runner of, and works on the same principle as, the machine invented by him for charging open hearth melting furnaces, a description of which will be found in the first part of this work. The original Wellman charger gripped the ingot as just described on each side, and, lifting it from the trolley, which had been run close to the door of the furnace, charged it and withdrew it when heated, laying it on a similar trolley to be taken to the mill, as in fig. 325.

Fig. 326, Plate xxvi., shows a self-contained charging machine made by Messrs. Booth Bros. of Rodley. In this machine a taper bar, brought almost to a point, is thrust under the ingot or slab, and the arm on the upper side of the slab, which is worked by a toothed segment, into which gears a worm driven by the square shaft shown on the further side of the machine, grips the slab firmly. The square shaft on the nearer side drives, by means of a worm, a worm wheel keyed to a shaft, on which is a pinion gearing into a toothed quadrant lying between the riveted cheeks; by means of this the outer end of the slab can be raised or lowered to lift the piece from a trolley, and raise it sufficiently high to enter the furnace door. The whole machine can be turned round into any position on the truck on which it stands, which can in turn be travelled up and down the rails; the riveted girders carrying the gripping appliance can be travelled to or from the truck, in a straight line, the square shafts sliding through the wheels, by which the motion is conveyed to them: in this way the slab can be thrust into and withdrawn from the furnace as required. The whole of the motions are obtained from the small pair of engines mounted on the machine, which are supplied with steam from the vertical boiler.

The Wellman-Seaver Charger.—The most recent form of horizontal charger is the overhead machine manufactured by the Wellman-Seaver Engineering Co., of Cleveland, Ohio, U.S.A., who have kindly supplied the drawings from which Plate xxvii. (figs. 327 and 328) has been prepared.

The machine consists of a pair of cross girders, attached to end carriages, provided with travelling wheels running on rails near the roof, as in an ordinary overhead travelling crane. The longitudinal travel is performed by the electric motor, A, at a speed of 300 feet per minute. On rails situated near the lower flanges of the cross girders travels a crab, B, which can be run across the shop by the motor, C, at a speed of 200 feet per minute; from the under side of this crab depends a triangular framework, X, which can be rotated round a vertical axis, N (fig. 329), by the motor, D. This frame carries a rising and falling platform, E, on which sits the workman who operates the machine, the platform being raised or lowered by the motor, F, through gearing acting on the crank, G, and link, H. The platform is always maintained in a horizontal position by the links K L, which form a parallel motion. On the platform is the gripping contrivance, very similar in action to an ordinary adjustable spanner, which, when lowered on to an ingot or slab, will grip it by its ends. As this gripper has no parts projecting beyond the sides of an ingot, the latter may be laid close beside the next one in the furnace; and as the gripper lays the ingot down and picks it up vertically, the furnace bottom is not injured by the thrusting of a peel beneath the ingot, or by dragging it along the bottom.

The action of the gripper, which will be understood if fig. 330 is examined, is most ingenious. The charging bar, *a*, is carried on the centre pin, *b*, which is raised and lowered with the platform, to which it is rigidly attached, with the result that its longer end, *c*, falls downwards, as shown in the upper position, until the shoulder, *d*, near the pin, *b*, comes in contact

with the stop, *e*. On the under side of the charging bar slides the block, *f*, between which and the hooked nose of the charging bar, the piece to be lifted is grasped. If the nose of the bar is laid on this piece, and the platform is lowered so that the pin, *b*, descends, the jaws will open as shown in the lower position, until they can be slipped over the piece which will lie between them. The platform is then raised, lifting the pin, *b*, when the shorter end, *g*, of the charging bar will rise, and by means of the link, *h*, straighten out the toggle levers, *k*, *l*; as the pin, *m*, is attached to the platform, the rod, *n*, is forced forward, and the sliding block, *f*, grips the piece to be raised, as shown in the upper position; the heavier this piece is the tighter becomes the grip upon it. The rod, *n*, is not of one uniform length, but consists of a screw working in a nut which is turned by the motor, M (fig. 328), which merely serves to adjust rapidly the width of the jaw, the weight of the charging bar and piece to be lifted doing the actual gripping.

All the motors are enclosed, so as to be dust-proof, and the machine can pick up an ingot or slab as it lies on the floor, in whatever direction it may chance to point; can deposit it in the furnace, remove it again when heated, and transport it to the live roller bed, which carries it to the mill. The machine will serve six heating furnaces, and is particularly suited for handling slabs which are to be rolled into plates.

Where the buildings covering the furnaces are of sufficient height and strength to carry the overhead girders and rails on which such a machine runs, the overhead arrangement is usually preferred, as it leaves the floor free from obstruction; but many existing buildings do not permit of such an arrangement, and a charger must then be used which can run on rails on the floor.

A machine of this kind by the same makers is illustrated in fig. 331, Plate xxviii. The main frame consists of two long girders laid parallel to each other, having travelling wheels at each end, running on rails sunk flush with the floor. These rails are laid parallel with the line of heating furnaces, so that the machine may be brought opposite any door in any of the furnaces. Between the main girders, and carried by them, is a pair of rails at right angles to those on the floor, on which the travelling carriage, shown in dotted lines in the cut, runs backwards or forwards, to or from the furnace; and on this carriage is a framework capable of rotation around a vertical axis. This framework carries the peel, one end of which can be lowered and thrust under ingots or billets lying on the floor of the shop, anywhere within the range of the machine, either between or outside the main line of rails. The peel can lift the ingots whether they lie in a line with it, or at right angles to it. The peel is then lifted to the requisite height, swung round to face the furnace door, the travelling carriage is run towards the furnace, and the peel deposits the piece to be heated within it, by lowering it on to suitable supports on the furnace bed. The piece is removed by a reversal of these operations. All the motions are worked by electric motors, which are supplied by an overhead wire slung from the underside of the roof ties, the current passing down through the swivelling arm carried on a mast on the top of the frame, immediately over the centre of the axis on which the frame revolves.

Charging very Heavy Ingots.—The large ingots for armour plates, which take many hours to heat through, are handled rather differently. The largest are now generally forged under a press, in which case only one end need be heated. To effect this a "porter bar," which is fully described in the chapters on forging (figs. 526 and 543), is secured to that end of the ingot which occupied, when cast, the top of the mould; suitable balance

[*To face p.* 566.

eaver Low-Form Charging Machine.

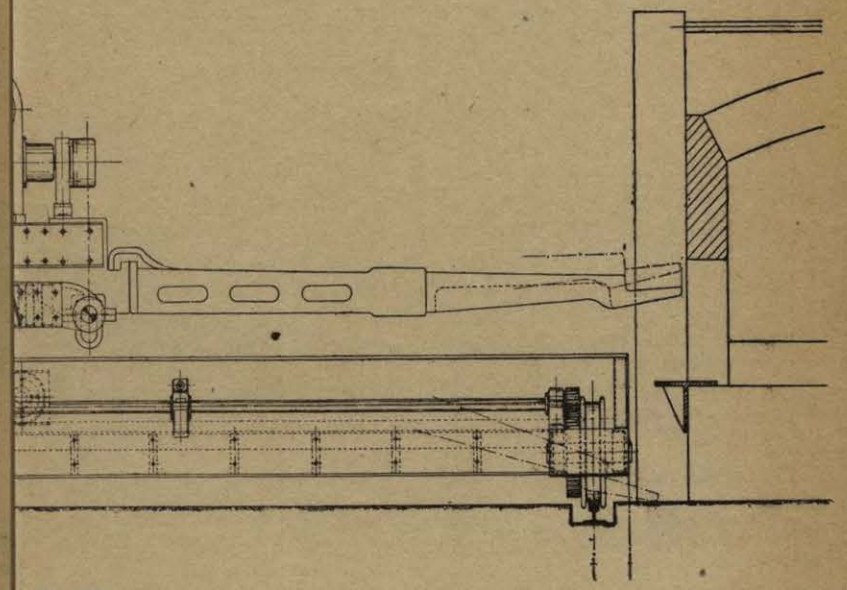

Fig. 331.

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PLATE XXVIII.—Wellman-Seaver Low-Form Charging Machine.

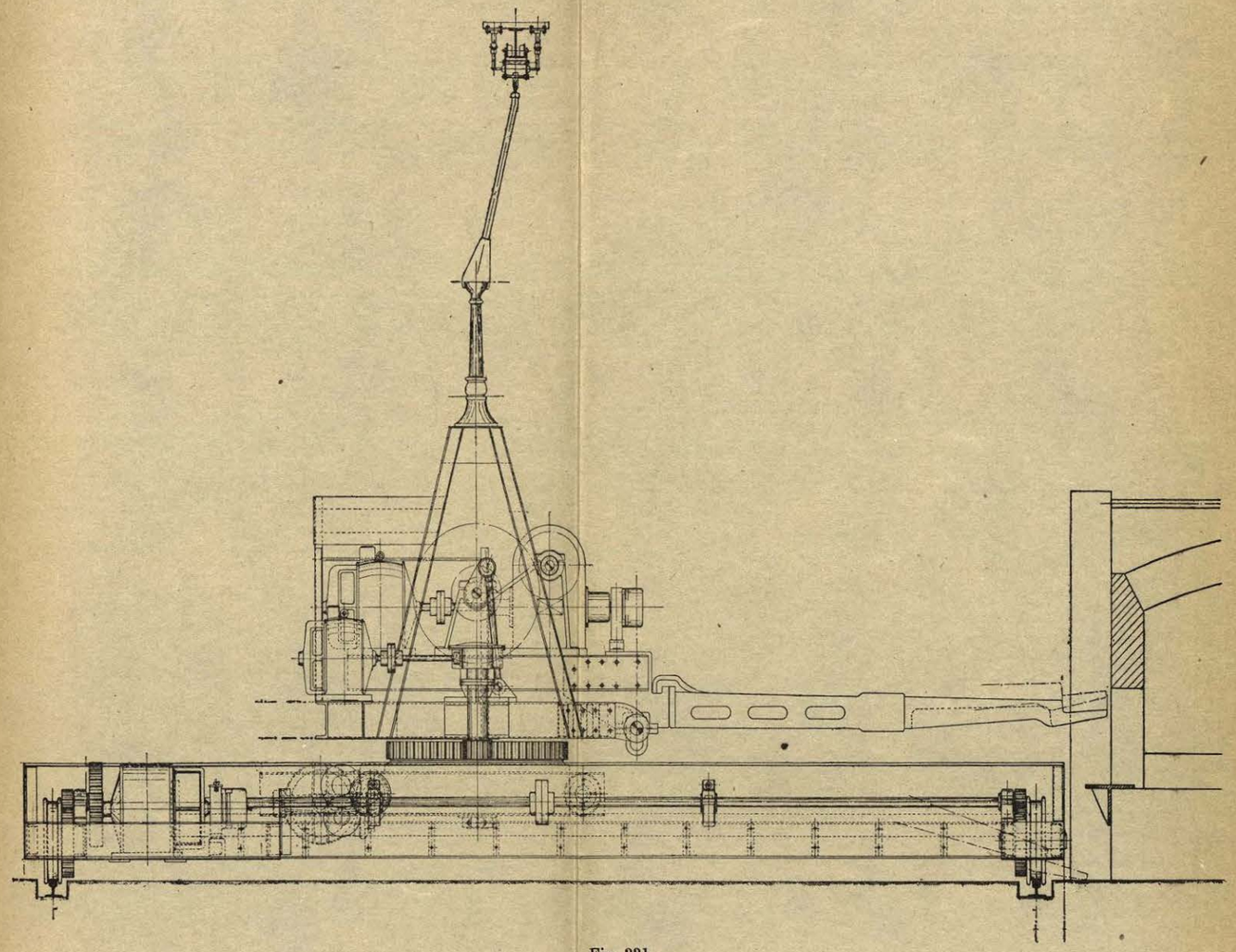


Fig. 331.

weights having been secured to the other end of the bar to balance the weight of the ingot, the whole is lifted by a crane, and the one end of the ingot inserted in the furnace; the door is lowered upon it, and any space between its sides and the door jambs is filled in temporarily with bricks, which are daubed over with loam to exclude air.

If the ingot is to be rolled in a mill, the whole of it must be heated, to effect which it must be charged bodily into the furnace. At one famous French works this is done by a large peel shaped like the letter ⊂. This is slung from an overhead travelling crane, the point of attachment on the upper leg being immediately over that of the centre of gravity of the piece to be lifted. The lower leg, like the fork in fig. 339, is placed beneath the ingot, which is deposited by it on piles of bricks which stand about a foot above the furnace bed, the lower leg of the ⊂ passing through the door in the side of the furnace, and the upper outside above its roof. When heated, the ingot is removed by the same appliance, which lays it on the live rollers leading to the mill.

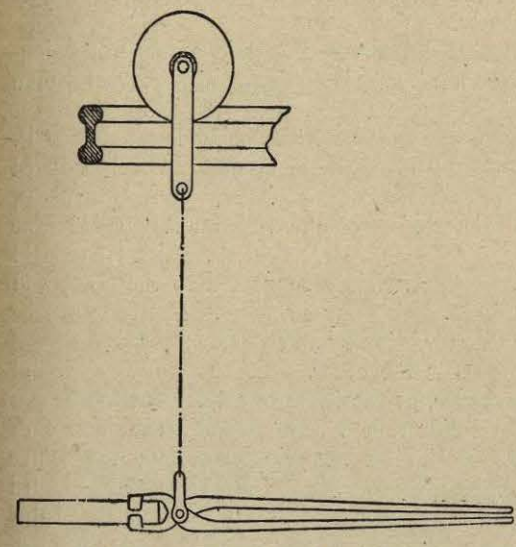


Fig. 332.—"Telegraph" Tongs running on rail.

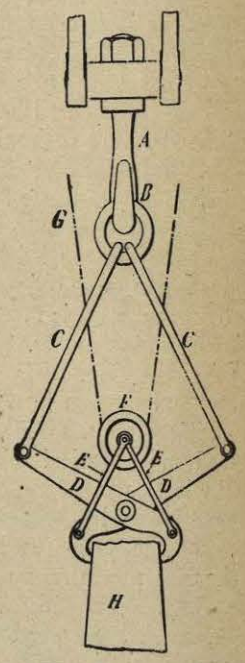


Fig. 333.—Tongs for Charging Vertical Heating Furnaces.

Another method employed at Essen, and at Sheffield, is to construct the bottom of the furnace on a wheeled truck, which can be entirely withdrawn by some suitable means, when the door at the front of the furnace is raised. The ingot is laid by a crane on the removable bottom, which is pushed into the furnace, and the door closed. When the ingot is sufficiently heated, the bottom is withdrawn, and the ingot lifted from it by the same crane, which places it on the live rollers in front of the mill. To keep the truck supporting the bed of the furnace cool, air is allowed to circulate below it, the joint between the bed and side walls, necessary to exclude air, being provided by a sand seal.

Charging Small Pieces.—Small pieces which can be picked up with hand tongs are easily put into the furnace and as easily turned over and withdrawn. When the furnace is near to the mill, the heated billets are thrown down on to the mill floor, which is often made to slope, and they glide easily along the floor plates to the roller. If the furnace must be placed any distance away, a stout wire is stretched just below the roof, with a slight slope from the furnace towards the mill. On this wire runs a pulley, from which hang the tongs which hold the billet. By means of this simple contrivance a boy can easily run it quickly for a considerable distance. The appliance is known as "the telegraph." For heavier weights rails may be hung from the roof (see fig. 332).

Charging Furnaces Vertically.—The method employed for seizing the ingot is much the same in every case. From the crane hook, A (fig. 333), are hung by the ring, B, and links, C, a pair of gripping tongs, D. To the other ends of the gripping jaws are attached other links, E, E, connected to the pulley, F, capable of being lifted by the chain, G, which has an adjustment independent of the main lifting chain. By lowering A more rapidly than F, the jaws open, and can be dropped on to the top of the ingot, H. If A only is now tightened, the grips grasp the ingot, but directly the weight of the ingot rests on the bottom of the pit, any further lowering relieves the strain on the links, C, and the tongs being free, can be withdrawn by hauling on A and G simultaneously.

Wellman-Seaver Overhead Charger.—A certain amount of swinging is inevitable, where tongs are hung from a chain, and, moreover, a man is needed on the floor to adjust the tongs, and to steady the ingot, so that it may not strike the brickwork of the furnace while being lowered into it. To overcome these objections, the Wellman-Seaver Company have produced the overhead electric machine for charging soaking pits and vertical furnaces, which is shown in fig. 334. This consists of an overhead travelling crane carrying the crab, B, from which depends a large tube, C, which is steadied at top and bottom in a framework, A, rigidly connected to the crab, and travelling with it, so effectually preventing any swinging. The tube can be rotated on its vertical axis in either direction by an electric motor, and carries within it two other tubes, one inside the other, which rotate with it, and may be lowered one out of the other, as the tubes of a telescope are drawn out. To the bottom end of the inside tube, D, are attached the inner ends of the two toggle levers, E, E, which close the gripping tongs; the centre pins, F, F, round which the grippers, G, G, turn, are fastened in a T-shaped block, H, at the lower end of a rod which passes up the centre of the tube. When the gripping tongs are lowered on to an ingot, the T head is arrested, but the tube, continuing its descent, pulls inwards the upper ends of the jaws, the lower ends opening and slipping over the ingot. On raising the tube, the toggle levers are straightened out, and the ingot, I, is gripped and lifted, and the heavier the ingot the tighter is the grip.

The method of releasing the grip when the ingot is deposited, is simple and ingenious, and is effected as follows:—The crab carries a large grooved drum, K, round which are coiled three chains, the two outer ones secured to the inside tube, and the third middle one to the inside rod. The two outer chains pass direct from the drum to the tube, but the chain attached to the rod passes between a set of three guide pulleys, mounted on parallel axes, the top and bottom pulley being fixed one over the other, and the middle pulley, which is on the opposite side of the chain, being movable horizontally by means of a screw actuated by a motor. The three chains

are wound and unwound simultaneously, but when the movable pulley touching the centre chain is thrust forward by the motor in the direction of the other two, the portion of chain lying between the top and bottom guide pulley is pushed out of plumb in the form of a >, the effect of which is virtually to shorten the chain connected to the T head, thus causing the

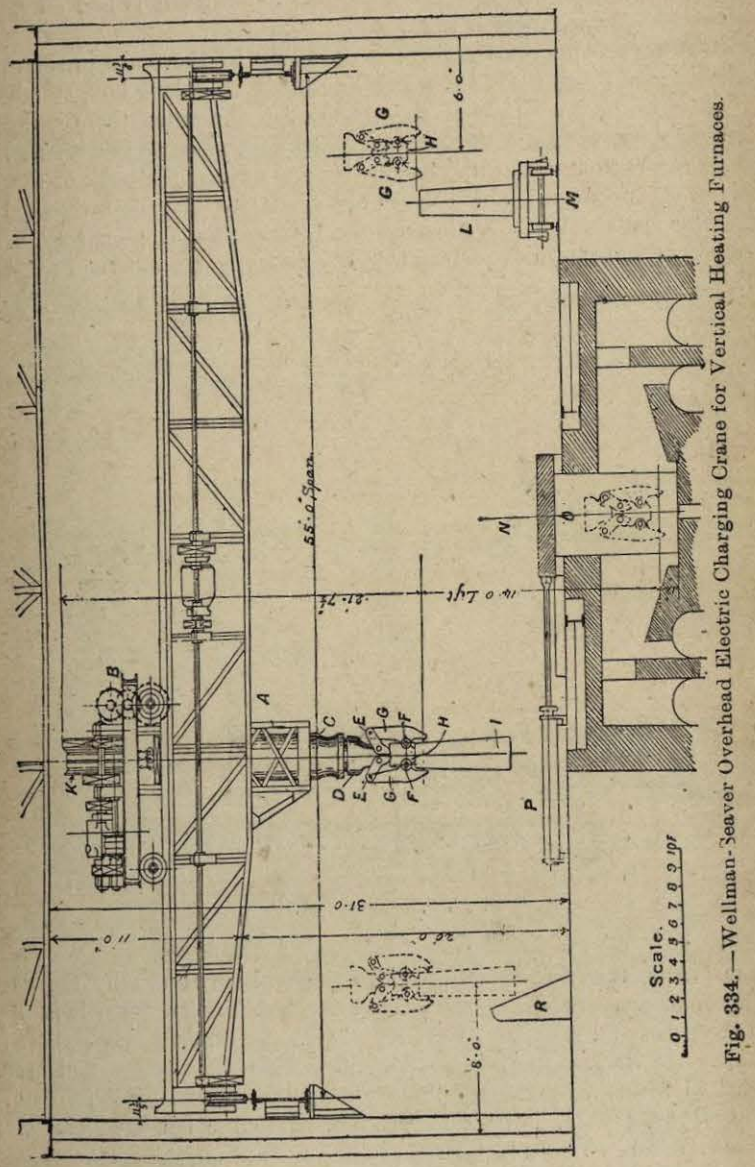


Fig. 334.—Wellman-Seaver Overhead Electric Charging Crane for Vertical Heating Furnaces.

jaws to open, and release the ingot. The reason for employing tubes one within another, is to enable them to fold up into a short space, just as a telescope may be shut up. By doing this it is not necessary to allow a large amount of head room above the crab; in the earlier designs it carried upon it a tall latticed tower, which guided the upper end of the long movable tube, and required an excessively high roof to accommodate the machine.

In fig. 334 the ingot, L, is brought from the stripping house on the casting bogie, M, from which it is lifted by the charger, the workman operating it being seated in a cage attached to the crab and travelling with it. The cover, N, of the vertical heating furnace, O, is drawn back by the hydraulic cylinder, P, to allow of the insertion of the ingot, which, when heated, is lifted out and deposited in the tumbler, R, by which it is laid on the bed of live rollers, which carry it to the mill.

Tumblers.—The heated ingot is deposited by the crane in the tipping cradle or tumbler, B (fig. 335), which consists of an oblong box, standing on one end with its back inclined slightly towards the mill; there is no front nor top to this box, and the ingot, A, when laid in it, rests with its larger end on the bottom, and with one side leaning against the back of the box; a pivot, E, is provided, round which the whole box may be turned. When the water contained in the left-hand end of the cylinder, C, is released, the pressure of water, which is maintained constantly on the right-hand side

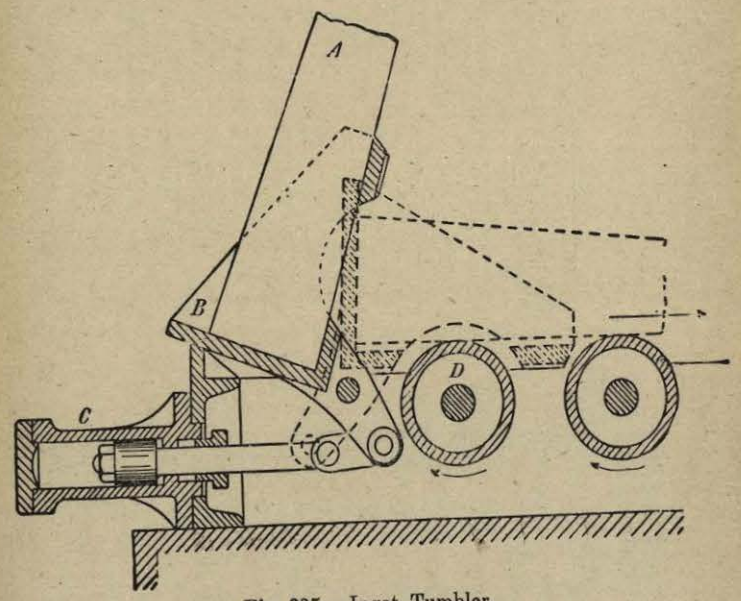
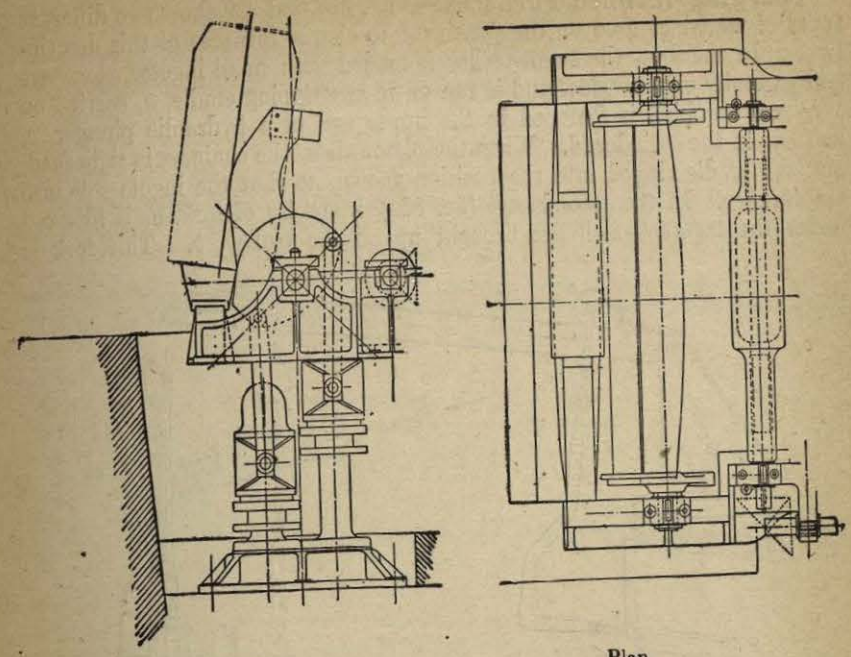


Fig. 335.—Ingot Tumbler.

of the piston, tips the cradle over into the position shown by the dotted lines. A piece is cut out of the back of the box, so that when it is tipped into the horizontal position, the roller, D, next the tumbler may project into it, above the back of the box, so that the ingot is lifted clear, and may be carried to the mill by the revolving rollers. When the ingot is removed, the pressure of water is once more admitted to the left-hand end of the cylinder, which, overcoming the constant pressure on the smaller area on the right hand of the piston, raises the tumbler into position to receive another ingot.

Figs. 336 and 337 show a tumbler for a plate mill, with a skeleton box or cradle wide enough to admit either an ingot or a cogged slab. The cradle is tipped and lowered and brought back again by admitting water through the centre of one or other of the fixed rams below it, on which slide cylinders, which are inverted, so that scale cannot fall into the packings.



Elevation. Plan.

Figs. 336 and 337.—Tumbler adapted to take Ingots or Cogged Slabs.

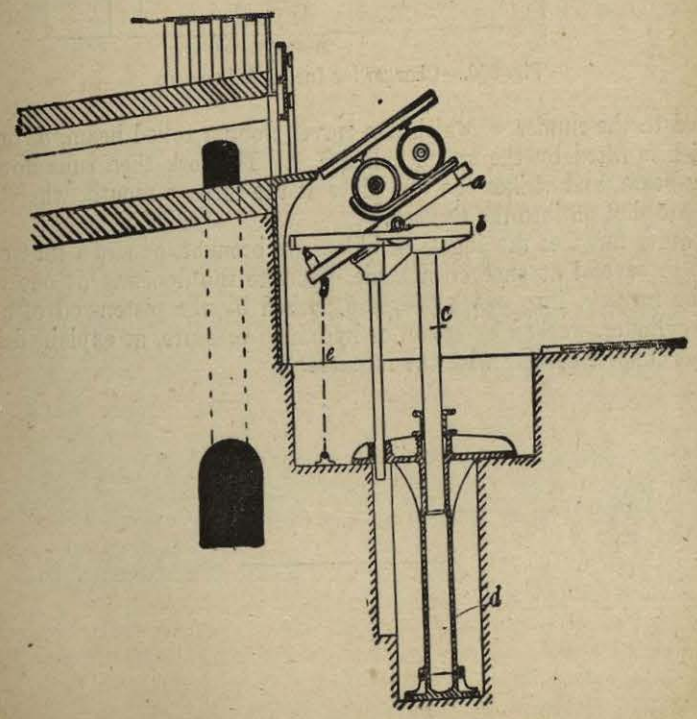


Fig. 338.—Charger for Inclined Furnaces.

Charging Inclined Furnaces.—Figs. 338 and 339 show two different types of machines used on the Continent to charge furnaces of this description. In the first, the small trolley is loaded with small ingots, which are laid carefully side by side, and is run on to the tipping cradle, *a*, carried on a frame, *b*, which is fastened to the upper end of a hydraulic plunger, *c*, working in the cylinder, *d*. When the piston rises, the chain, *e*, is tightened, and the cradle tipped into the position shown, so that the ingots roll into the furnace. In the second case (fig. 339), a species of fork, *a*, is inserted under the ingots, which are brought up on the trolley, *b*. This fork is

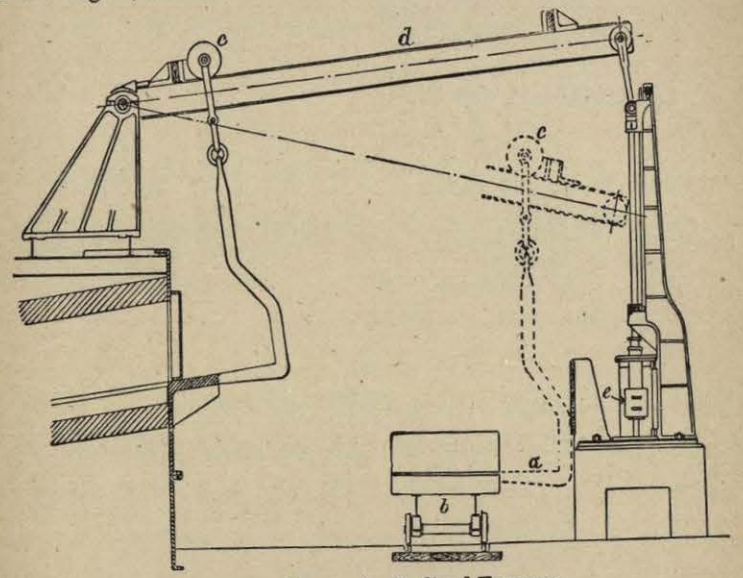


Fig. 339.—Charger for Inclined Furnaces.

fastened to the runner, *c*, which can travel along a rolled beam, *d*, one end of which is lifted by the steam cylinder, *e*. The fork then runs down the sloping beam, and strikes the fore plate at the furnace mouth, whereby the ingots are shot off into the furnace.

In other furnaces the ingots or billets are brought, one at a time on live rollers, or several at once on a bogie, opposite the doorway at one end of the long furnace, into which they are pushed by the piston-rod of a horizontal cylinder, worked by steam or hydraulic pressure, as explained in the previous chapter dealing with the furnaces.

CHAPTER XXIII.

DETAILS OF ROLLING MILLS.

The Rolls.—The rolling mill consists essentially of two rolls, mounted one over the other, both driven by some extraneous power in opposite directions, so that the upper side of the lower roll and the lower side of the upper roll travel at nearly the same speeds in the same direction. The piece to be rolled is put in between the two rolls which, by revolving, draw it forcibly through, and so reduce the section of the piece acted on. If plates or sheets are to be made, the rolls are plain cylinders; but if bars are wanted, grooves are formed in the rolls, which give the piece being rolled the section desired. The rolls are mostly made of good, tough cast iron, run into dried sand or loam moulds, except in those cases where it is desired to put a highly-finished surface on plates or sheets, when the rolls are "chilled."

When in the molten state cast iron holds in solution the Carbon it contains, which separates in the form of crystals of Graphite, distributed throughout the mass as the fluid cools, rendering the casting soft and grey. On the contrary, when cooled suddenly, there is not time enough for the Graphite to separate, its retention in solution rendering the chilled iron dense, white, intensely hard, and capable of receiving and retaining a high polish, which it can impart to materials pressed into intimate contact with it.

Chilling is effected by making the mould in sand as usual, except that portion destined to form the body or "barrel" of the roll, which is made up of heavy cast-iron rings, called "chills," which are carefully turned on the joints and bored out true inside. They are warmed to remove any moisture, and the insides washed with a coating of black lead, which dries upon them; when the iron is poured in through a passage or "git" running down to the bottom of the mould, as it rises it comes in contact with the chill, and is converted into white iron for a distance of $1\frac{1}{2}$ to $1\frac{1}{4}$ inches inwards from the surface, while the central portion retains its grey tough character. As the chills employed are costly and are destroyed by frequent use, while the slightest defect on the surface of the roll will leave a mark on every sheet rolled by it, and, therefore, ensure its rejection, and the labour of turning so hard a material is considerable, such rolls cost from 50 to 100 per cent. more than those cast in sand, and known as "grain rolls." The operation of chilling causes the different parts of the roll to cool at different speeds, and puts the whole casting into a condition of initial tension, with a peculiarly brittle surface, so that such rolls are very easily broken, and, as they are very susceptible to sudden changes of temperature, require considerable care on the part of the men using them; they are consequently employed only for purposes where a high finish is required on the rolled material. A "part-chill" roll is one which is chilled only at the end where the finishing grooves are situated.

Any iron not too high in Silicon can be chilled, but to obtain satisfactory chilled rolls, possessing both the requisite strength and hardness—*i.e.*, two characteristics more or less antagonistic—is by no means an easy matter. The best rolls are made from mixtures of cold-blast pig-iron smelted from the argillaceous ores of Staffordshire, Shropshire, or from Blaenavon, in South Wales.