The direct-acting hydraulic shears are simple, and the wear and tear is trifling, but they have the disadvantage that the same amount of power is consumed whether a large or small section is being cut. This defect is remedied in the shears by Messrs. Fielding & Platt, of Gloucester, shown in fig. 469, in which three cylinders are employed, so that by admitting the water to one, two, or three of the cylinders, three different powers may be obtained. All the cylinders are below ground, and are perfectly protected

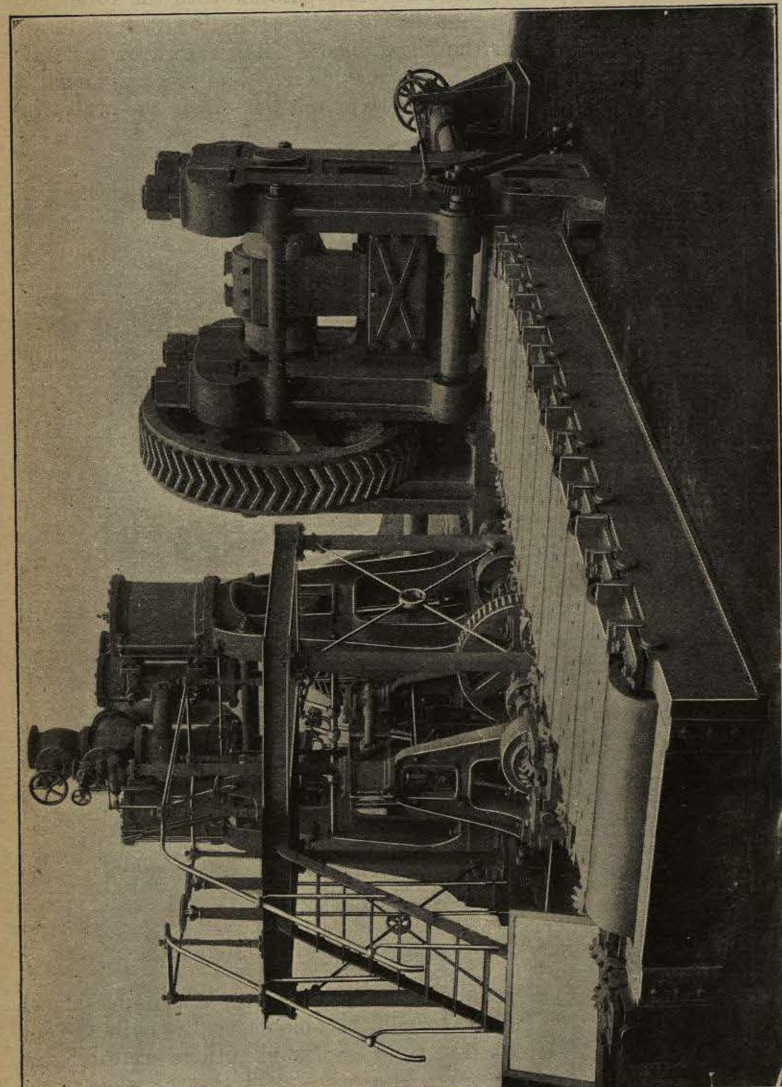

Fig. 470.—Bloom-Shearing Machine—Elevation.

from hot scale. The upper blade is balanced by the lowest cylinder, and the cut is made by drawing the blade downwards by the two large side-bolts attached to the crosshead below the machine, this crosshead being forced down by the working cylinders.

The other system on which bloom shears are constructed is that of actuating the blade by means of an eccentric on a shaft, which is driven by powerful steam engines through the medium of triple gearing. The figs.

PLATE

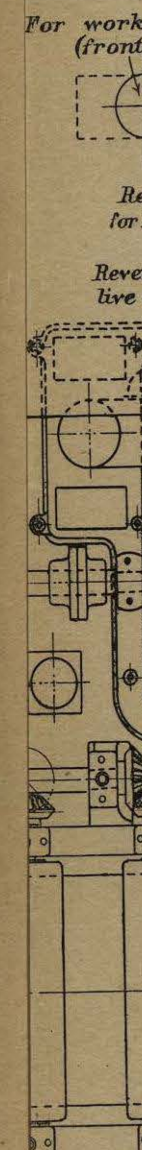

PLATE XLII.—Plan of Bloom-Shearing Machine. [To face p. 750.

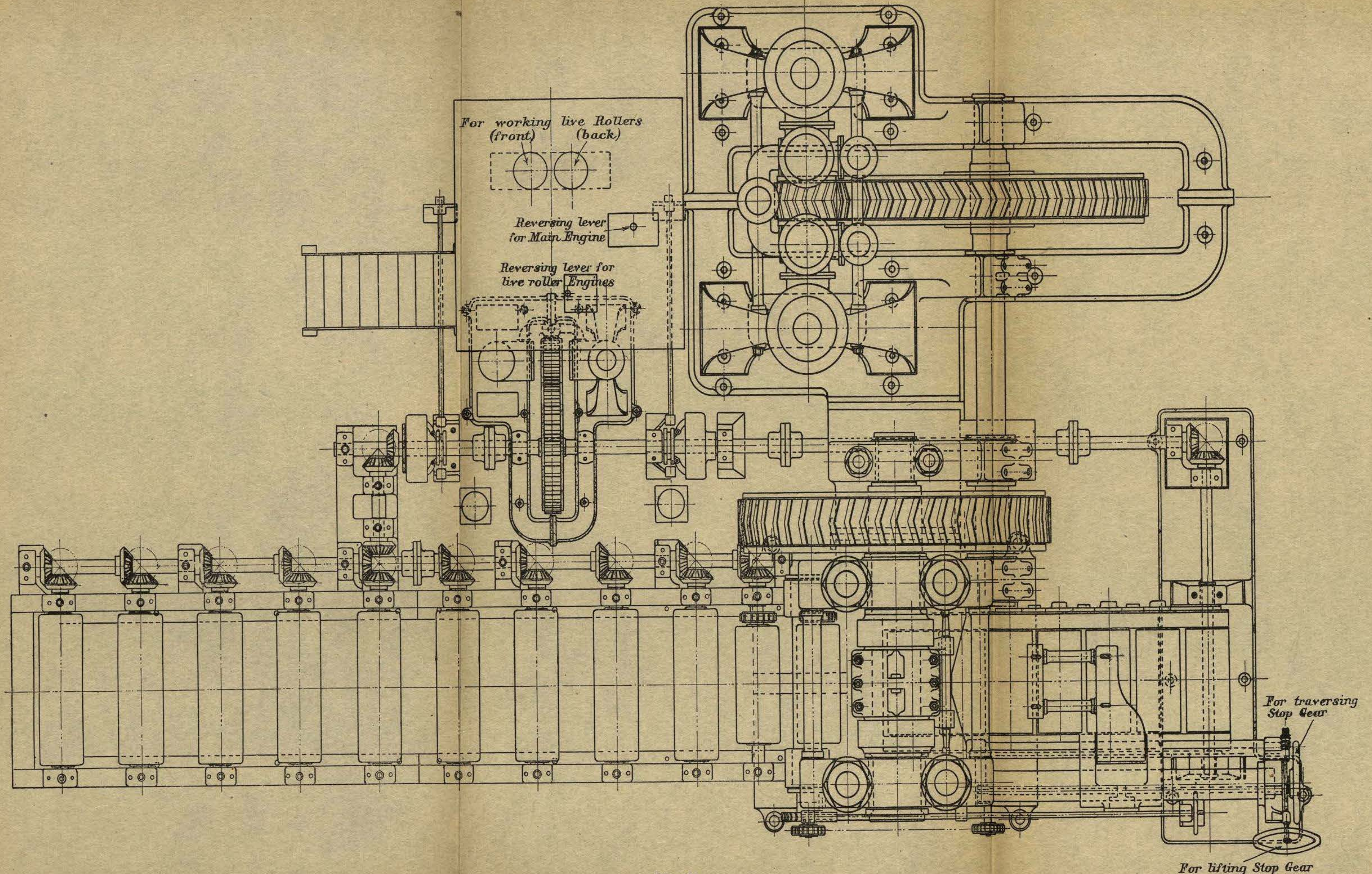

Fig. 471.

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470, 472, and fig. 471, Plate xlii., show such a pair of shears made by Messrs. Thomas Perry & Son, Ltd., of Bilston, for cutting hot plate slabs up to 30 inches wide by 10 inches thick, and fitted with live rollers driven by separate reversing engines.

The works for which these shears were designed were not provided with hydraulic power, consequently the measuring stop had to be moved by hand, which is much slower than hydraulic power.

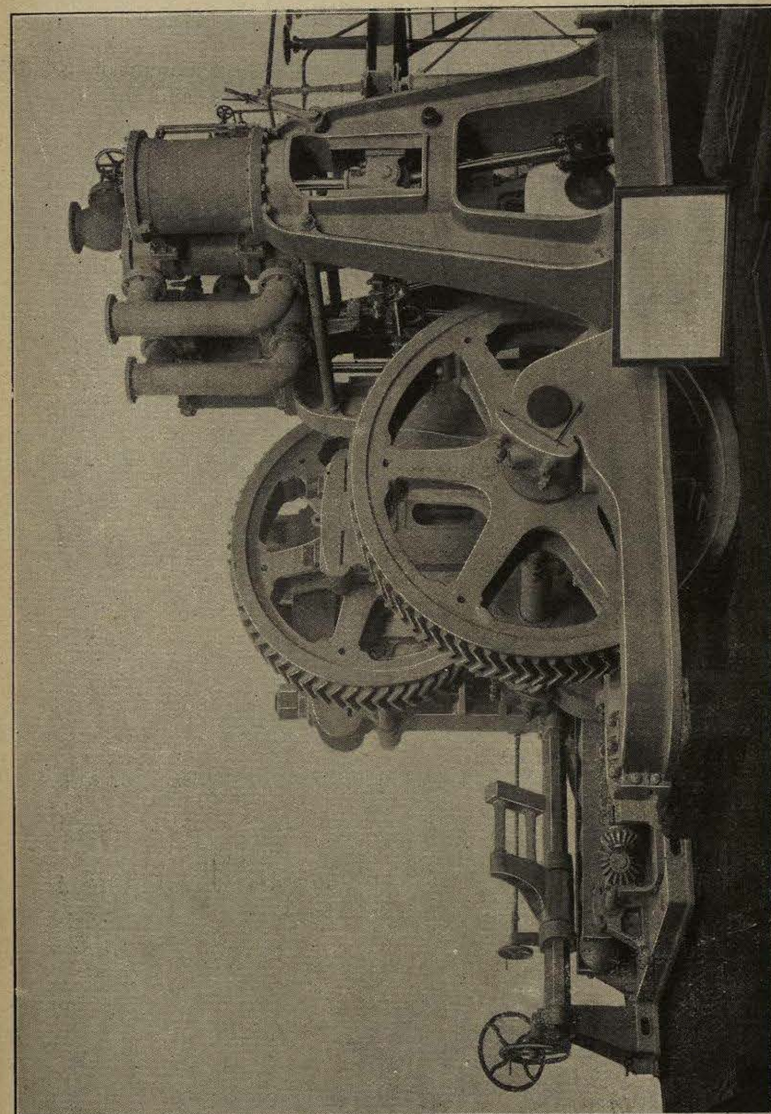


Fig. 472.—Bloom-Shearing Machine—View showing Measuring Stop.

Working without Cogging.—It is quite possible to work without cogging either by the hammer or in a mill, and to roll straight off from the ingot in one mill, but it is only advisable to do so where the output is too small to justify the cost of a separate cogging mill, which would have to stand idle for a large portion of the time. It may be taken that where the output of the works is less than 800 or 1,000 tons per week, it will not generally pay to provide so costly a plant as a cogging mill, but in that case only small ingots can be cast, and the disadvantages inseparable from their use must be faced. These are, that it is not easy to make small ingots, particularly those less than 6 inches square, as sound as large ones; that such ingots must be bottom cast, the runner bricks needed adding to their cost, while the loss from odd weights and crop ends is greater; and that the cost of handling small ingots is higher, seeing that a 3-ton ingot can be lifted as quickly, and to all intents and purposes as cheaply, as one weighing only half a ton, while the room occupied in the pits, and the space necessary for storing the ingots, and moulds, is obviously greater for half a dozen ingots of half a ton each than for one ingot of 3 tons. The large amount of surface exposed by the small ingots compared with their mass, and the rapidity with which they therefore cool, prevent the employment of soaking pits, which do not work satisfactorily with ingots of less than 2 tons weight each, thus involving an increased consumption of fuel, and increased loss by oxidation per ton of steel made. It is largely on this account that small steel works are unable to produce at the same cost as those having larger outputs and bigger mills, though both may be making finished sections of the same size.

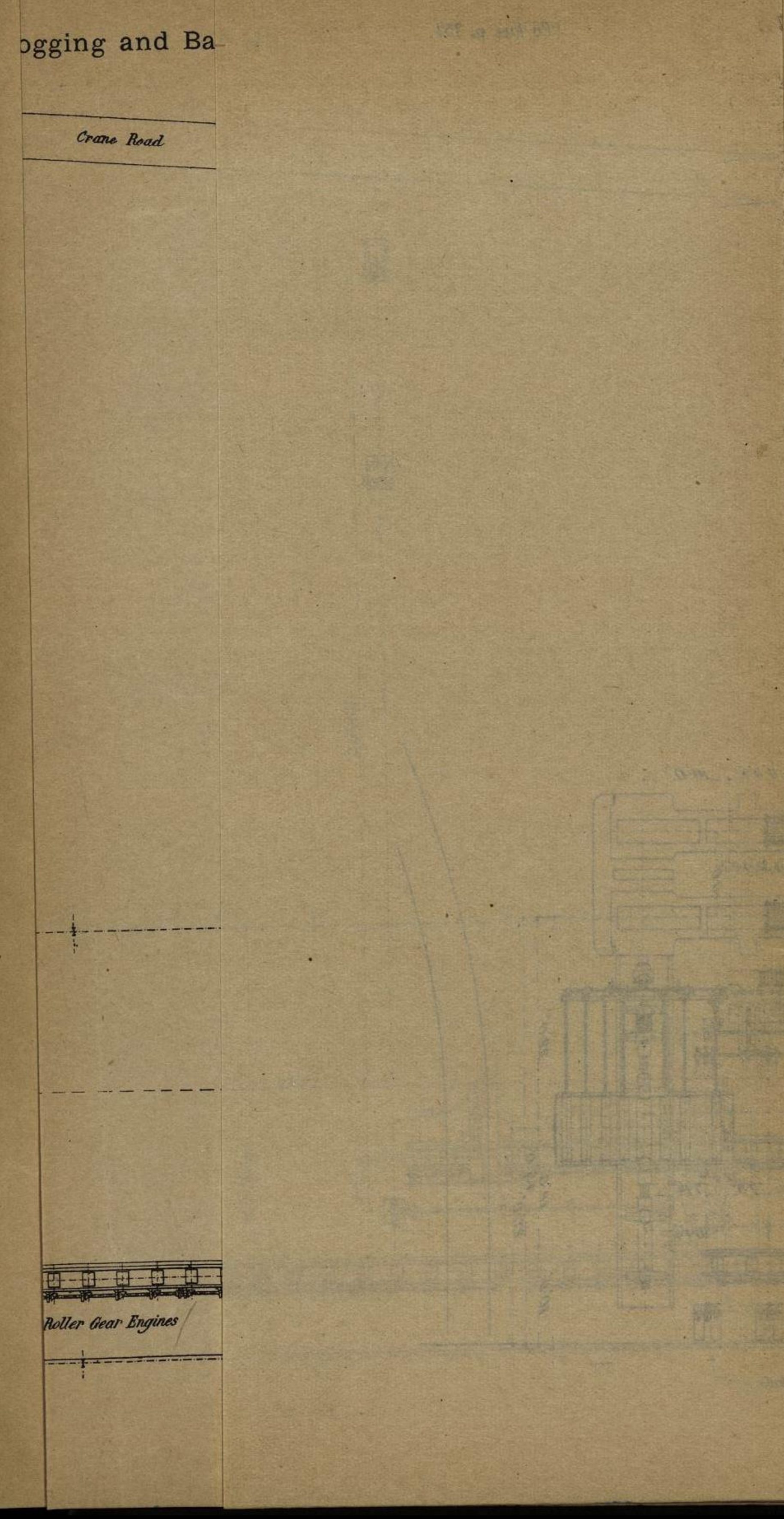
In spite of these drawbacks, some of the small steel works which are situated in convenient proximity to their markets, can hold their own, increased cost of production being balanced by the greater cost of carriage from more distant works, or by protective tariffs. The Hamilton Steel and Iron Co., of Ontario, who have only one 14-inch and one 10-inch mill, are casting ingots 6 inches square, and as much as $5\frac{1}{2}$ feet long, thus obtaining a considerable weight with a small cross section.

The Lilleshall Co., Limited, of Oakengates, who make basic Bessemer steel from metal taken direct from their blast furnaces, have entirely abandoned the use of their 10-ton cogging hammer, and now pass all the ingots made at their Priors Lee Works through the combined roughing and finishing mill shown in fig. 473, Plate xliii.

In addition to owning their own collieries, mines, blast furnaces, and iron and steel works, the company are extensive makers of iron and steel works plant, and have made this mill in their own workshops.

The ingots which vary in weight from $4\frac{3}{4}$ to 12 cwts. each, are charged hot from the Bessemer department into two Siemens new form heating furnaces to the right of the illustration, one furnace being usually sufficient to keep the mill running, and the second being held in reserve, or used for iron when any is rolled in the mill. The consumption of fuel is about $1\frac{1}{2}$ cwts. of slack per ton of ingots heated. The pair of coupled reversing engines have cylinders 32 inches in diameter, by 4 feet stroke, and are coupled direct on to the pinions without the intervention of any gearing. The roughing rolls are 20 inches diameter by 6 feet 6 inches long in the barrel, and are next the engines; the finishing rolls of the same diameter are only 5 feet long in the barrel. The rolls are changed by a steam crane running on the curved railway line seen on the right of the plan.

The mill, which has two-high rolls 20 inches in diameter, is employed for roughing out billets and slabs for rolling down into wire or other small sections in the other mills, or the billets are sold to other works rolling small sections. The larger billets are finished in the first pair of rolls, and are cut up into the requisite lengths by the larger pair of shears situated behind the roughing rolls. The sheared pieces are delivered by the live rollers on to a small bogie whose top is flush with the mill floor; the bogie, which is travelled to and fro by a wire rope actuated by the engines



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The ingot may be cogged down in the first stand of rolls next the engine into a billet of moderate section, cut to length by the billet shears, and removed on the "No. 1 Bogie" to be finished in a smaller mill.

Or, the roughed billet may be skidded across to the second bed of live rollers serving the second stand of rolls, which will reduce it to a billet of small section for use in guide mills; the small billets are cut into short lengths by the small billet shears on the extreme left, and removed on the "No. 2 Bogie."

Or, the cogged billet may be finished in the second stand of rolls into bars or angles, which are cut into suitable lengths while hot by the circular saw, and skidded on to the hot bed, from which the skids remove them when cool to the siding; a steam crane running on the Crane Road lifts them into the railway trucks.

PLATE XLIII.—Combined Cogging and Bar Mill.

[To face p. 752.

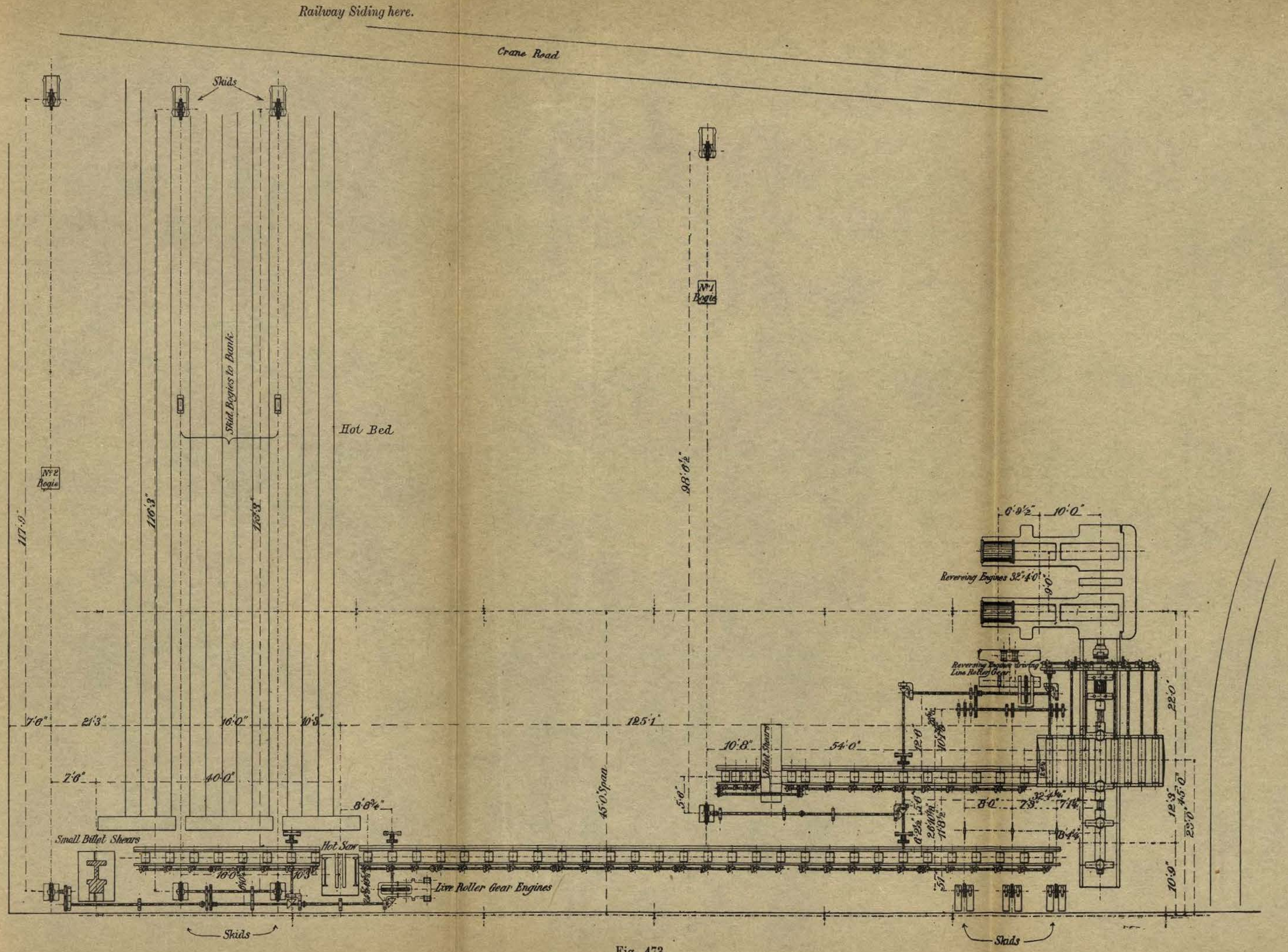

Fig. 473.

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used for driving the live rollers, is thus conveyed rapidly to the railway line, where the material is loaded up.

When plating bars, small billets, or sectional iron or steel are to be rolled, the cropped bloom is skidded by power on to the live rollers at the back of the second stand of rolls, and after being run through to the front is finished in the ordinary way, and passed on to the hot saw or small shears on the left of the plan, where the bars are sawn, and the small billets sheared to length, and taken by the skids on to the hot bed to cool. By the same means they are conveyed to the railway, which, owing to local conditions, cannot be sunk below the floor level, and the bars or billets are therefore loaded up into the railway trucks by a steam crane running on the line.

The range of sizes rolled in this mill is considerable. Flats are made from 2 inches by $\frac{1}{2}$ inch, up to 10 inches wide in steel or 12 inches in iron, those of 3 inches wide and upwards of any thickness, down to $\frac{3}{8}$ inch, and in some sizes down to $\frac{1}{4}$ inch. Rounds and squares are rolled from $2\frac{1}{2}$ inches to 6 inches, angles from $2\frac{1}{2}$ inches by $2\frac{1}{2}$ inches to 6 inches by 6 inches, and tees from 3 inches by 3 inches to 6 inches by 3 inches. When on light work it is not at all uncommon to roll bars up to 175 feet long, and then cut them up into the lengths required by customers.

The output of the mill varies, according to the sections rolled, from 450 to 550 tons per week, but with heavy sections and a sufficient supply of ingots, there is every reason to believe the output would be at least 700 tons per week.

The above is a good instance of the varied work which can be done on one mill in a small works; nevertheless, in cases where the amount of work will justify the outlay, a regular cogging mill is a good investment.

Billet Mills may be either large mills intended to roll the ingot down to billets about 6 inches square ready for cutting up for other mills, or small mills, taking the cogged bloom and rolling it down to $1\frac{3}{4}$ or $1\frac{1}{4}$ inches square for finishing in little mills. Many steel works sell large quantities of billets, from 4 inches down to $1\frac{1}{4}$ inches square, to the older iron works, which roll these out into the sections for which they possess rolls, or to the wire mills for rolling into wire rod. Some works do no finishing at all, and sell all their product in the form of billets.

A large billet mill will roll the billets in lengths of 300 or 400 feet, and will turn out 250 to 350 tons a shift, the smaller mills doing proportionately less. Billets are sometimes sawn hot, but are usually sheared, the large sizes when hot, and the small sizes when cold.

The Americans have carried the arrangements at their billet mills to great perfection, the billets being conveyed on rollers or travelling belts for 100 feet or more away from the mills, and carried over railway lines or other obstructions at a considerable height above ground; the first belt delivers on to others at right angles alongside the railway trucks; a boy placing a switch diagonally across the belt opposite any truck diverts the stream of billets into it, or if no trucks are available, or the billets are not wanted at the moment for despatch for any particular order, they are switched off the travelling band running 20 feet or so above the ground of the stock yard, where they lie in conical heaps to cool until an order is received for them. They are then dragged by hooked bars on to other travelling bands on the ground level, which rise sufficiently to deposit them in the trucks for despatch.

At the Homestead Works they have gone even further than this. The almost red hot billets are led into a hopper where water is run over them to cool them, and when a sufficient weight has accumulated in the hopper to form a truck load, they are dropped from the hopper into the truck, a method of loading which would scarcely meet with the approval of our railway companies.

The Duquesne mill will turn out 1,000 tons of billets 5 to 6 inches square in a single shift.

At the Grand Crossing Track Company's Works, near Chicago, there is a 36-inch combined cogging and billet mill, which reduces a 16-inch by 18-inch ingot to a $1\frac{3}{4}$-inch square billet, 450 feet long, in one heat, between one pair of rolls. The rolls are coupled direct to a three-cylinder reversing engine having cylinders 1 metre diameter by 1 metre stroke, made to run at 200 revolutions per minute with a steam pressure of nine atmospheres. The ingot is cogged in the ordinary way down to 4 inches square, and the end sheared off. The engine is then run in one direction only, the bar passing through a system of repeaters round the housing, as many as three portions being operated on at one time.*

Many mills are now provided with a few passes, either in the cogging or roughing rolls, in which ingots can be rolled into billets while the finishing rolls are being changed, so that the flow of ingots through the soaking pits may not be interrupted, as the success of soaking depends upon the regularity of the flow.

Changing the Rolls.—Rolls have frequently to be changed unless large orders are received at one time for a particular section. While the changing is proceeding, the mill, with its attendant heating furnaces, and the workmen employed about them are idle, but salaries, dead charges, and other expenses of the establishment continue running as if the mill were at work, while fuel must also be burnt to keep the furnaces and boilers hot. Changing rolls is therefore a serious expense. To reduce the time lost in changing, which may vary from three or four hours in large mills down to twenty minutes in small ones, travelling cranes, worked by power, run above all mills to handle any rolls much over 12 inches in diameter. Changing the rolls themselves does not generally take so long as fitting guides and guards in place, which is a troublesome business in the case of rolls producing complicated sections.

To still further economise time, some works are furnished with cranes powerful enough to remove the housings with the rolls and all guides and guards attached at a single lift, and to replace them with a duplicate pair of housings in which the next pair of rolls, with all needful accessories, have been previously fitted together on a duplicate bed. This can only be done when the feet of the housings are arranged so as to find their position instantly when dropped on the bed-plate, and to be held in place by tightening up a few bolts; lining and wedging are out of the question for work of this sort. The plan is very convenient, particularly when rolls for a new section have to be fitted for the first time, and reduces the time required for changing rolls to about half an hour, even in a large mill; but for such a mill the crane must be capable of lifting nearly 100 tons.

There is no doubt as to the saving in the case of a three-high mill, the fixing of guides and guards to which occupies much time, but some engineers doubt if the additional cost of so powerful a crane is justified in the case of a two-high mill.

In some Continental works the difficulty is got over by having complete duplicate mills, each with its own compound reversing engine, one mill standing while the other is running, and in some English works mills are

* *Iron Age*, August 4, 1904, p. 16.

placed on each side of an engine, which can be coupled to either mill, while the rolls are being changed in the other.

Usually the rolls are lifted out by sling chains, but the appliance (fig. 474) was devised by the author for changing rolls in a semi-continuous mill, and has proved very satisfactory for this purpose. It consists of a cast-steel frame shaped like an ˥ suspended from a socket, the position of which along the upper horizontal leg is adjustable by a screw worked by a hand chain, so that the point of suspension may always be directly over the centre of gravity of the roll to be lifted, whatever be the length of the barrel. A weight to balance the vertical leg is moved by the same screw, the relative pitch of the two threads cut upon it being such that, whatever the point of suspension, the frame always hangs with the upper leg truly horizontal.

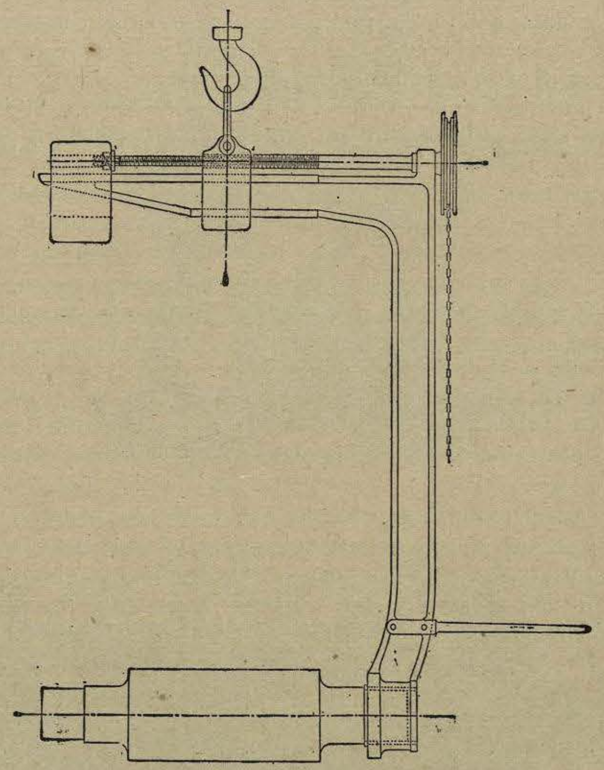

Fig. 474.—Device for Changing Rolls.

At the bottom of the vertical leg is a slight tapered socket, which fits freely over the wobbler of the roll, and a T-shaped handle wherewith the workman steadies the frame as the craneman moves the socket over the wobbler. When the socket is in place the roll is lifted, and as the frame is balanced, and the point of suspension exactly over the centre of gravity of the roll, the roll always remains perfectly horizontal, and is moved out of the housing.

Even when the works possess the requisite rolls, customers requiring a few tons of bars of a section not in common use may have to wait a long time for delivery until orders for similar bars have come in from other sources sufficient to justify putting in the rolls; or, if the material must be had at once, the purchaser must pay such a sum as will at least partially compensate the manufacturers for the time lost in changing. To reduce this inconvenience as far as practicable, many works send out a post card every week to their chief customers, giving a list of all the sections for which they expect to put in the rolls during the next fortnight.

Section Mills.—The mills used for rolling such sections as girders, channels, and large tees or angles, vary in size from 36 inches down to 24 inches. The 36-inch rolls are used for the very heavy joists; 32-inch rolls for joists from 15 down to 10 inches in depth, and for tram rails, sleepers, etc.; 30-inch rolls for 8 × 8 to 6 × 6 T and L sections or 12 × 3 channels; 28-inch for joists 10 inches deep and below, and for main line rails; and 24-inch for smaller rails or heavy bars. These are about the size of rolls it is generally considered advisable to employ, but the sections mentioned can be rolled, though not to the same advantage, in rolls considerably less; thus 6 × 6 angles *have* been made in an 18-inch mill, but such work must be considered as exceptional and not as good practice.

Section mills, with rolls of 36 to 24 inches in diameter, will, if provided with engines having cylinders of 45 to 30 inches in diameter coupled direct to the mill, run sufficiently fast to finish joists in lengths of 200 or 300 feet, which can be sawn up while hot into the requisite lengths with very little waste from crops. Such mills, if provided with suitable live roller gear and other auxiliaries, will turn out 300 or 400 tons of sections in a shift of ten hours, though probably 150 to 200 tons more closely represents current practice. It is not often that a mill can be run at its maximum rate of output, want of ingots, insufficient boilers or heating furnaces, or frequent changes of rolls so often reducing the make.

Cutting to Length and Straightening.—Sections, while red hot, are cut into lengths by circular saws before passing to the hot beds to cool. Fig. 475 shows a saw of the type usually employed in this country as made by Messrs. Francis Berry & Son, of Sowerby Bridge. The rolled section is carried past the saw by the live rollers, on which it rests while being cut; the saw is fixed on a spindle driven by belts from the two large pulleys on the crank-shaft of the engine. The bearings in which this spindle runs can be simultaneously pushed forward horizontally by means either of a hand lever or a steam or hydraulic cylinder, when the saw cuts through the bar. The teeth of the saw travel at a speed of about 13,000 feet per minute (nearly 150 miles an hour), and the saw will cut almost any section in three or four seconds. The crop end is lifted away by tongs, the section run up to a measuring stop by the live rollers, and cut up into the lengths required.

When sections require to be cut to exact length, they are cut cold by means of the cold saw. Fig. 476 shows one of such machines as made by Messrs. Isaac Hill & Son, of Derby. A saw must be of high Carbon steel hardened and tempered, or it will not be hard enough to cut cold metal. If the teeth travel faster than some 50 feet per minute, there is not sufficient time for the sharpened tooth to force a passage through the metal and take off a shaving; when this speed is exceeded, the tooth is simply dragged over the surface of the steel, and its point rapidly ground down, the heat so generated drawing the temper of the cutting edge.* Hence cold saws are much slower in their action than hot saws, and to prevent the heat developed destroying their temper, the lower edge of the saw runs in a trough

* High-speed saws are now obtainable, which can be run at a peripheral speed of over 100 feet per minute.

filled with soap suds. It takes over an hour to cut through a large girder when cold, instead of the few seconds needed to cut it when hot.

Light sections are straightened by laying them on a block two or three feet apart, with the convex side up, and striking the top with a sledge; heavier sections are straightened in a press, which acts on the same principle, except that pressure is employed instead of a blow. A plunger is

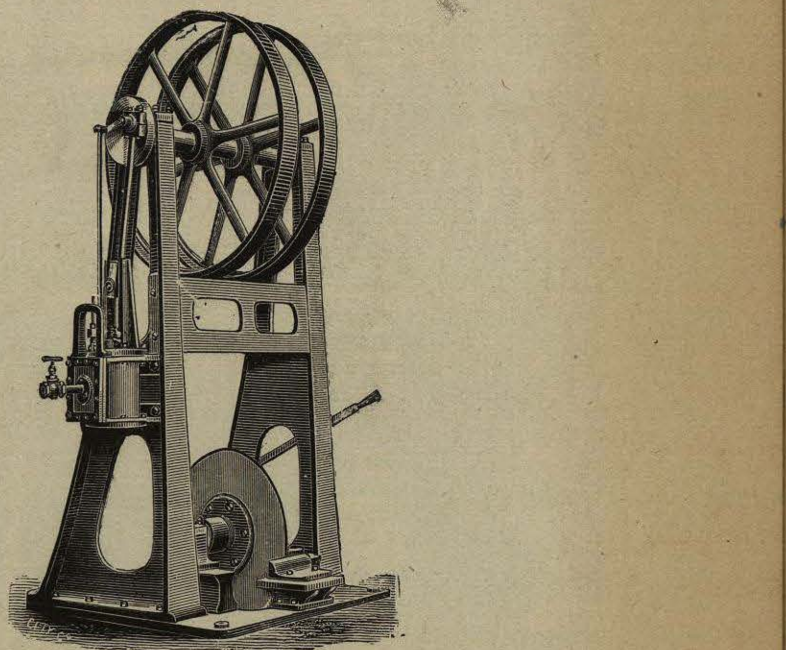

Fig. 475.—Hot Saw.

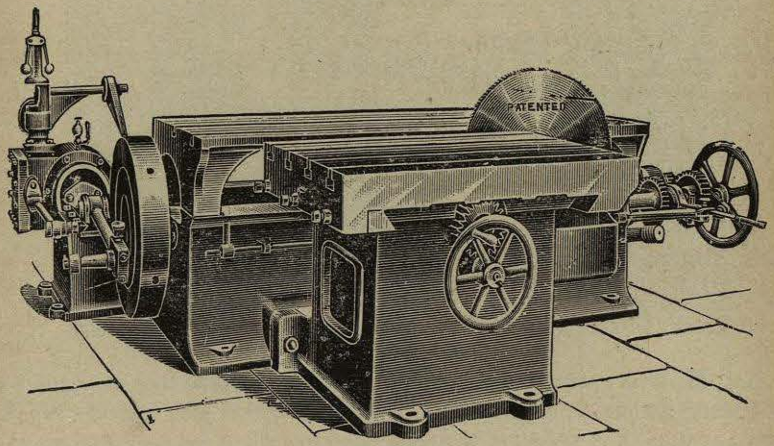

Fig. 476.—Cold Saw.

moved backwards and forwards by power opposite two blocks capable of adjustment, and the section passed through the machine is thus straightened.

The form of machine shown in fig. 477, made by the Hills & Jones Co., of Delaware, U.S.A., is much more rapid in its action than the press, and can deal with sections which are still hot. There are three pairs of rolls