CHAPTER XXXVI.

CONTINUOUS BILLET, BAR, AND STRIP MILLS.

The continuous mill had given such satisfactory results in the production of wire rods, that Messrs. Jones & Laughlin, Limited, of Pittsburg, finding, in 1892, that the demand for merchant bars was greater than they could meet with their existing mills for making small bars, turned their attention to the question of applying the continuous principle to the production of such bars. They requested the Morgan Construction Company to design them a mill capable of taking the 4-inch by 5-inch bloom, as it left the cogging mill in a length of 80 feet, and finishing it right out without reheating, so as to avoid the loss arising from crop ends, when the bloom is cut up into short lengths before going to the finishing mills.

To reduce such a billet to a $1\frac{1}{2}$ square bar in one length, would have necessitated discharging from the rolls a bar over 600 feet long, which, apart from any other consideration, was a greater length than Messrs. Jones & Laughlin's yard could accommodate. To obviate this difficulty, Mr. Victor E. Edwards suggested the daring innovation of a "flying shear," which should accompany the bar as it travelled at a speed of 6 to 8 feet per second, and cut it up into lengths suitable for loading into the railway waggons ready for sale.

Fig. 512 shows this shear, which consists of an upper sliding blade, A, attached to the inclined link, B, pivotted on the pin, C, so that when the swinging frame, D, is moved to the right, the blade, A, descends. The lower blade, E, is attached to the swinging frame, D, which swings on the centre, F. The bar to be cut, G (fig. 513), is travelling rapidly between the blades in the direction of the arrow, as shown in the explanatory diagram (fig. 513), in position No. 1, and when the length required to be cut off has passed through, the end of the bar touches a trigger, whose distance can be adjusted so that any desired length can be cut off. This trigger admits water from a steam intensifier into the upper end of the inclined cylinder, H, and the links, J, attached to the crosshead, K, draw the swinging frame to the right, carrying the shear blades with it, into position No. 2, whereby the bar is cut through. As the cut is made the valve begins to close, the swinging frame slows down, and the end of the uncut bar, continuing to move at the same speed as before, pushes aside the upper blade, A, which is hinged on a pin at its upper end expressly to permit of this movement (see position No. 3). The shears are then returned by the constant pressure of water into the No. 1 position ready for the next cut, all this occupying less than 1 second to perform. To prevent slamming at high speed a cataract cylinder, M, is provided. The shear proved perfectly satisfactory, and several are now in use in America.

To cut strip two drums are used, having blades fastened across their faces; the strip runs between the drums, which are driven at different speeds, so that the knives only come together at the instant when the drums have made the number of revolutions needed to cut off the length required. The wheels driving the drums are changed to suit the length to be cut.

Fig. 514, Plate xlvi., shows the arrangement of Messrs. Jones & Laughlin's mill, which was for some time the most massive mill of the type built. Between it and the cogging mill is placed a pair of shears, which are of a similar design to those just described, but stronger and slower

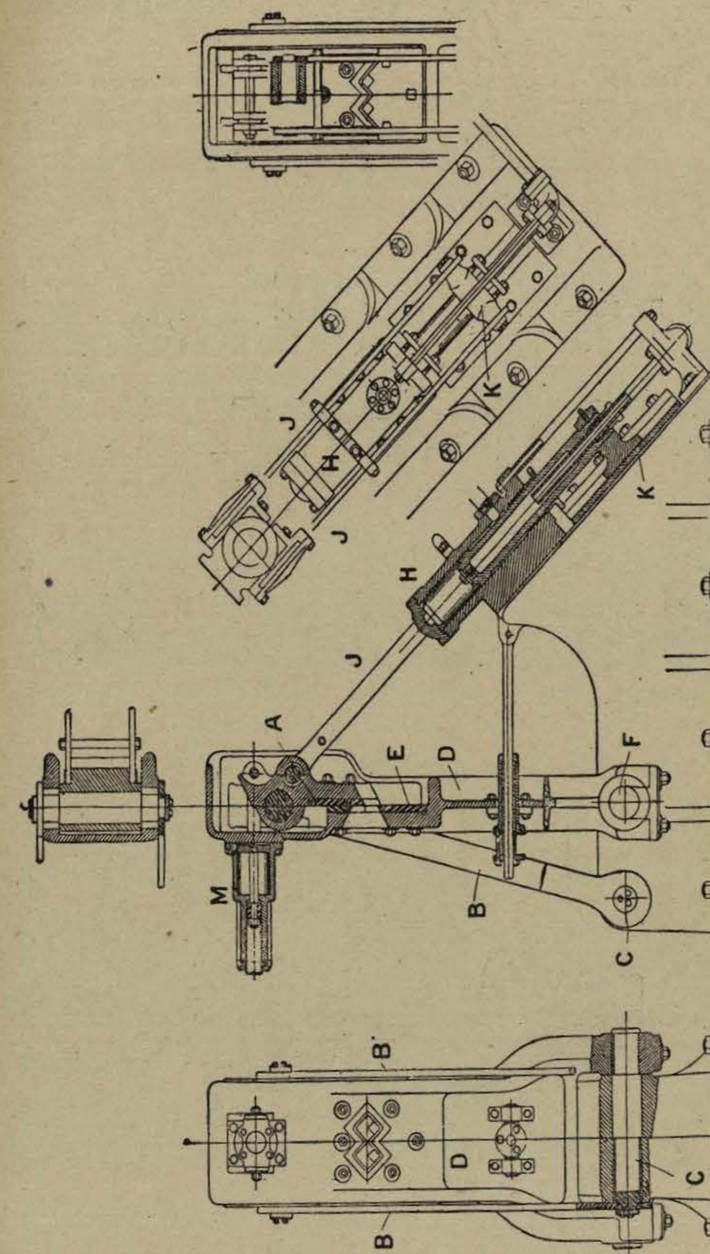

Fig. 512.—Flying Shears for cutting rod into lengths while it is moving.

in action, intended to crop any blooms which may leave the cogging mill with imperfect ends. The continuous mill consists of 9 stands of rolls, with pinions carried in independent housings, mounted on separate longitudinal beds, running the entire length of the mill; a third bed carries the

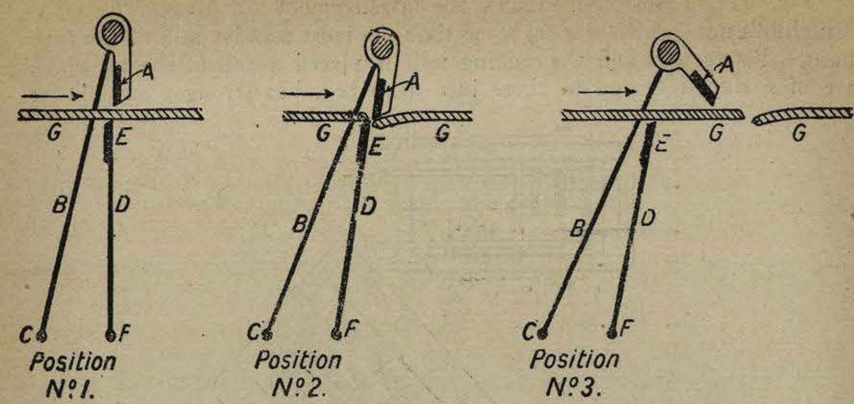

Fig. 513.—Diagram to explain Action of Flying Shears.

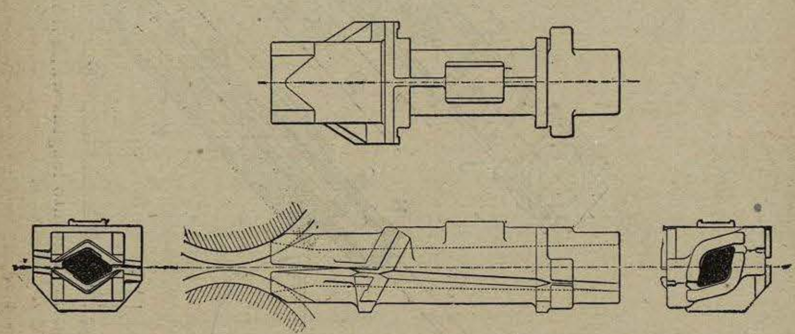

Fig. 515.—Twisting Guides used in Continuous Mills.

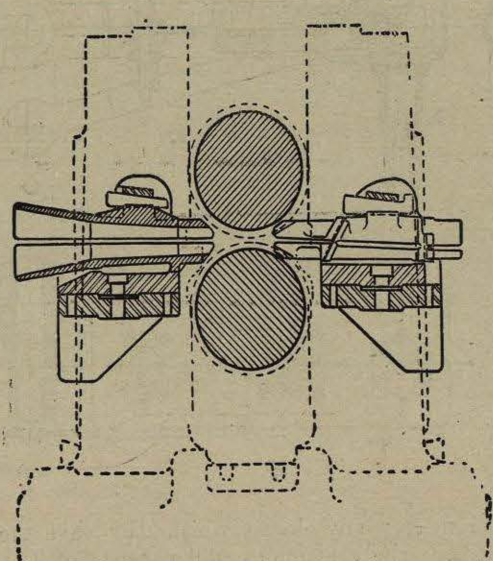

Fig. 516.--Method of Securing Twisting Guides.

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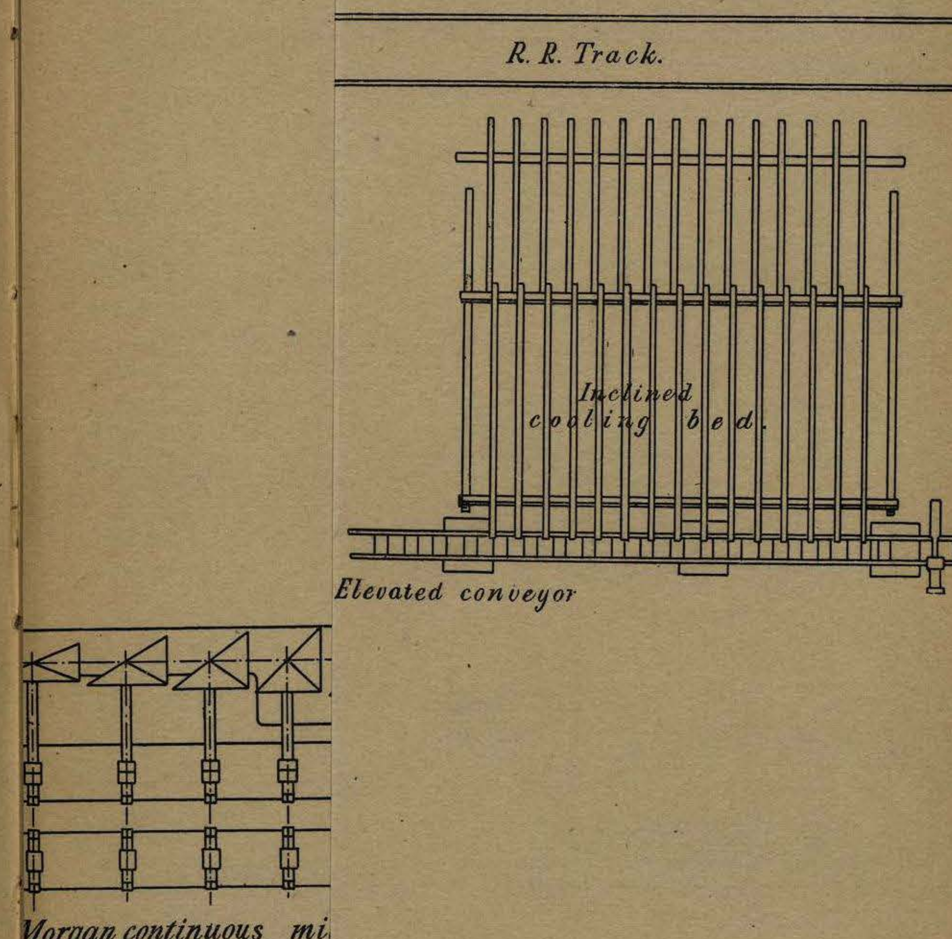

PLATE XLVI.—Continuous Billet Mill.

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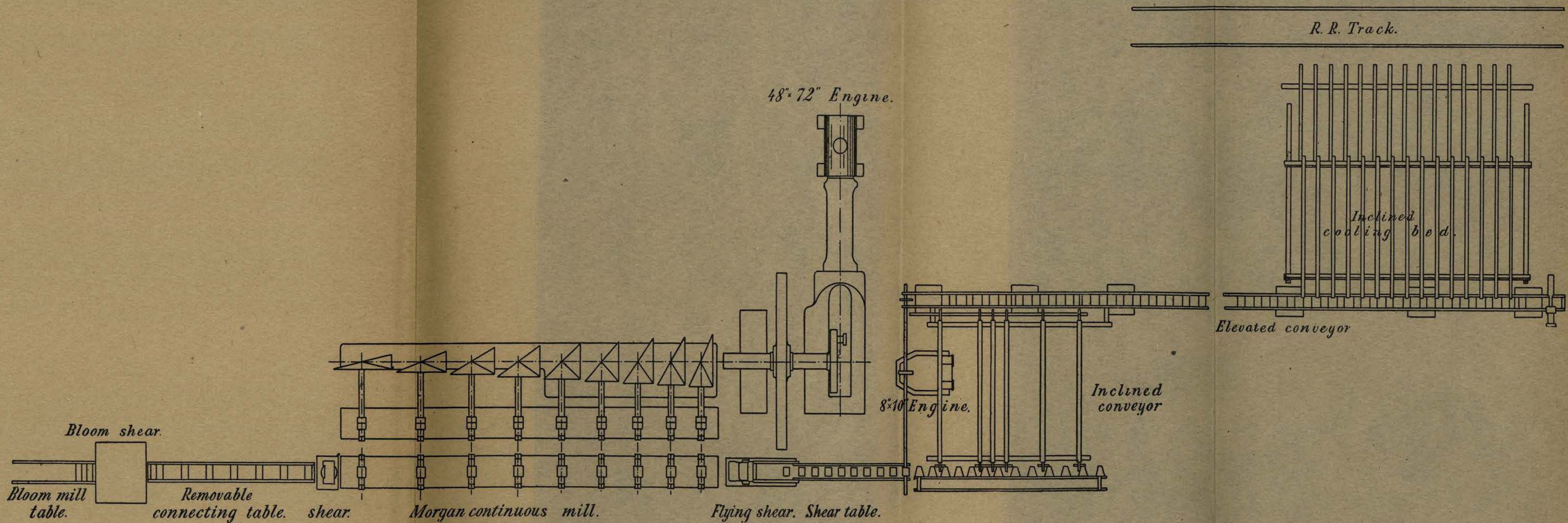


Fig. 514.

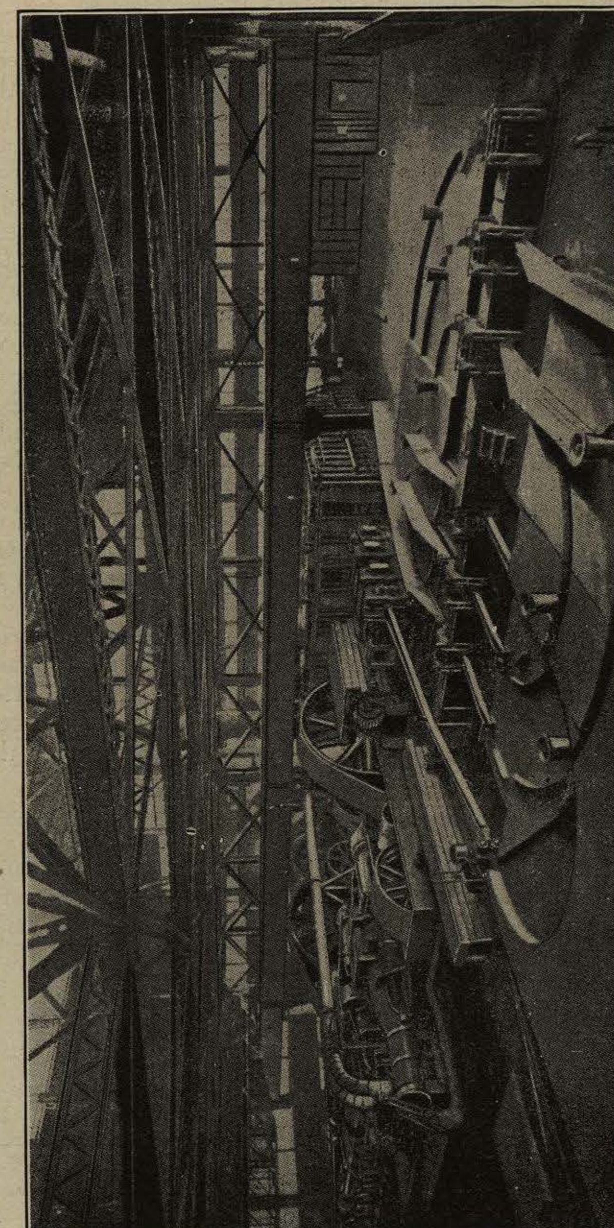


Fig. 517.—Combination Continuous Mill for Rolling Sections, at Duquesne, Pa.

driving shaft, which is the extended end of the crank shaft of a Reynolds-Corliss engine, having a cylinder 48 inches diameter, by 6 feet stroke. The continuous mill is in line with the cogging mill, with which it is connected by a roll table, capable of being quickly tipped on end, so as to leave the floor clear if required for rolling ordinary finished blooms.

At the delivery end of the continuous mill, beyond the flying shear, is a set of live rollers, conveyors, and cooling beds for receiving the finished bar, and to avoid the net-work of railway lines at this spot it was necessary to elevate the billets and convey them beyond; the method adopted is shown in the plan. To illustrate the rapidity and smoothness with which the whole works, a 4-inch by 5-inch bloom can be received from the cogging mill, enter the continuous mill, have its first end rolled to 1½ inches square, be cut into lengths, and taken to the cooling bed ready to despatch, before the last end of the bloom has left the table of the cogging mill; so that, at the same instant, part of the original ingot may be on its way to the continuous mill to be reduced, part in the continuous mill in process of reduction, and part finished and delivered to the cooling bed. This was the first continuous mill to deal with such heavy sections, and it seems extraordinary that it was possible to turn them on edge by means of twisted guides; to enable it to be done, the second stand of rolls is placed at a distance of about 9 feet from the first pair, the distance between the stands being reduced as the section gets smaller.

Fig. 515 shows the construction of the twisting guides of a continuous mill, which are used to turn the bar on edge between one stand of rolls and the next succeeding stand, and fig. 516 shows how these guides are held in position.

Fig. 517 shows a combination mill used for rolling various sections, and is similar in principle to the combination mill for rolling wire made by the Mossberg Company, and described in the previous chapter. The billet is roughed down in four stands of continuous rolls, and then passed to what is essentially a Belgian rod mill, the roughed bar being guided through the various stands by repeaters fixed in the floor of the mill.

A form of continuous mill in which the bar does not need to be turned on edge is that used for the production of sheet bars, which are cut up to roll down into sheets. The drawing (fig. 518) shows the arrangement of the housings in the mill used for this purpose at the Vandergrift Works, near Pittsburg, belonging to the Apollo Iron and Steel Company. It has two groups of such rolls, each consisting of three pairs of 16-inch rolls, each pair provided with the usual pinions. In this case the necessary variation between the speeds of the different stands is obtained, not with bevel, but with spur-wheels, the power being delivered to the centre shaft, A, of each set of gearing. This shaft is coupled direct to the lower roll, A, in the centre stand; the speed is reduced by the spur-wheels for the stand to the left hand, B, and increased for that to the right, C, the shafts, B and C, being coupled to the top roll in each case, so as to cause the rolls to run in the direction needed. The bloom enters between the rolls to the left hand, and passes towards the right in the direction of the arrows. The screws for adjusting the rolls are geared together in such a way that if the top roll of the finishing pair is raised or lowered, all the other top rolls are adjusted proportionally to suit; but, at the same time, any individual screw may be disconnected and adjusted separately if required. By this arrangement, which has been found to work well, it is possible to change from one thickness of bar to another, and be certain to get the first bar rolled to the correct

weight, which cannot be done in the ordinary continuous mill. The blooms supplied to the mill are 7½ inches wide by 2½ to 4 inches thick, according to the weight of bar. The mill can deal with bars up to 200 feet long; each bar as it is rolled is pushed aside laterally by a series of arms, and four or five can thus be placed side by side for shearing.

The Morgan Construction Company, whose president, Mr. Charles H. Morgan, has been identified with continuous rolling for the last thirty years, and to whose efforts the practical development of the system is largely due, have kindly supplied the drawing from which fig. 519 is prepared. This drawing does not show any mill in actual operation, for in nearly every case some modification is required to suit the site available, but it is intended to illustrate the system, and is practically a combination of four different mills, and more comprehensive than the plan of any one mill could well be.

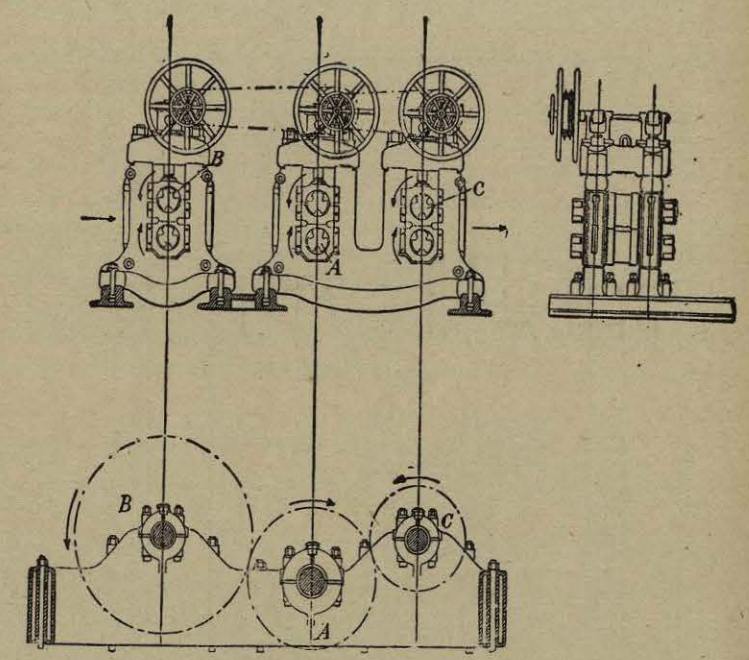
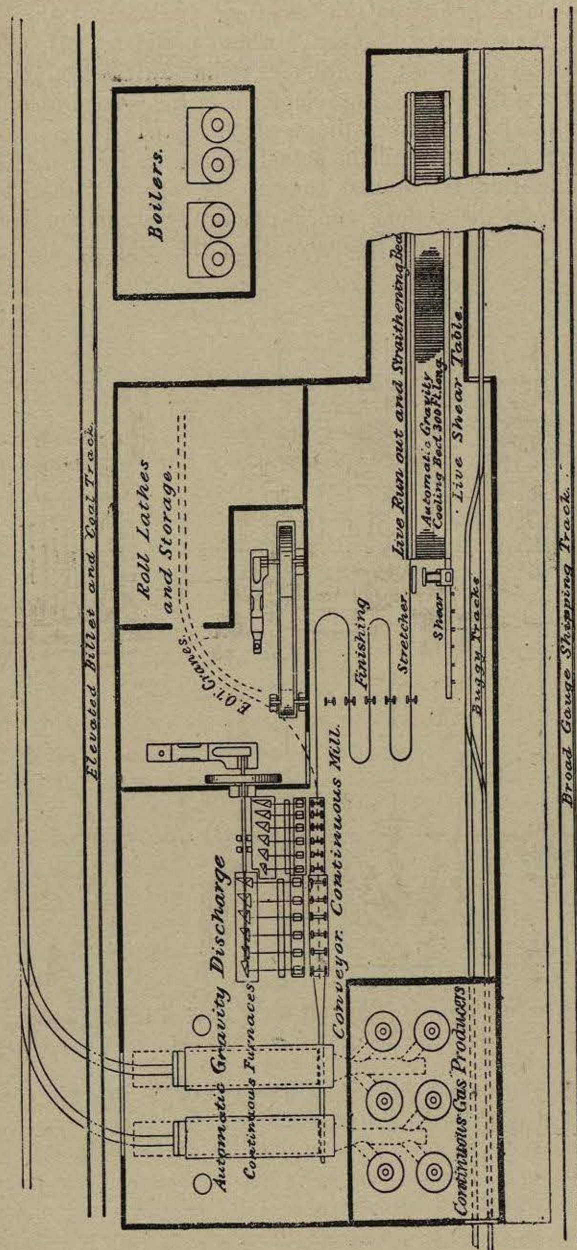


Fig. 518.—Continuous Tin-Bar Mill and Method of Driving same.

The heated billet, 4 inches square, is delivered to the train of continuous rolls in which it is reduced to ½ inch square, or to whatever size may be needed, and finished to accurate size by hand in an ordinary mill; thence it passes on to the conveyor, which is set to run slightly faster than the finishing rolls, to avoid any chance of its bending out of a straight line.

When the last end of the bar is clear of the rolls, one end is caught by a grip attached to a steam stretcher, and the other end fastened by a boy into an adjustable grip, and the bar pulled straight; the gripper being out of line with the conveyor removes the bar at the same time out of the way of the next. When the strain is relaxed the bar settles on an inclined cooling bed on which it is maintained straight by resting in the angle formed by the sloping supports of the cooling bed on one side, and a series of removable fingers on the other, which are removed as soon as the next bar is ready for stretching, and the bar, sliding a few inches down the incline, is stopped by



Composite Plan of Four Morgan Merchant Mills.

Fig. 519.

a second set of fingers. All the fingers are connected and worked by means of a steam cylinder controlled by a boy, who allows the bars to move down the incline intermittently, much as the escapement of a clock allows one tooth at a time to pass at each swing of the pendulum.

When once stretched the bars are by this means kept straight, and pass one at a time down the slope on to a narrow level bed, from which they are removed in groups of 10 or 20 at a time to the table of the shear, whence they are loaded up and put into stock.

A 13-inch mill has a capacity of 400 to 600 tons in 24 hours, and a 10-inch mill, in January, 1903, rolled 433 tons of $\frac{3}{4}$-inch round in the same time.

The bars, which are in lengths up to 300 feet, show the point of recalescence in a very clear manner, contracting rapidly at first, the contraction then gradually decreasing till it ceases entirely, and in a few seconds the bars begin to lengthen, slowly at first and then more rapidly; this soon ceases, and the final contraction sets in. The expansion while cooling often amounts to 2 or 3 inches in bars over 200 feet long, and the movement is sufficiently rapid to be easily followed by the eye.

At the Duquesne Works of Messrs. Carnegie & Co. there is a very heavy continuous mill, with steel housings, in which billets 5 inches by 5 inches have been reduced to $1\frac{1}{2}$ inches by $1\frac{1}{2}$ inches in seven passes. This mill, which is fitted with a flying shear actuated by steam, quicker even than the one at Messrs. Jones & Laughlin's, is capable of turning out 1,500 tons in twenty-four hours.

The National Steel Company at Youngstown, Ohio, put down a mill in 1895 for rolling small flats, such as barrel hoops and cotton ties about $\frac{7}{8}$ inch wide by 19 gauge thick, from billets of 300 lbs. weight each, the ordinary weight of billet for such a purpose being 40 lbs. It is said to roll so accurately to gauge that no difference can be detected between the thickness of the strip at the two ends when measured by a micrometer gauge, even when the strip is 2,500 feet long.

The Illinois Steel Company have such a mill at Joliet which, when producing similar ties, has turned out 50 tons in a single twelve-hour shift, and gives an average output of 180 tons per day when rolling $\frac{9}{16}$ inch squares.

The National Steel Company's mill at Mingo Junction, rolling $1\frac{1}{8}$-inch squares, produced the following weight in May, 1899 :—

8 hours,	261,045 lbs.,	say	106 tons.
12 ,,	388,120 ,,	,,	173 ,,
24 ,,	725,665 ,,	,,	324 ,,
1 week,	3,623,915 ,,	,,	1,618 ,,

The above figures have been kindly supplied to the author by the Morgan Construction Company.

About a dozen such mills have been built by the Morgan Company; they are capable of giving an enormous output with very few men, Messrs. Carnegie's having only four men employed on the mill proper, two at the mill and two at the shears. The cost of rolling small billets in such a mill, in America, is said by Mr. Sahlin to be only 1s. 3d. to 1s. 6d., "including allowance for interest and depreciation." They are only suitable where orders for enormous quantities of the same sections are obtainable. Where such are available they possess the following advantages over the more usual type :—

First.—They finish the metal very rapidly, allowing little time for oxidation and cooling, and, the speed being low, they take little power to drive.

Secondly.—They require scarcely any skilled labour to work them, being almost automatic.

Thirdly.—The shocks set up are fewer, and the rolls so short as to be almost unbreakable, even when several rods are rolled at once side by side.

Fourthly.—The lengths rolled are so great that the finished bars can be cut up in lengths with very little waste from crop-ends.

When first designed for bar-rolling, the cooling beds were made only 100 feet long, bars being finished in America at that time in lengths of 40 feet; beds 200, 300, and 360 feet long have been provided for subsequent mills.

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CHAPTER XXXVII.

HANDLING MATERIAL IN THE STOCK YARD.

MATERIAL cannot always be loaded up and despatched just as it leaves the rolls; for instance, orders are constantly received for rolled joists to be used in building construction, which frequently require a great variety of different sections and lengths to be despatched in one consignment, and even in one truck load. To enable such an order to be executed promptly, without frequently changing rolls or cutting long lengths to waste, heavy stocks of such sections are kept on hand, many works stocking 5,000 tons, while the Peine Works, near Hanover, are said to stock 35,000 tons. The girders are stacked in heaps, those of similar section together, and from these heaps are selected the lengths nearest approaching those required, which are sent to the cold saws to be cut to the exact length ordered. To stock such material, so that it can be readily sorted, requires, according to the variety of the sections and the output of the mills, from 2 to 5 acres of ground, and its transport over such an area by gangs of men armed with crowbars, who pushed it up and down on small trolleys, was so costly, that other means had perforce to be devised.

In most works, where heavy sections were rolled, columns and girders were erected to form a gauntry on which ran travelling cranes, the spans of such cranes ranging from 50 to 100 feet, and the cranes travelling to and fro at speeds varying from 50 to 150 feet per minute. To save the expense of providing a crane for every span, the Schuckert Electric Company of Nuremberg have constructed for a works at Aix-la-Chapelle, a transfer crane (fig. 520), running on girders, placed 9 metres above the ground, and $3\frac{1}{2}$ metres above, and at right angles to, the girders on which the usual cranes travel. By means of this traverser, the cranes

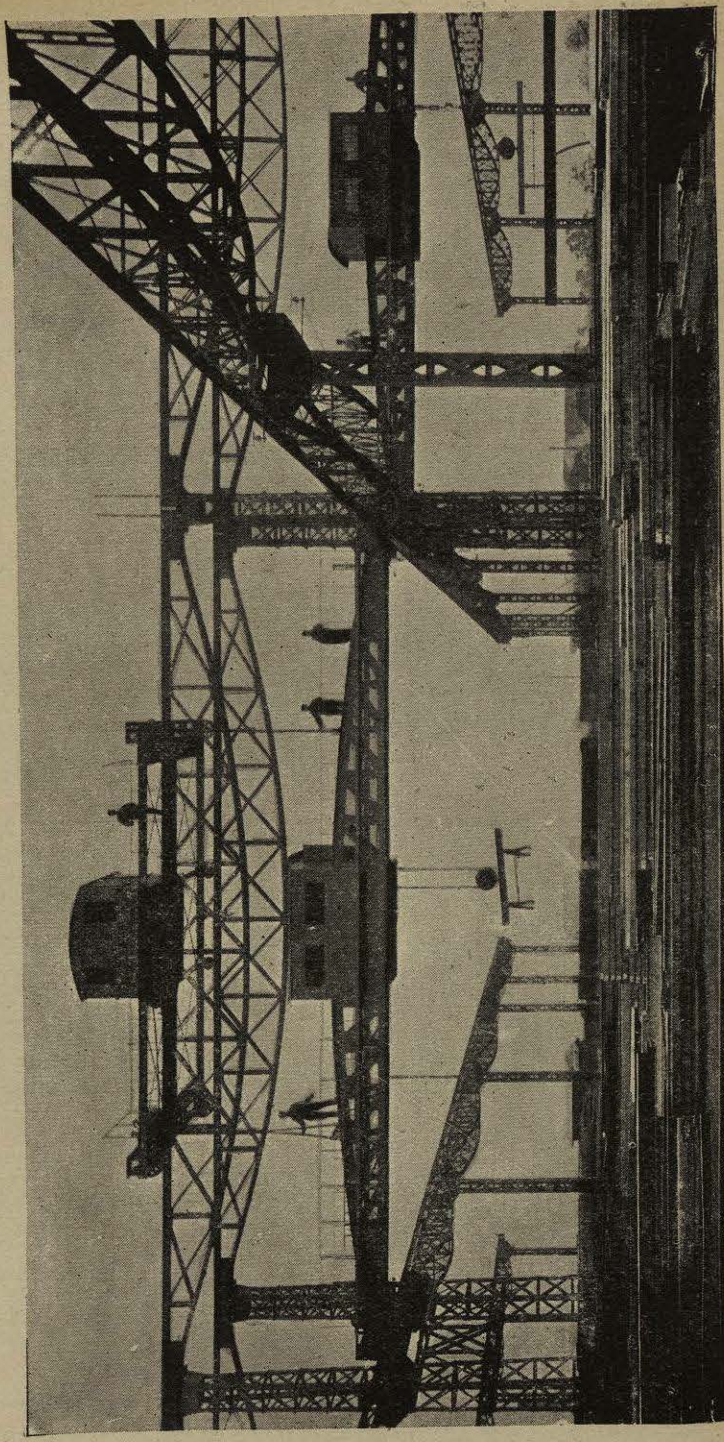

Fig. 520.—Stock Yard Commanded by Travelling and Transfer Cranes.

which have each a span of 21 metres, and are capable of lifting a load of 3 tons, can be transferred bodily to any span desired. All the cranes and the traverser are driven by means of a three-phase alternating current, actuating motors on the cranes.

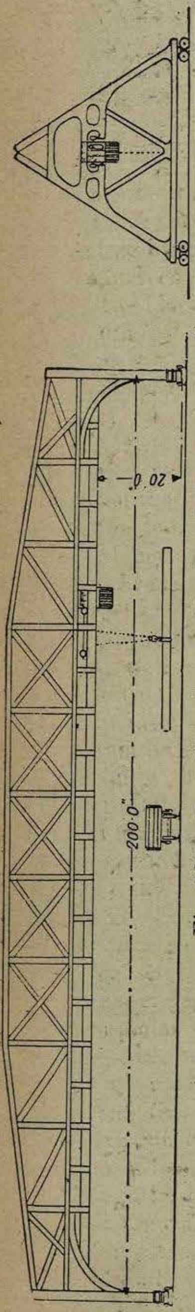

Fig. 521.—Travelling Crane at Cambria Iron Works.

With the object of saving the cost of columns and girders, some works have adopted cranes of the "Goliath" pattern, which consist of travelling trestles running on rails laid on the ground level, these trestles carrying the crane; two of these installed at the works of the Cambria Iron Company (fig 521), have a span of as much as 200 feet, and travel at a speed of 200 feet per minute, while the load can be raised at a speed of 20 feet, and transported laterally at a speed of 400 feet per minute, the power being obtained from an electric motor of 50 H.P. on each crane.

Where several parallel rows of cranes are employed, a railway must be run into every span, taking up a large proportion of the space available under the crane, particularly if the span of the crane is small, so that there is every inducement to make the span as wide as possible; and where it is possible to do so, the railway is run in a direction at right angles to the cranes, thus traversing every span in turn. In either case, if the different pieces required to make up a truck load are lying in different spans, the truck must be shunted into each span in turn, which causes difficulty in handling the traffic. To surmount this inconvenience, the Brown Hoisting and Conveying Machine Company, of Cleveland, Ohio, have introduced the type of loading crane, shown in fig. 522, which may be described as a travelling tower whose four feet run on rails laid on the ground, the waggons to be loaded resting on rails which are most conveniently laid between the legs. From each side of the tower projects a cantilever, and on these run, side by side, two small travelling trolleys, each taking hold of one end of the girder to be lifted, so raising it horizontally; the trolleys are then run in along the arms, and the girder is deposited in the railway truck, the distance between the legs being such that girders up to 60 feet long can be carried between them parallel to the railway. The distance over the ends of the two arms is 325 feet, and the strength of the structure such that loads of 5 tons can be raised at any point covered by the machine, this load being raised at a speed of 200 feet per minute, the trolleys running in with it at a speed of 750 feet per minute, while the complete crane travels along the rails on which it runs at 400 feet per minute; any one of the different motions can be operated independently or together, and at any speed between zero, and the maxima given above. With one of these cranes, six men should handle, from stock into railway waggons, or *vice versâ*, over 500 tons

in a working day of ten hours. Cranes of this kind are at work in several places in this country, in America, and on the Continent.

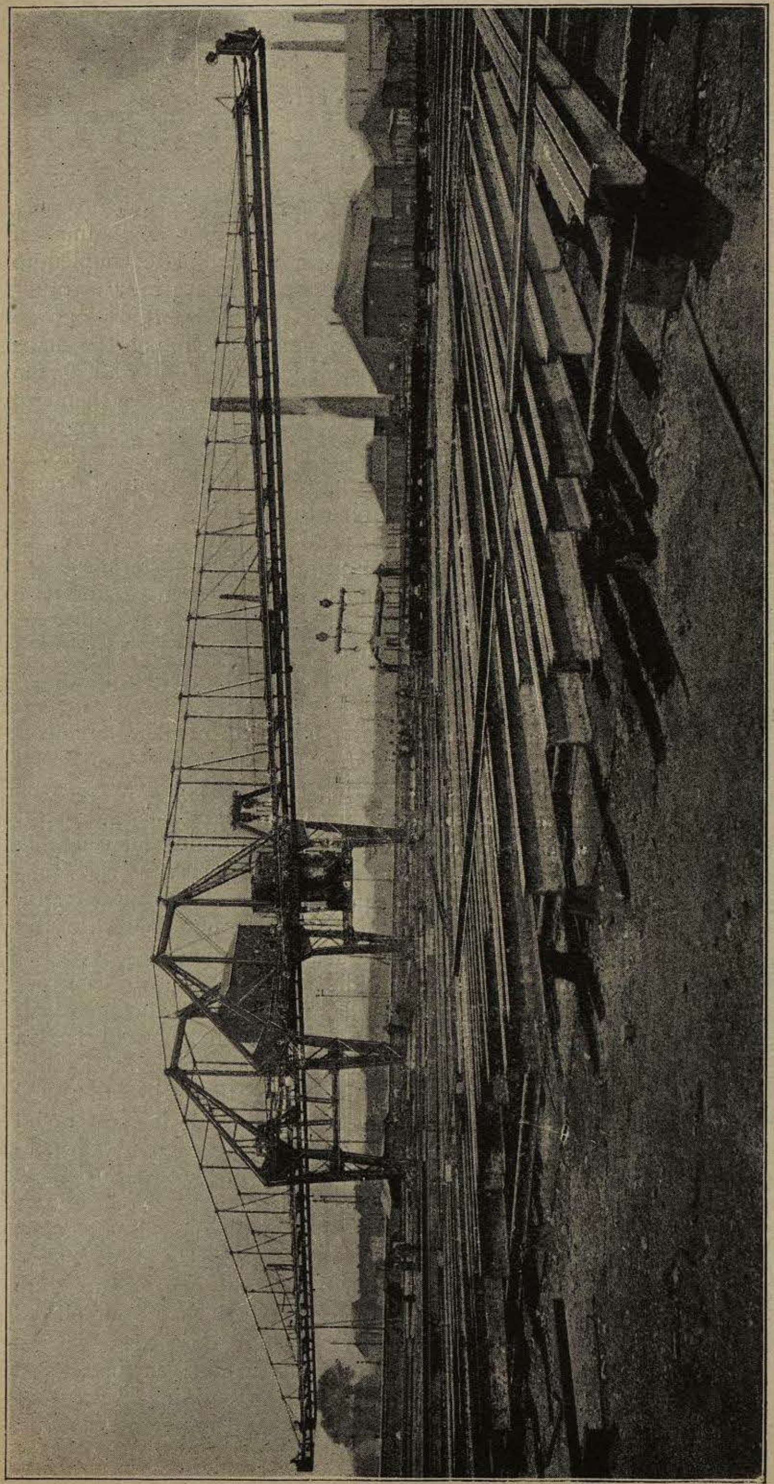

Fig. 522.—Travelling Crane by the Brown Hoisting and Conveying Machine Company.