in a bearing in the trolley, and can slide loose on the shaft, H, of cruciform section, which can be rotated to and fro through a portion of a circle, by admitting water under pressure to one or other of the hydraulic cylinders, J K.

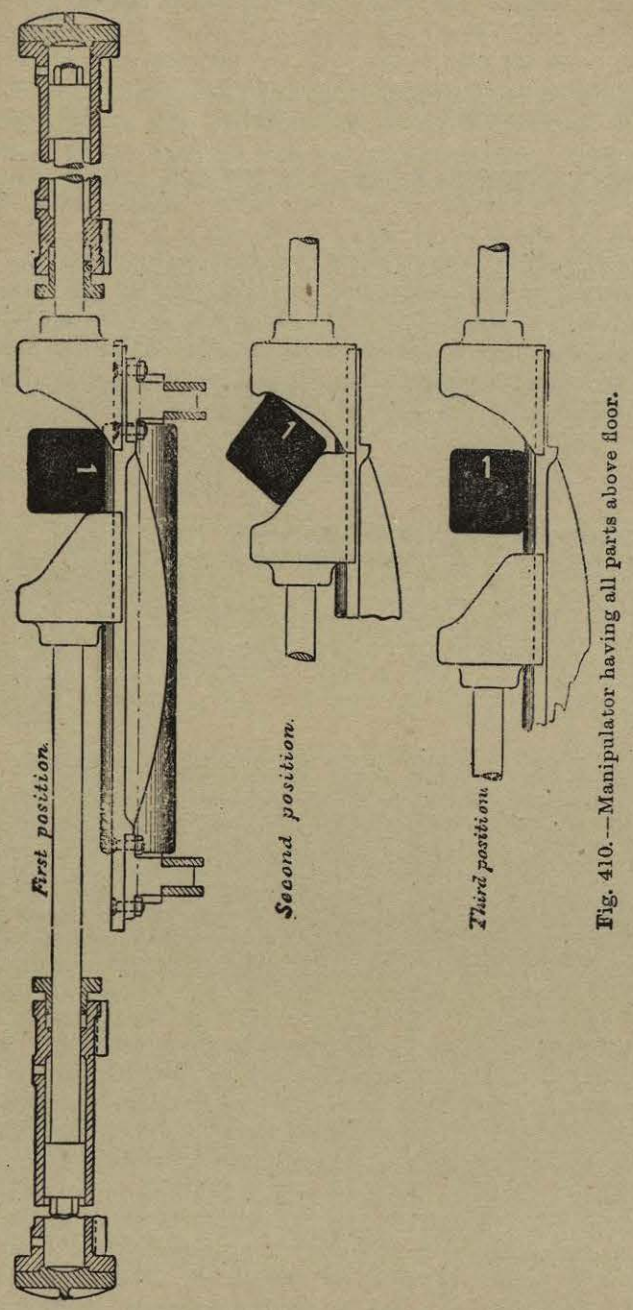


Fig. 410.—Manipulator having all parts above floor.

When the shaft, H, is rotated, the tappets, C C C C, are raised by the quadrants, D D D D, and the ingot is turned over on its side; L, L, &c., are the live rollers, and M the roll in the mill. The tilter used for the Volga mill (fig. 465, Plate xl.) is practically identical with this one.

Fig. 409 shows an arrangement in which the rails, on which the trolley runs, are mounted on the top of a lifting ram, placed in a pit below the mill, the lifting of the trolley towards the roller bed having the same effect as lowering the roller bed on to the trolley. In yet another arrangement the trolley and rails are in one, and the rails move to and fro over sheaves which are raised and lowered on the ends of bell-cranks. Various modifications of the principle are possible.

There is a third class of manipulator in which neither trolley nor tappets rise and fall, but fingers are employed which turn over side ways. One of the simplest consists of a trolley running on fixed rails, carrying a three-armed lever in the shape of the letter Y, having, at the junction of the three arms a pin round which it can be turned. The two upper arms are at right angles to each other, and by moving the bottom arm through half a right angle to right or left either of the upper arms will point vertically and its companion horizontally. If the right-hand arm is horizontal, the trolley is moved to the right and the horizontal arm passes under the ingot; the end of the bottom lever is then moved to the right, raising the arm beneath the ingot into the vertical position, and turning the other arm horizontal, by which means the ingot is turned over on to its left side. The ingot can, of course, be skidded across the face of the rolls by the same appliance. The objection to it is that the fingers cannot be withdrawn below the rollers, and are, therefore, often bent by the piece as it leaves the rolls. Moreover, the ingot can only be turned through one quarter of a circle, unless the upper arms of the Y are parallel, shaped like a U, and worked by a semi-circular toothed segment gearing into a rack. In that case the bar can not only be turned completely over, but, if of suitable shape, can be turned up for edging. The defect can also be remedied, if each arm of the Y has an independent stem, and is carried upon a separate carriage.

The next manipulator (fig. 410), acts on an entirely different principle. The head on the right has a curved inclined surface, while that on the left has a straight inclined face with a shoulder at the lower part to push the ingot up the curved surface on the right, so turning it through rather more than one-eighth of a circle, as shown in the second position. On withdrawing the left-hand head the ingot rolls over into the third position. The action of the apparatus is wonderfully smooth and regular, and it will deal with an ingot of 20 inches square until it is reduced to a billet 5 or 6 inches square, which can be turned over into any position, or moved across the face of the rolls opposite any groove. The moving parts of this tilter, which are few, are all above the level of the roller bed, where they can be seen and oiled; the rubbing surfaces are so ample that there is very little wear and tear, and the repacking of the cylinders is easily done from the mill floor.

A V-shaped trough, hinged near its base, will suffice to turn over and transfer small square sections from one pass to the next. This trough, with one of its sides vertical, receives the piece as it leaves the mill, and then rolls over with its other side vertical, when the bar is presented ready to return through the next pass, and in the case of a three-high mill, if hinged on one edge, will lower the piece to the pass below the middle roll, at the same time as it turns it on edge. To minimise friction the trough may be formed of a series of rollers, and turned on edge to edge the bar.

The appliances described so far can deal only with pieces of approximately square section. A thin slab, turned up thus on to its narrow edge, would roll over on to its second flat face, and to prevent this a second set of fingers are required. In Finlayson's tilter (fig. 411), the moving trolley is provided

with two hydraulic cylinders, each actuating its own lifting finger, by which the slab can be turned over in either direction, or supported on its edge when entering the rolls to be "edged." Buckton and Millward's manipulator used in several English works, consists, in effect, of two carriages similar essentially to fig. 408, capable of movement to any distance apart from each other, the secondary carriage, however, moving on the top of the first, and each carriage carrying tappets, capable of being raised or lowered at will by vertical hydraulic cylinders carried in the carriages. The fingers of one carriage are moved into position below that edge of the slab it is desired to tilt, and those of the other are raised sufficiently to prevent the slab slipping away; when the plate is nearly vertical the two sets of fingers approach each other, and hold the slab on edge between them; it can then be moved opposite to any pass in the rolls. By placing one set of fingers or tappets under each edge, the slab can be lifted bodily off a bogie which has been run in between them, and the finished plate can be replaced in the same way. The water is conveyed to the cylinders of Finlayson's by telescopic, and to Buckton and Millward's tilter by jointed pipes.

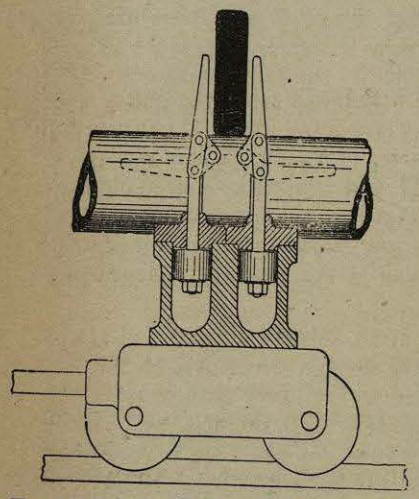


Fig. 411.—Tilter fitted with Arrangement for Edging Slabs.

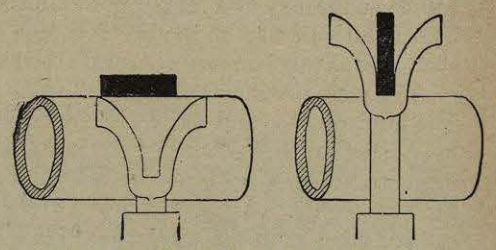
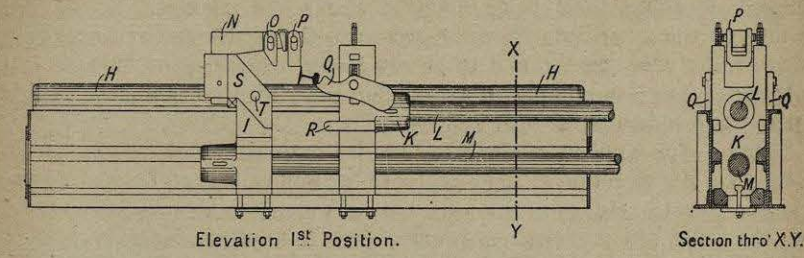


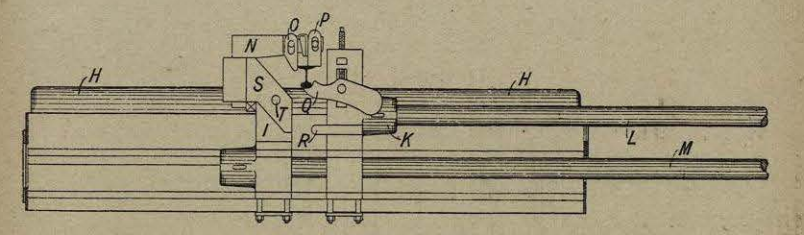
Fig. 412.—Manipulator for Handling Flats.

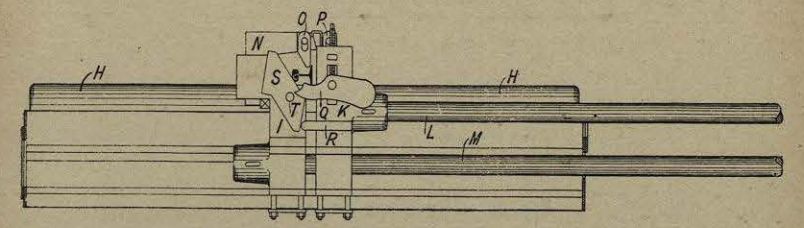
The manipulators so far described have been capable of dealing only with rectangular sections, or slabs, and are, therefore, suitable only for the cogging mill, to which their use is usually confined. In most roughing and finishing mills the turning over of the piece is still done by numerous workmen armed with forks and levers. Occasionally the guards can be set so as to twist the piece as it leaves one or more of the intermediate passes, which facilitates the process of turning it over before it enters the next pass, but this is rarely of much assistance. If only one section had to be rolled in the mill, there would be little difficulty in devising mechanical appliances to turn it over. For instance, the simple appliance shown in fig. 412 will deal with ordinary flats; but where, as is usually the case, a variety of sections have to be produced in one mill, a separate contrivance would be required for each section, which is impracticable, and some contrivance is needed which can be rapidly adapted to take the varying sections whenever the rolls are changed.

The most successful contrivance so far produced is Evans & Lewis' manipulator, which was first used at the Cyfartha Works in South Wales, and has

since been introduced into a great many English works. Fig. 413 shows this appliance. The apparatus consists of two heads—viz., I and K—which are moved by hydraulic cylinders through the rods L and M. The cylinders may be placed either two on one side of the roll train, or one each side of the roll train. Attached to the head, I, is the arm, N, holding the two teeth, O and P. In the first position both heads are brought up to the rail,







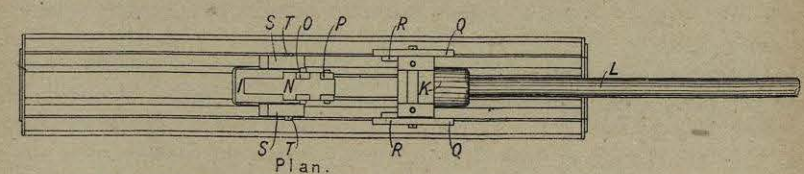


Fig. 413.—Evans & Lewis' Patent Manipulator for Finishing Train.

the head, K, being held stationary whilst the head, I, is pushed forward; this brings the rail into the second position, the tooth, P, rising of its own accord, due to its oval hole. On further proceeding with the action, the head, I, by means of the tooth, O, brings the rail as shown into the third position, the hook, Q, being depressed by the weight of the rail; the pusher, R, engaging

the cheek, S, of the head, I, holds the rail in a truly horizontal position. This shows a complete half-turn to the rail, which is entered into the rolls by means of the live rollers, H, after which the two heads are separated. It will be noticed that the two cheeks, S, are pivoted at T.

This manipulator can be arranged to deal with any section of rails, angles, tees, &c.; different sections can be handled by one pair of heads, the changes necessary to adapt them being made in about five minutes. By its use the men on the roller beds are dispensed with, thus reducing the wages bill, and generally enabling the mill to be run faster, increasing its output, and enabling the piece to be finished at a higher heat, with a consequent saving in power and reduction of wear and tear.

Skids.—The appliances described so far have provided for the travel of the piece in a direction at right angles to the mill train, and for its transfer from one pass to another in the rolls, but have not provided for its removal from the roller bed opposite one stand of rolls to another alongside it, as is required when passing the bloom from the roughing to the finishing stand. For transferring moderate weights the pulleys on which the hand levers are

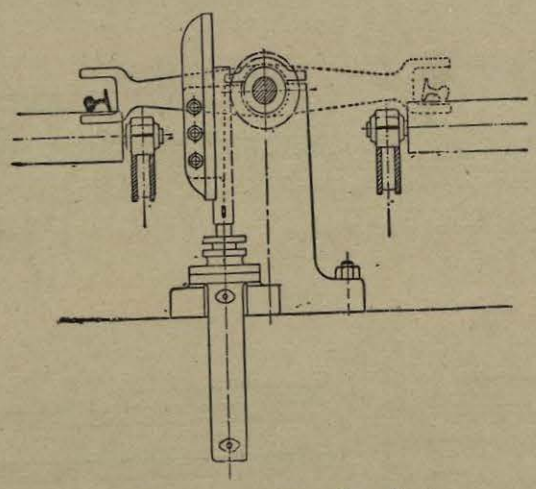


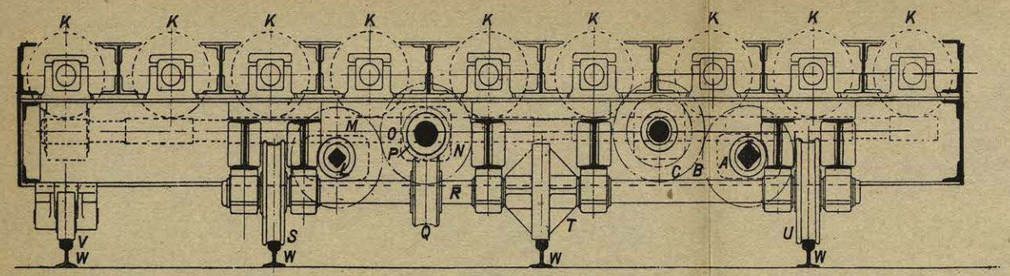
Fig. 414.—Turnover Transfer.

hung can be drawn by power along the bar on which they run, but when the piece is too heavy for this, it may, if short, be transferred by means of horizontal bars which lie between the rollers forming the bed of the roughing stand, the one end turning on pins between the corresponding rollers opposite the finishing stand, to which the roughened bloom is to be transferred. The upper surface of these bars is kept just below that of the rollers until the bloom is to be transferred, when the free end of the bars is raised by means of cylinders placed below the floor, which lift the bars with the bloom on them until they are sloping at such an inclination towards the finishing bed, that the bloom slides down them to the new position desired, when the bars are allowed to fall back. Another contrivance, shown in fig. 414, by the act of transferring the bar, also turns it over. It consists of a long shaft, on which are keyed a series of forks. The shaft lies between the two tables, and is revolved through a half-circle by hydraulic or electric power.

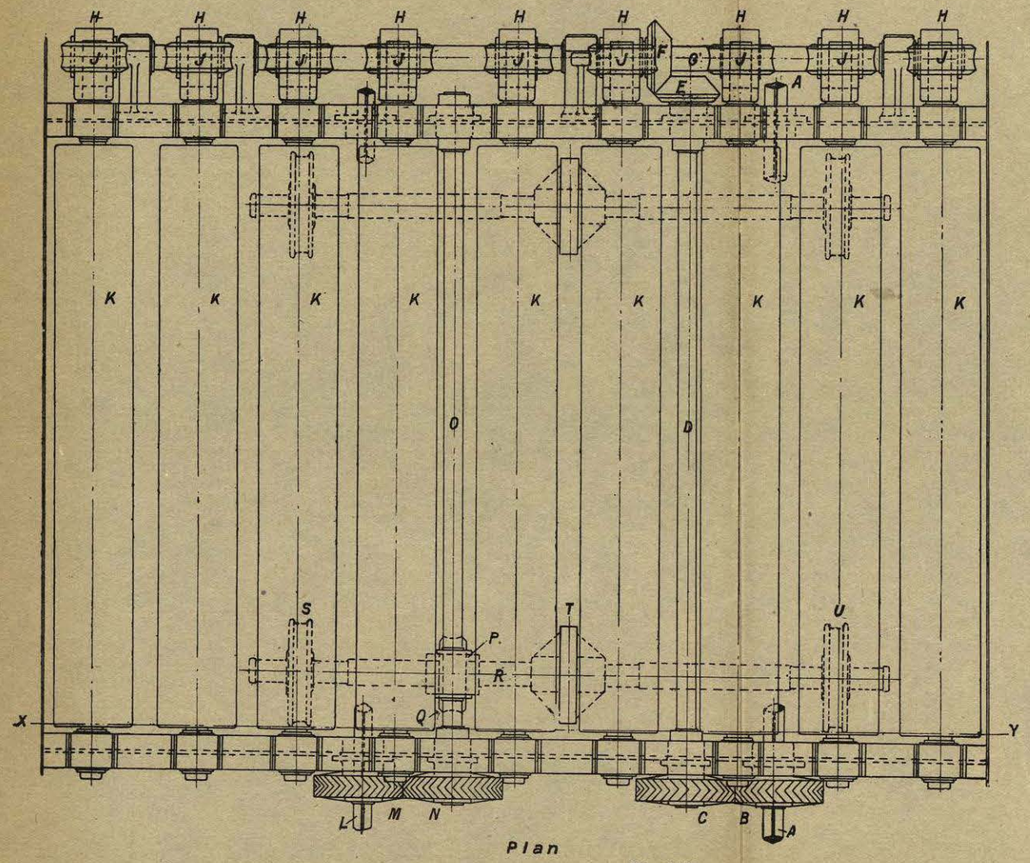
These appliances can only transfer the bloom from one position to one other position, and it is found much more convenient to use a "skid," which

To face p. 651.]

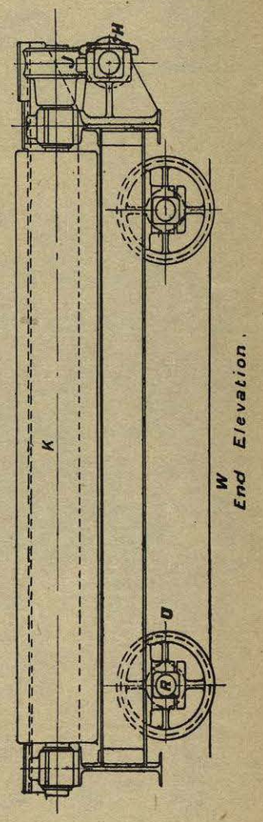
PLATE XXX.—Travelling Table, Fitted with Live Rollers.



Section on X.Y.



Plan



End Elevation.

Fig. 416.

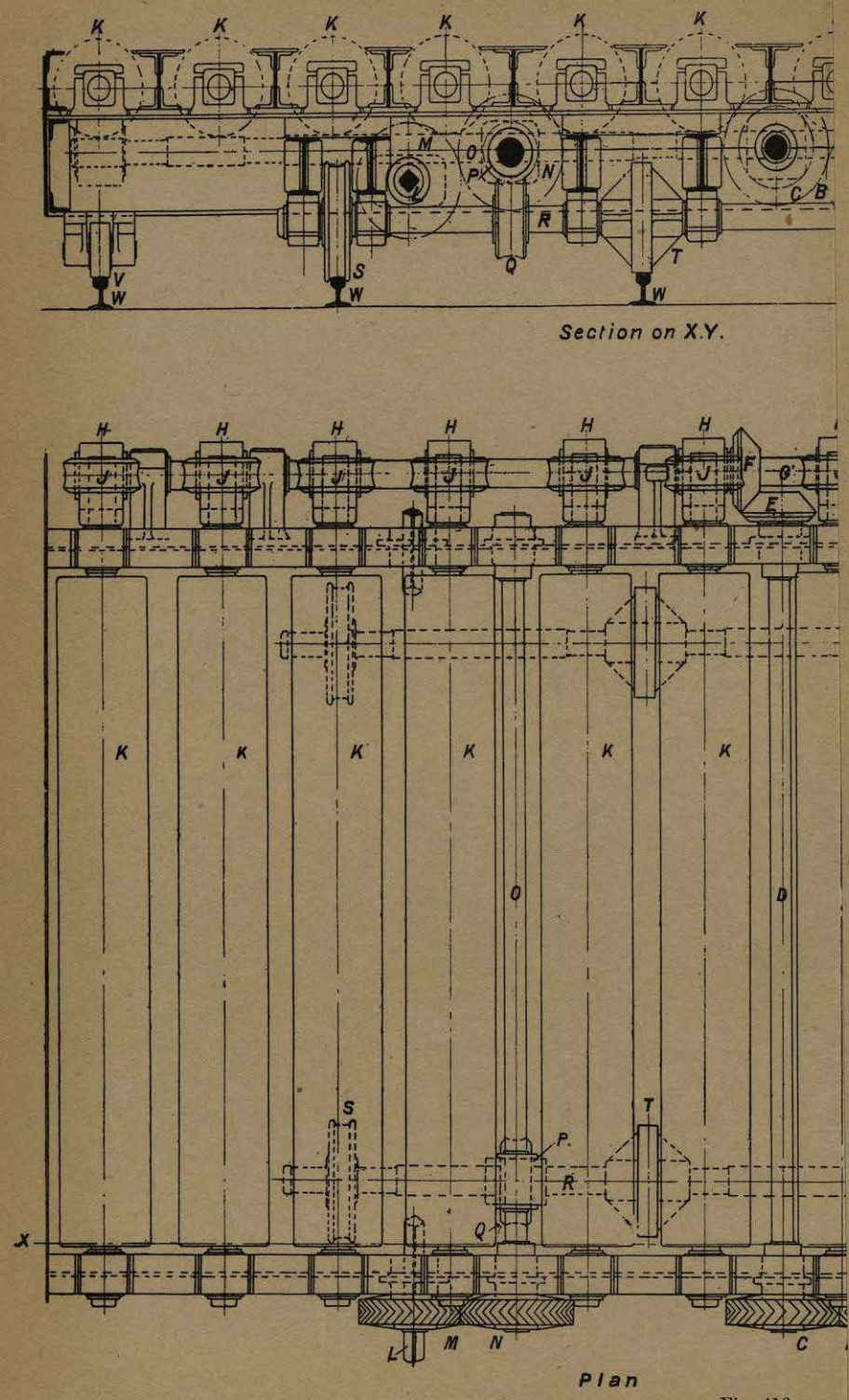


Fig. 416.

can move the bar any distance required, and keep on transferring it so as to stop opposite any pass desired in either stand.

A skid (fig. 415) consists of a small runner travelling to and fro in a trough placed parallel to and between the live rollers, and having a finger or tappet projecting upwards so as to be well above the surface of the roller bed. The runner with its projecting finger is so arranged as to be hauled backwards and forwards by a chain or wire rope, which is secured to one end of it; this chain or rope is given a half-turn round a pulley on one side of the roller beds, returned along the ground beneath them, over a similar pulley on the other side, and the end secured to the other end of the runner, so that the whole forms an endless chain running over the two opposite pulleys (see fig. 415). Several of these are provided at convenient intervals apart, along the roller beds, all the pulleys on one side being keyed on one long horizontal shaft laid at right angles to the rollers, and capable of being driven in either direction as desired by a small pair of reversing engines, or electric motors; by this means the piece being rolled can be "skidded" along the live rollers in the direction of their axes to bring it opposite any pass desired, or to remove it from the roller bed, when finished, to be sawn or cooled.

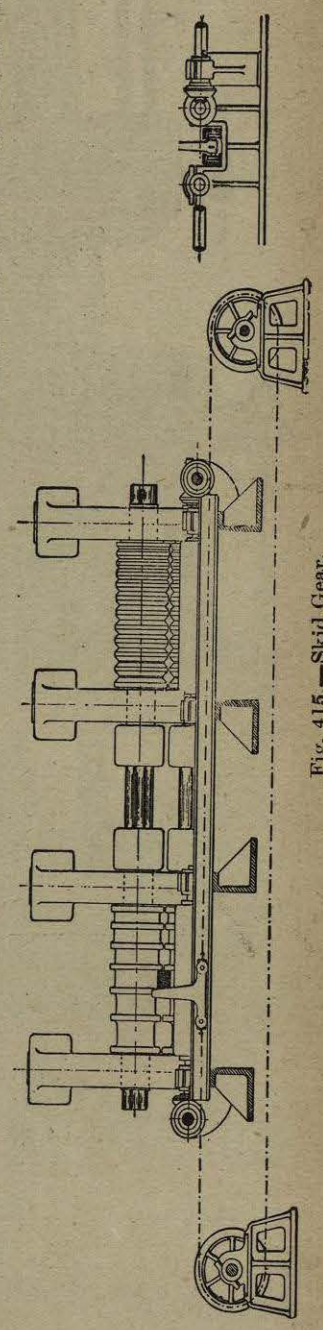


Fig. 415.—Skid Gear.

Travelling Tables.—A plate in this country is rolled in a reversing mill, and the same side remains at the top during the whole continuance of the rolling, so that no tilters are needed to turn the piece over, nor skids to transfer it latterly from one pass to another; but as plates are roughed down in a pair of grain rolls, and finished in another stand of chilled rolls, which are coupled end to end with the first pair, the plate has to be transferred laterally from the roughing to the finishing rolls. A convenient way of doing this is to put all the live rollers at the back of the mill (except those which lie between the housings) into a movable frame, which can be transferred bodily with the plate on it, so as to face and serve either stand of rolls.

Fig. 416, Plate xxx., shows a movable live roller table of this kind, made by Messrs. Andrew Barclay, Sons & Co., of Kilmarnock, N.B. The power for driving the live rollers is conveyed to the table by the square shaft, A, on which slides the helical wheel, B, which, by means of the wheel,

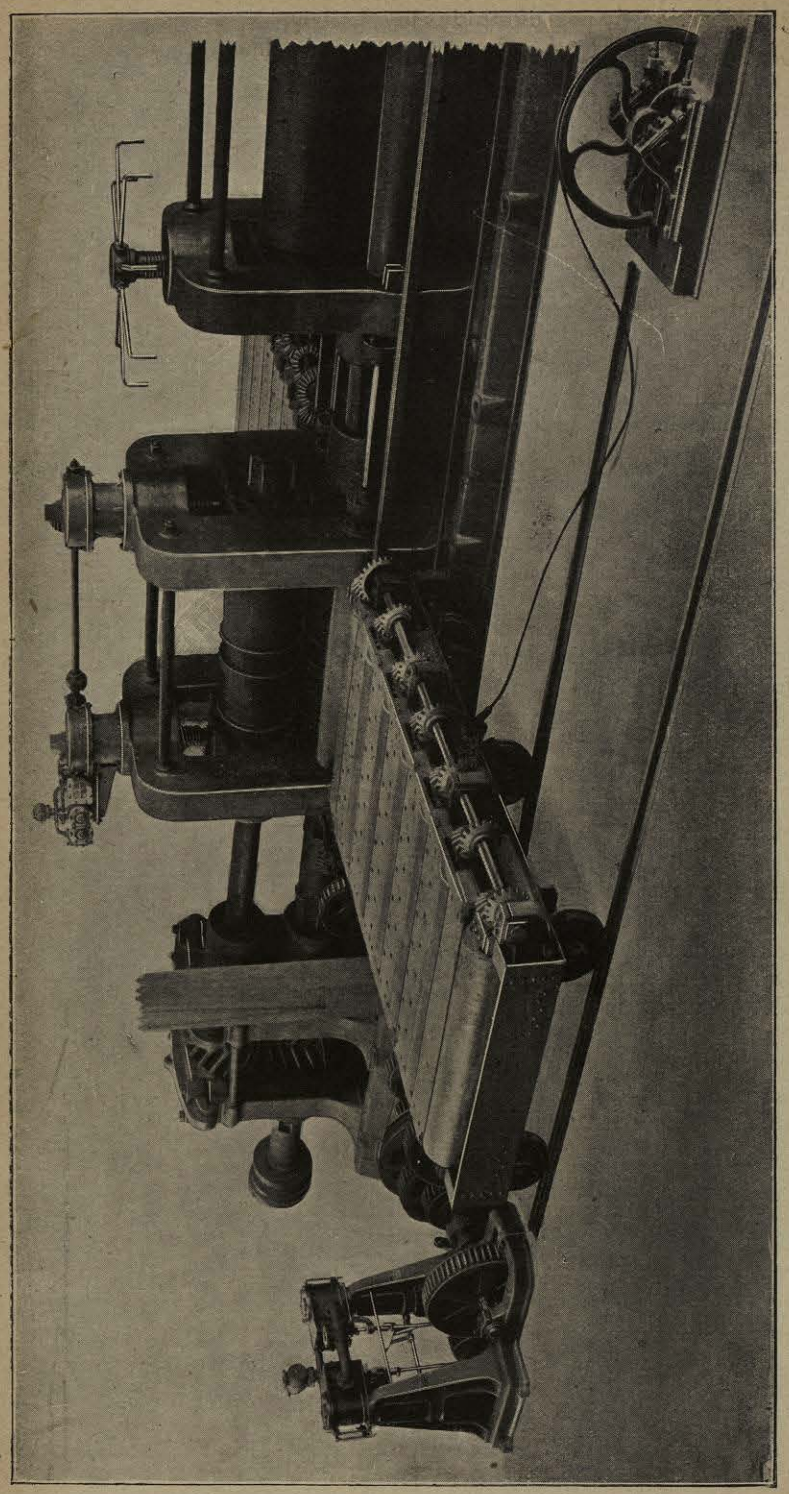


Fig. 417.—Plate Mill, with Travelling Tables.

C, drives the shaft, D, on the opposite end of which is the mitre wheel, E, gearing with the corresponding wheel, F, fast on the shaft, G, which has keyed on it a series of worms, H H, &c., geared into the worm-wheels, which are keyed on the axles of the live rollers, K. By driving A in either direction the rollers, K, can be made to revolve in the same direction. The transfer of the table from one stand to the other is effected by the square shaft, L, which, by means of the wheels, M and N, actuates the shaft, O, on which is a worm, P, which drives the worm-wheel, Q, fast on the shaft, R, on which in turn are keyed the carrying wheels, S, T, U, V, running on the rails, W, at the bottom of the pit, in which the table travels, with its upper surface flush with the floor of the mill.

Fig. 417 has been prepared from a photo. of a mill by Messrs. Thomas Perry & Sons, Limited, of Bilston, and shows a table of a similar kind, which is drawn to and fro by a wire rope in the same manner as the skids previously described; the rollers are driven by the square shaft just against the housings. This mill being installed in a foreign country, where there is not sufficient demand to keep the mill always running on plates, grooved rolls (shown in the cut) are also provided, which can be substituted for the plate rolls and used to cog down ingots for other purposes.

Tables are now often actuated by electro-motors which travel with the table, the current being picked up by a brass shoe sliding on a copper rod.

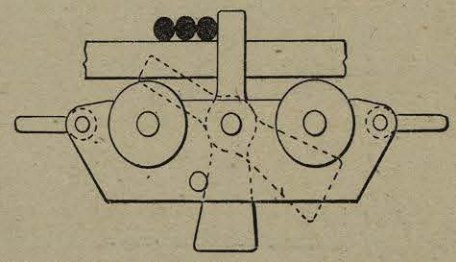


Fig. 418.—Skid for Hot Bed, fitted with Movable Finger.

The **Hot Bed** consists of a series of rails or flat bars laid on edge horizontally at right angles to the direction in which the hot bars or sections leave the rolls, and on to which they are pushed by the skids, where they are left to cool. The rails are supported on dwarf walls or iron stands, and the floor is excavated below the rails, so that the air may be able to circulate all round the hot bars; as fast as they are fed hot on to one end of the supporting rails they are removed when cool from the other end by other skids. The first set of skids being simply required to push the bars on to the hot bed, may be of almost any construction, but a skid to withdraw them from the other end must pass under the bars it is desired to remove. Such a skid is furnished with a movable finger weighted so as to stand upright, but capable of being folded over when pressed in one direction, as shown in dotted lines in fig. 418, but held rigid by a stop against pressure in the other direction. The skid having been passed to the right under so many bars as it is desired to remove, is hauled back again to the left, the finger driving before it the bars coloured black in the illustration.

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CHAPTER XXIX.

THE SUPPLY OF POWER.

(1) Producing the Steam.

Introductory.—The production of power for driving the mills forms no inconsiderable part of the cost of steel. The amount of fuel burnt under the boilers is generally more than is used for melting, and much more than is used for reheating.

In an iron works the steam required for driving the engines can usually be raised from the waste heat escaping from the puddling and mill furnaces, so that there is little inducement to use steam economically. But, in a steel works, as neither the Bessemer nor Siemens processes give out any waste heat which can be profitably employed for steam raising, the boilers must be heated by coal, except in those cases where boilers are attached to reheating furnaces, and can use their waste heat; but as these, in any case, can supply only a small proportion of the requisite steam, economy in its use becomes a matter of importance. Yet even now little attention is paid, in many works, to the preventable waste due to the continued use of low pressures of steam, and the omission to superheat it, to condense it after use, or to treat and heat the feed-water, &c.

In an electric lighting station, where the bill for boiler fuel is about half the amount of the sales, such neglect would be fatal. And though this proportion is far less in a steel works, nevertheless the manager should have a sound knowledge of what conduces to economy in the production of power. Therefore, although space forbids a full treatment, it seems desirable to give at least an outline of the subject in a work dealing with the manufacture of steel.

Sources of Heat.—Generally the power required for driving the mills is obtained from steam engines. A limited portion of the steam used by them is sometimes supplied by boilers heated by the waste gases from reheating furnaces, and usually spoken of as "furnace-fired boilers"; but much the larger portion, often the whole, has to be raised in a battery of boilers, directly heated by coal. These boilers are called by the workmen "coal-fired" or "hand-fired boilers" (even though some form of mechanical stoker be employed), in contradistinction to those heated by the waste gases.

Spare gas, which will burn under the boilers, can sometimes be obtained from the blast furnaces, when these are near the steel works; but where such gas is available it is now more often burnt directly in the cylinders of gas engines, to generate electric current, which is used for lighting, for driving the auxiliary machinery, or even, in some cases, for driving the mills themselves. This method of obtaining and using power will be treated in Chapter xxxi.