casting pit and the hot metal poured into the ingot molds through the bottom of the ladle in the usual way.

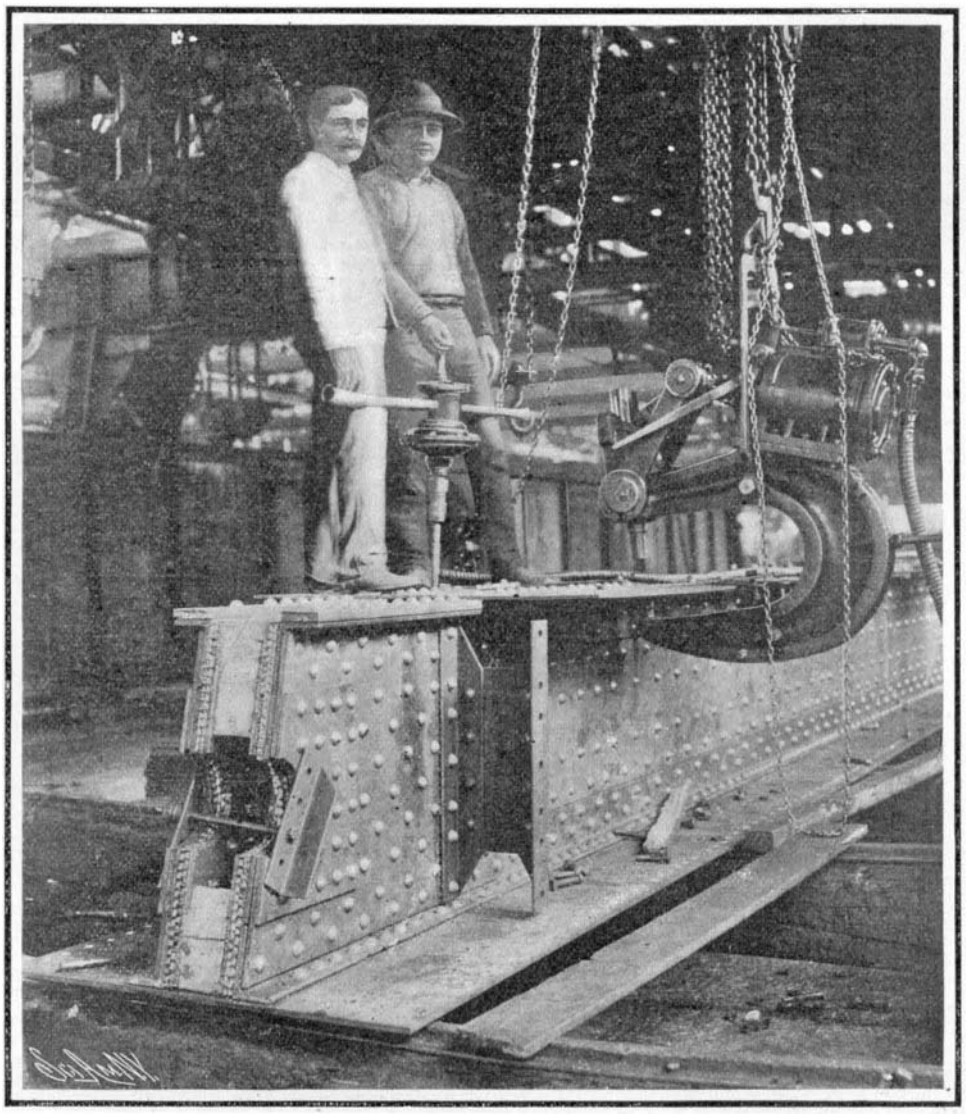
ROLLING MILLS.—To take care of the 46,000 tons of ingots turned out every week from the open-hearth department calls for an extensive plant in the rolling mills. This consists of a 23-inch three-high roll train used for rolling shapes; a 12-inch three-high roll train used for small bars, angles, T-irons, etc., and a large 23 to 28-inch mill, comprising a 28-inch two-high reversing roughing mill, and a 23-inch three-high finishing mill, each driven by 30 x 36-inch double reversing engines, geared direct to the mills. In this mill, whose weekly output is from 2,000 to 3,000 tons, angles are rolled up to 190 feet in length, and beams up to 100 feet the blooms from which they are made weighing from 1,150 to 6,000 pounds each. Lastly, there is a 36-inch two-high mill, which prepares the steel for the finishing mills, that has turned out as much as 3,800 tons of blooms and billets per week. When the shapes are rolled they are sawed into the desired lengths, taken to the hot-beds to cool, straightened, and then cut to exact length. The material is now ready for the construction shop.

BRIDGE AND CONSTRUCTION SHOP.—In this department, which is housed in a building 200 feet wide by 460 feet long, great care has been taken to make the operation of building the angles, channels, tees, and various shapes up into finished bridge members

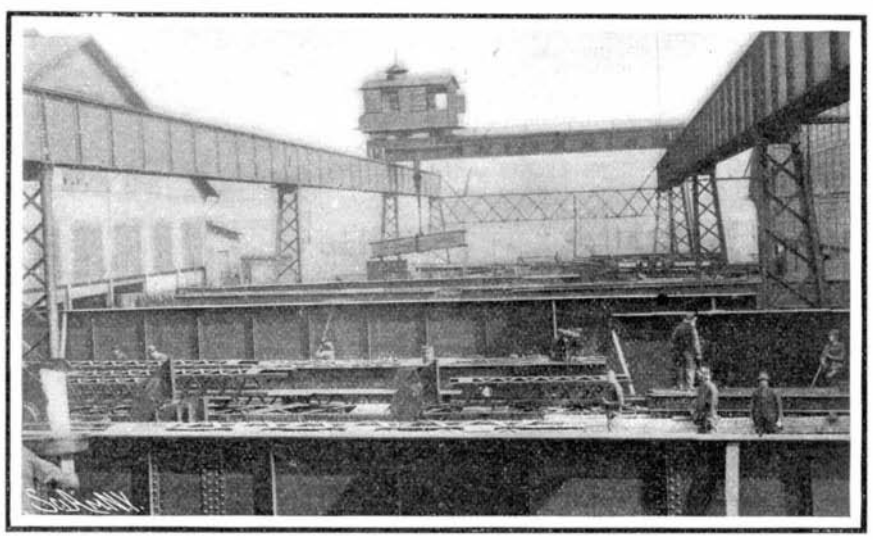
as continuous as possible, with a minimum of handling and transportation. At the end of the shop next the rolling mills the shapes are carefully laid out by wooden templates, in which the exact position of every rivet, angle, gusset, etc., is marked. The operation of building up the bridge material is a simple one, the chief requisites being great care and accuracy. The shapes are sawn or sheared to exact length, and, where it is called for by the drawings, the sides and ends are planed and faced down. All pinholes are first punched and then bored to exact diameters; but the smaller holes for bolts and rivets are punched, and for doing this work some very highly developed machinery, driven by electrical power, has been installed. The preliminary work being now completed, the pieces are assembled, bolted together, rivet holes properly registered (by reaming them if necessary), and finally they are riveted up by hydraulic and pneumatic riveters. One of our illustrations shows a portable pneumatic riveter at work upon a large end post, weighing 30 tons, for a bridge across the Mississippi, and another represents a massive floor beam intended for the same bridge, being riveted in a large under-hung 100-ton hydraulic lift riveter. The development of labor-saving machinery in this shop is an exceedingly interesting study, which limitations of space alone prevent us from taking up at this time. Steam has given place entirely to electricity, practically all of the tools being driven by independent electric motors, while electric power hoists and reamers, pneumatic riveters, and other pneumatic tools are supplied so liberally that it is a rarity to see hand work being done in any part of the shop. As the work is completed, it reaches the opposite end of the shop from that at which it entered, from which it is moved out into the yard for finished material, where it is loaded onto the cars by two overhead cranes of 30 tons capacity and shipped to its destination. The total capacity of the bridge and construction department, including the eye-bar and forge shops, is 9,000 tons of finished material per month. When plans of enlargement have been carried out, the capacity will be raised to about 15,000 tons per month.

EYE-BAR SHOP.—One of the most important branches of bridge manufacture is the construction of eye-bars, and in the shop devoted to this work is found a complete equipment of hydraulic machinery, including pumps, accumulators, an upsetting machine for forming the heads of the eye-bars, and a collection of shearing, punching, rolling, and straightening tools with the necessary heating and annealing furnaces. The upsetting of the eye-bars is done in an ingenious hydraulic machine, in which the heated end of the eye-bar is brought up to the desired circular form by means of a hydraulic press, carrying a three-fold die. The formation of the head is completed in a single operation. The head is then forged and punched at one heat, ready for the finish boring. Eye-bars are formed up in this machine to a size of 8 inches width of body and 18 inches diameter of head. When an order of eye-bars is completed, a full-sized test is sometimes made by pulling one of the bars asunder in a hydraulic testing machine with a maximum capacity of 700 tons.

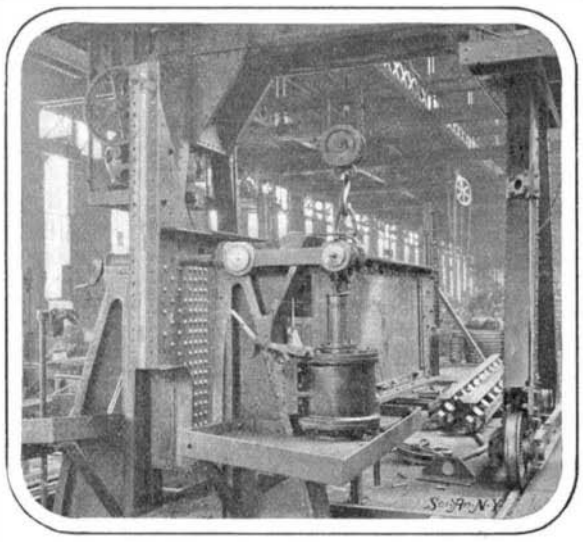
In conclusion we give some facts regarding the rivet and bolt shops. As we have indicated in the opening of this paper, a special grade of steel, known as rivet steel, is used which has an ultimate breaking strength of from 48,000 to 58,000 pounds. The rivets and bolts are made in special machines which turn them out with extraordinary rapidity. Thus, in a single month over 850,000 pounds of rivets and about 220,000 pounds of bolts have been made in this department. As illustrating the remarkable growth of a single typical American bridge and construction works, it may be noted that whereas in 1853, the first year of operation of the works, the total output was 304 gross tons, it had grown in 1860 to 1,475 tons; in 1870 to 6,700 tons; in 1880 to over 15,000 tons. By 1890, the bridge and construction department turned out 26,065 tons and the rolling mill department 48,230 tons; while in 1902 the respective totals were 87,000 and 180,000 tons.



RIVETING UP A MASSIVE 35-TON CHORD SECTION FOR NEW BRIDGE ACROSS THE MISSISSIPPI AT THEBES, ILL.

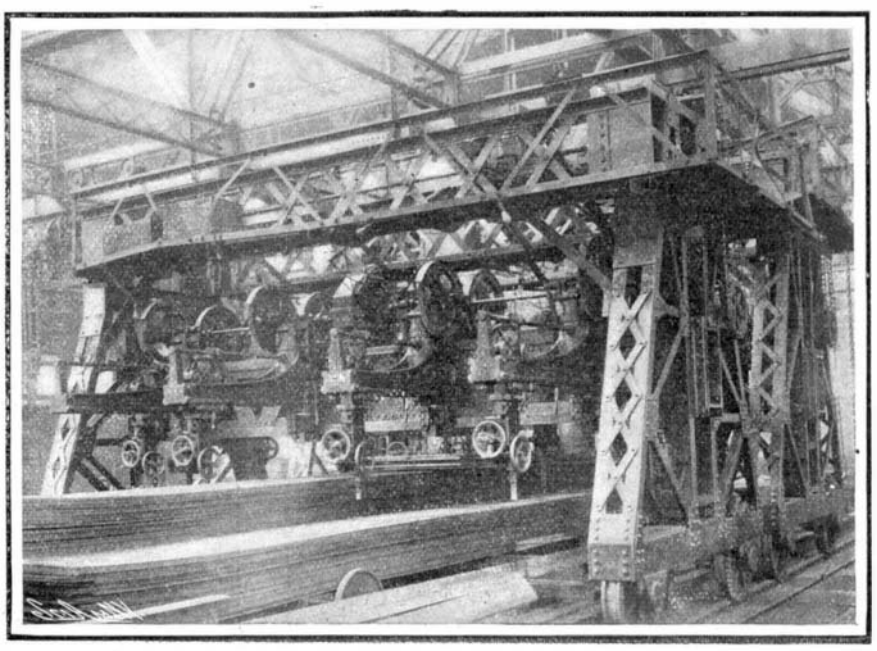


THE SHIPPING YARD, WITH COMPLETED PLATE-GIRDER BRIDGES, READY FOR SHIPMENT.

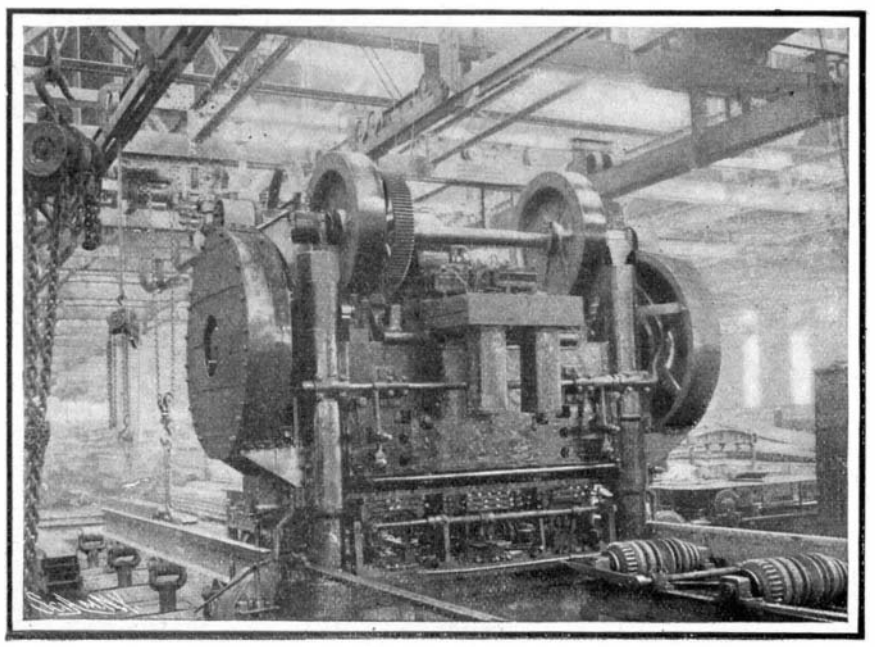


100-TON HYDRAULIC RIVETER AT WORK ON HEAVY FLOORBEAM.

The Trinity House authorities have given notice of several important alterations at the lighthouses on the south coast of England and in the English Channel. The one of the greatest importance to all navigators of the Channel is that relating to the Lizard lighthouses. Here the two fixed white lights hitherto exhibited have been discontinued, and in lieu thereof a white electric light, of great brilliancy, is exhibited from the eastern tower, flashing once every five seconds, and lasting only for a quarter of a second. In addition a continuous light of small power may be visible for about twelve miles under certain circumstances. The subsidiary fixed white light proposed to be exhibited from the eastern tower will not be shown for the present.



A PAIR OF LARGE ELECTRIC GANTRY DRILLING MACHINES, EACH CARRYING EIGHT DRILLS OF FIVE-FOOT RADIUS.



ELECTRIC BEAM PUNCHING MACHINE; WORK IS FED BY MOTOR-DRIVEN ROLLER TABLES AT RIGHT OF CUT.