June 21, 1932. R. H. EURICH ET AL 1,864,270

METHOD OF CONTINUOUS CENTRIFUGAL CASTING

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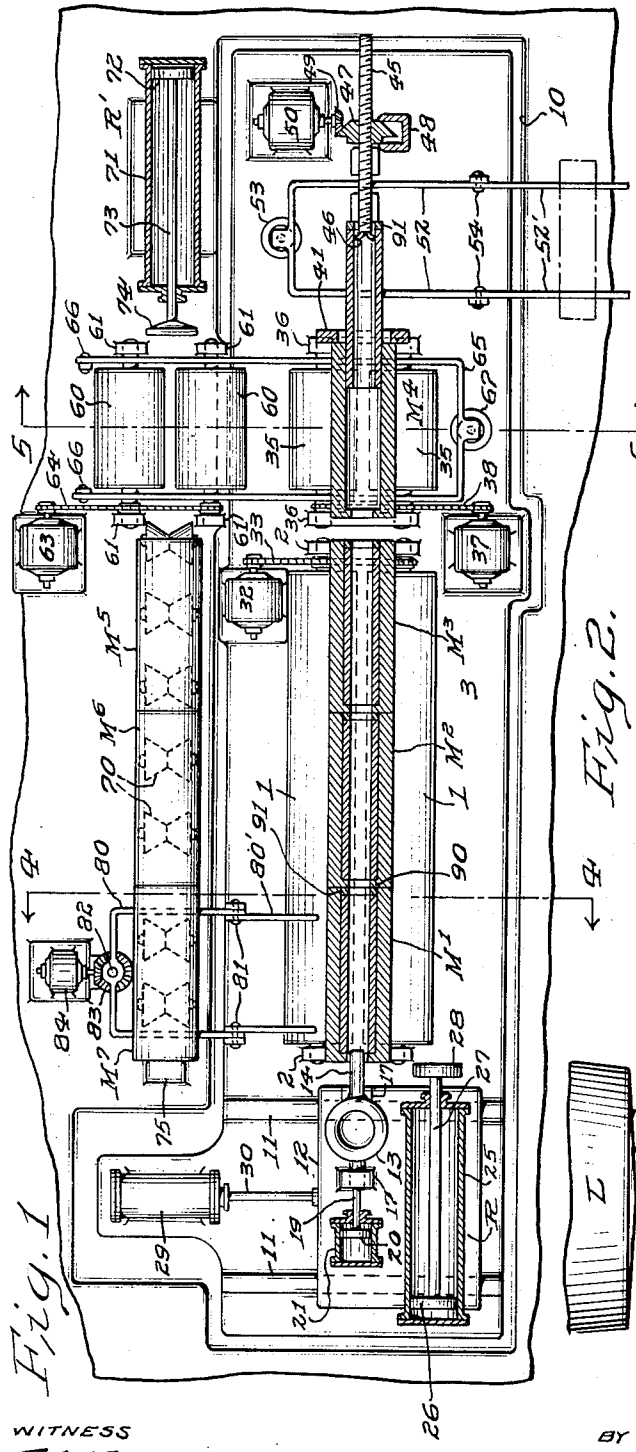


Fig. 1

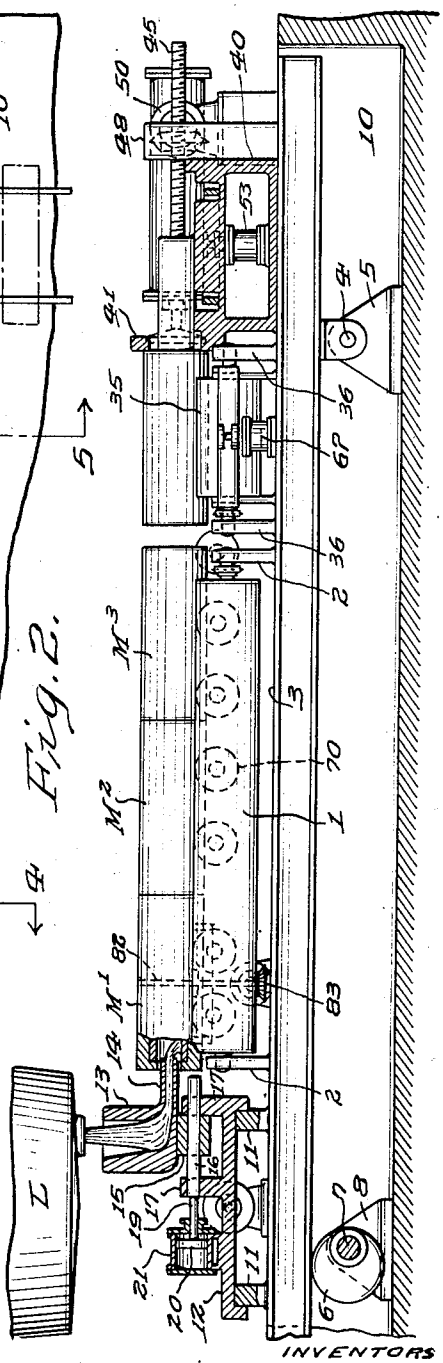


Fig. 2.

WITNESS
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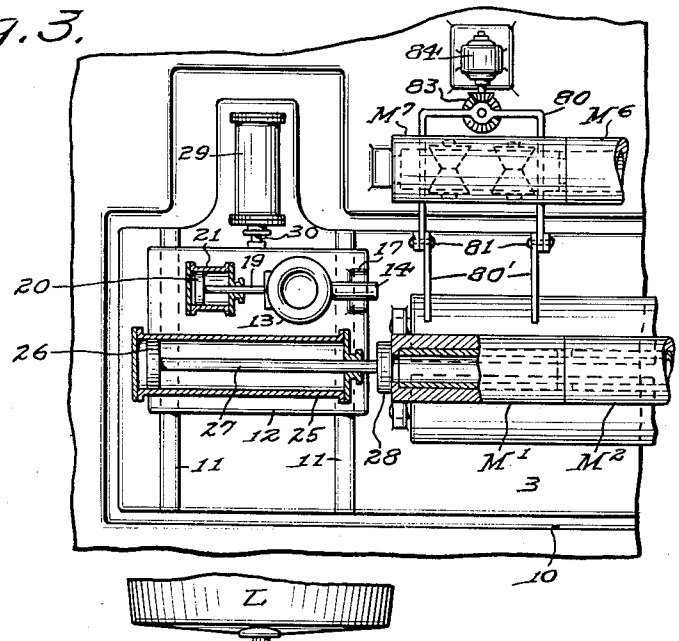
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June 21, 1932. R. H. EURICH ET AL 1,864,270

METHOD OF CONTINUOUS CENTRIFUGAL CASTING

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Fig. 3.



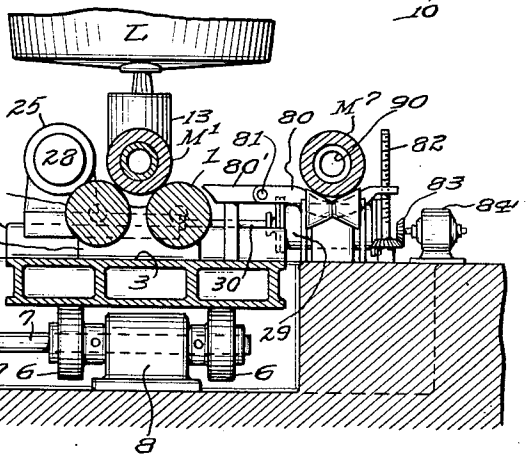
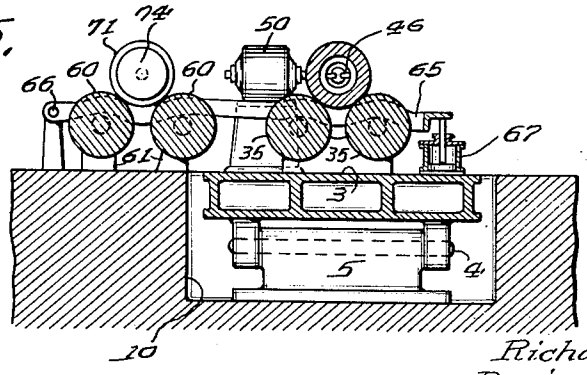


Fig. 4.

Fig. 5.



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METHOD OF CONTINUOUS CENTRIFUGAL CASTING

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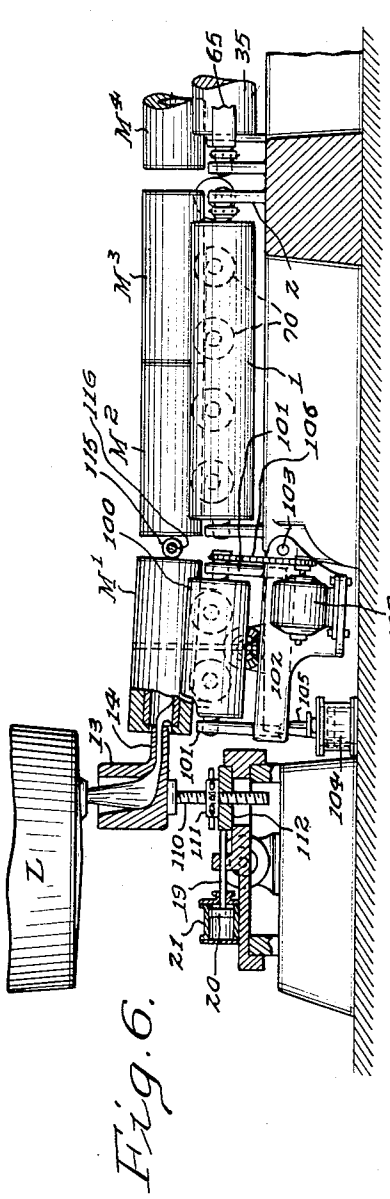


Fig. 6.

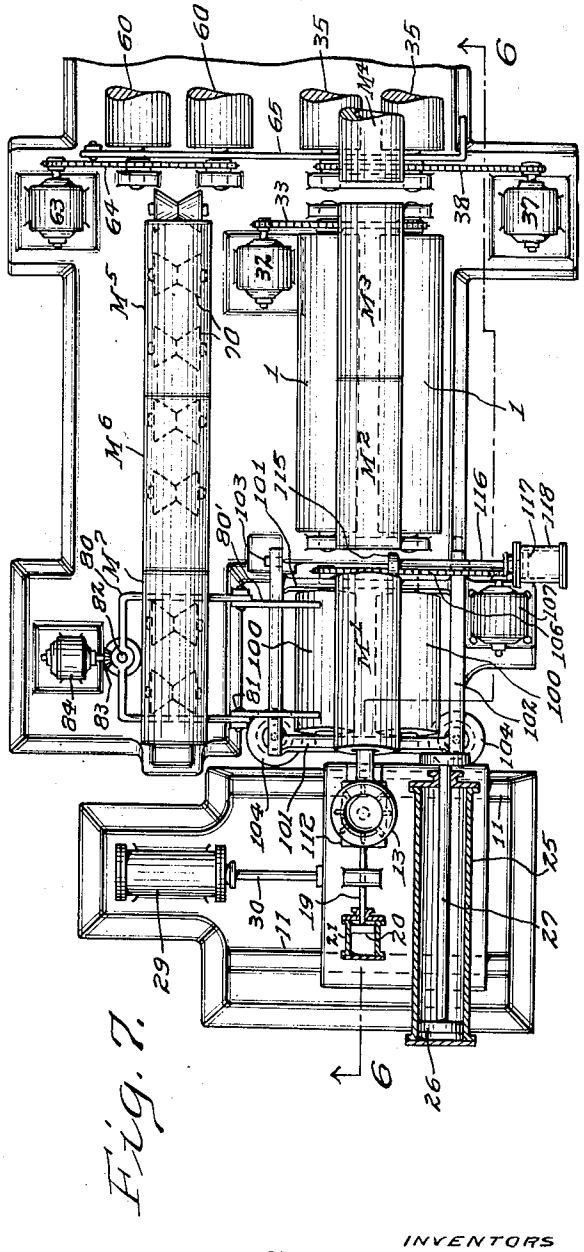


Fig. 7.

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METHOD OF CONTINUOUS CENTRIFUGAL CASTING

Application filed May 7, 1930. Serial No. 450,339.

Our invention relates to the art of making centrifugal castings and to a novel method of making such castings continuously or in a cyclic manner whereby they may be produced with maximum rapidity and economy, the invention more particularly being especially suitable for, but not confined to, the production of steel ingots of relatively large size intended for subsequent manufacture into pipes and tubes.

Our invention further includes the provision of a machine adapted for the performance of the said method and claimed in an application for U. S. Letters Patent filed May 20, 1932, Ser. No. 612,611 as a division hereof; this machine we prefer to use in the practice of the method, although if desired other forms of machines or apparatus suitable therefor may be employed.

Other objects, advantages and novel operations and features comprehended by our invention are hereinafter more particularly pointed out or will be apparent to those skilled in the art from the following description of one manner of performing our said method by means of a machine or apparatus constructed in accordance with our invention and which, in its preferred embodiment, as well as in a modified form, we have illustrated in the accompanying drawings forming part of this specification.

To facilitate a thorough understanding of our invention we shall first refer in a very general way to the series of principal steps or operations incident to the preferred practice of our said continuous or cyclic method as employed in the production of a series of hollow cylindrical ingots and shall then more particularly describe the construction of the said machines and their operation when used in the performance thereof.

Thus, for the practice of the method we provide a plurality of hollow cylindrical molds whose internal diameter corresponds with the external diameter of the ingots to be formed therein. At one end each mold is provided with an inwardly directed web or flange desirably integral with the mold and having a circular opening in its center which is of less diameter than the internal diameter of the desired ingot, and at its opposite end with a retaining ring, also of less internal diameter than the ingot, which removably seats in the end of the mold to form an annular dam for the fluid metal; these rings are preferably disposed in the molds before the latter are brought to the charging or pouring station as hereinafter more fully described. Thus the length of each mold exceeds the maximum length of the ingot it is designed to produce by an amount approximating the combined thickness of the flange and ring.

The molds after suitable preparation for the reception of the molten metal and with the rings assembled in position are consecutively brought to the pouring station and there axially rotated at a suitable speed and, under certain conditions, with their axes slightly inclined to the horizontal. A quantity of the molten metal sufficient to form the ingot is then run into the rotating mold through the opening in the webbed end thereof by means of a pouring spout introduced into the opening at the center of the web so as to properly guide the molten metal into the mold as it is received in the spout from a ladle suspended thereabove, and as the metal is received in the rotating mold it is distributed and compacted uniformly throughout the interior thereof by centrifugal force, the axial inclination of the mold if employed assisting in effecting a more rapid distribution of the metal lengthwise of the mold, so that by the time sufficient metal has been introduced to form an ingot of the desired wall thickness, the fluid metal has assumed a hollow cylindrical form and has been thoroughly compacted against the mold wall. The inflow of metal is then discontinued and the mold while still rotating is translated substantially axially by suitable mechanism to a new position in which its rotation is continued while the pouring of the following mold is carried out. This following mold is then in turn longitudinally translated to the position previously assumed by the leading mold and the latter thus projected forwardly and while rotating to still another position, and it will thus be apparent that the filled molds are con-

secutively moved away from the pouring station with a step-by-step motion while continuously rotating about their own axes and that during this stage or period of progressive though intermittent movement the ingots are gradually solidifying in the molds. Thus when the leading mold has progressed for a distance and through an interval of time sufficient to permit its contained ingot to become solid or substantially so, that mold is given one more longitudinal movement of translation to thereby carry it to a stripping station where its axial rotation is discontinued and the ingot and retaining ring longitudinally stripped from the mold by suitable stripping mechanism, after which the ingot is in condition for transportation to some other point preliminary to further operations thereon which form no part of the present invention. The mold, thus freed of the ingot, is then moved transversely of its former path but without disturbing its substantial axial alignment therewith to another station disposed laterally of the stripping station and is there cleaned and otherwise prepared for a second cast and the same or a fresh retaining ring assembled in its end. Thereupon, and preferably by a step-by-step movement effected by suitable means, the mold is again axially translated along a cooling table, forming a path substantially parallel to that of its initial axial movement but extending in the opposite or reverse direction so as to finally bring the mold to a station in substantial transverse alignment with the pouring station, the mold meanwhile being cooled by exposure to the atmosphere or in any other suitable way to a point at which it is in proper condition to receive a fresh charge of the molten metal. Finally, from this last mentioned station the mold is transferred, preferably by a transverse movement, to the pouring station in position to receive a second charge of fluid metal, thereby completing the cycle.

Thus in accordance with the preferred practice of our method, whenever a mold is disposed at the pouring station, other rotating molds containing ingots in a gradually increasing state of solidification are disposed in advance thereof, another mold is disposed at the stripping station where the solidified ingot is being stripped therefrom, one or more molds are being prepared for casting, and still other molds, suitably prepared for casting, are disposed on the cooling table preparatory to consecutive transfer to the pouring station in the progress of the cycle.

We shall now describe more particularly certain machines, as illustrated in the accompanying drawings, constructed in accordance with our invention and suitable for performing the various steps and operations comprehended by our said method of continuously centrifugally casting hollow ingots, Fig. 1 being a top plan view, with certain parts in horizontal section, of that form of machine which under most circumstances we prefer to employ and Fig. 2 being a front elevation thereof with certain parts shown in vertical section, the pouring spout and adjacent parts being shown in the position assumed while a mold is being poured. Fig. 3 is a fragmentary detail plan view generally corresponding to Fig. 1 but showing the pouring spout and adjacent parts in the position assumed after a mold has been poured; Fig. 4 is a transverse vertical section of the machine on the line 4—4 in Fig. 1, and Fig. 5 is a corresponding section on the line 5—5 in said figure. In Figs. 6 and 7 we have shown a slightly modified form of machine, Fig. 6 being a vertical section thereof on line 6—6 in Fig. 7 and Fig. 7 a top plan view, generally corresponding to Fig. 1, with certain parts shown in horizontal section, the stripping mechanism and adjacent parts being omitted in both of these figures as the same are fully shown in the preceding figures. Like characters of reference are used to designate corresponding parts throughout the drawings, and the directions in which the various sectional views are taken are indicated by the arrows on the section lines.

Primarily it should be understood that as the machines embody numerous means and mechanisms in common use in the steel and other industries for the performance of certain functions analogous or similar to those for which they are employed in our machines, detailed illustration and description thereof would be superfluous and of no advantage in contributing to a proper and adequate comprehension of our invention; therefore, the said drawings may, with respect to the details of such means and mechanisms, be considered as diagrammatic or substantially so, being neither designed nor intended to specifically illustrate the same.

The machine shown in Figs. 1 to 5 inclusive comprises a pair of parallel rolls 1—1 suitably journaled for rotation in pedestals 2—2 disposed adjacent the ends of the rolls. These pedestals in turn are desirably supported on a platform 3 which, for a purpose hereinafter described, may be so mounted that one end thereof may be elevated to thereby slightly incline the axes of the rolls. Preferably, therefore, the platform is supported adjacent one end on a horizontal trunnion shaft 4 extending transversely of and below the platform and carried by a pedestal 5, thereby providing an axis about which the opposite end of the platform can be raised or lowered by suitable means disposed adjacent and beneath said end such as cams 6 on a cam shaft 7 carried by a pedestal 8; thus by rotating the cam shaft the adjacent end of the platform

may be lifted to an extent determined by the throw of the cams to thereby incline the platform downwardly from left to right when viewed as in Figs. 1 and 2.

The platform is preferably disposed in a pit 10 in the floor of the building in which the machine is housed and of such depth that the upper surface of the platform is substantially level with said floor upon which those parts of the machine not carried by the platform are supported.

Adjacent its left hand end, the platform is provided with longitudinally spaced ways 11 on which is mounted a table 12 for reciprocation transversely of the platform. This table serves to support the pouring spout 13 through which the fluid metal is introduced to the molds, the spout, which is formed entirely of or lined with suitable refractory material, being approximately cup-shaped and provided near the bottom with a runner 14 extending toward the rolls 1—1. The spout is arranged for limited reciprocation in a direction generally parallel to the axes of the rolls 1—1, conveniently by supporting the spout on a block 15 in turn seated on a plunger 16 slidable in guides 17 carried by the table and connected to a piston rod 19 and fluid actuated piston 20 in a cylinder 21 supported on the table.

The table 12 is also operative to support a ram, generally designated as R, by means of which the molds can be pushed longitudinally along the rolls as hereinafter described; this ram may comprise a cylinder 25 containing a piston 26 whose rod 27 extends parallel to the axis of the rolls and at the end adjacent thereto is provided with a head 28. The ram is positioned at one side of the pouring spout and either the spout or the ram can be brought into alignment with the mold at the pouring station when desired by moving the table transversely of the platform by any convenient mechanism such, for example, as a cylinder 29 containing a fluid actuated piston whose rod 30 is connected with the table.

The rolls 1—1 are driven in the same direction by any suitable means such as a motor 32 disposed on the platform and connected with sprockets on the roll shafts by silent chains 33, or by motors which form an integral part of the rolls in the manner frequently employed in driving heavy rolls in the steel and allied industries.

Disposed adjacent the end of the rolls 1—1 remote from the pouring spout and respectively in axial alignment with said rolls, is another pair of rolls 35—35 journaled for rotation in pedestals 36 carried by the platform and driven in the same direction as but independently of the rolls 1—1 by any suitable means such as a motor 37 and silent chain 38. These rolls form a receiving station for the ingot molds as they are respectively moved from the rolls 1—1 as hereinafter described and also support the molds while the ingots are being stripped therefrom, during which operation they are held stationary by shutting off the motor 37 or other driving means.

Beyond that end of the rolls 35—35 remote from the rolls 1—1, stripping means are provided for stripping the ingots longitudinally from the molds as they are supported on the rolls 35—35, said means desirably comprising a stripping table, generally designated as 40, and adapted to receive the ingot as it is withdrawn from the mold; this table is supported on the platform 3 and adjacent the rolls is provided with an annular or other suitable stop 41 to prevent the ingot mold from moving longitudinally while the ingot is being withdrawn, the stop having an opening aligned with the axis of the molds of sufficient diameter to permit the ingot to be drawn therethrough and away from the mold in the manner clearly shown in Figs. 1 and 2. For engaging and withdrawing the ingot any suitable means may be employed, the particular embodiment thereof which we have chosen to illustrate comprising an externally threaded plunger 45 having expansible jaws 46 at its forward end adapted to bite into the inner wall of the ingot after they have been projected into its bore. Upon the plunger 45 is mounted an internally threaded bevel gear 47 prevented from longitudinal movement by a guide 48 carried by the table and engaged by a pinion 49 actuated by a reversing motor 50 in such manner that the gear may be revolved in either direction as desired and the plunger thus projected toward or retracted from the rolls 35.

For ejecting the stripped ingot from the stripping table, a pivoted U-shaped skid 52 is arranged beneath it to extend transversely of the platform to other skids 52′ extending away from the machine to a point, such as a soaking furnace or tube mill, at which the ingot is to be subjected to further treatment, and means such as a cylinder 53 having a fluid actuated vertically movable piston and piston rod are arranged in association with the skid in such manner that the latter can be raised about its pivots 54 so as to form an inclined plane down which the ingot can roll to the stationary skids 52′ after the upward movement of the U-shaped skid has first lifted the ingot from the stripping table.

After the ingot has been stripped from the mold, the latter is transferred from the rolls 35—35 to another pair of rolls 60—60 journaled in pedestals 61 disposed on the floor of the building in rear of the pit 10; these rolls are in transverse alignment with the rolls 35—35 and are independently driven, preferably in the same direction as the latter, by suitable means such as a motor 63 and silent chain 64.

For transferring the molds from one set of rolls to the other, a U-shaped skid 65 gen-

erally similar to the skid 52 already described may be employed, the free ends of the skid being pivoted at 66 on suitable supports on the floor beyond the rolls 60—60 which, together with the rolls 35—35, are thus surrounded by the skid, while for raising and lowering the closed end of the skid an actuating cylinder 67 having its piston rod extending upwardly beneath the skid is mounted on the platform, so that by movement of the piston rod at the proper time in the cycle of operations the adjacent end of the skid may be lifted to raise the mold from the rolls 35—35 and then form an inclined plane down which the mold can roll to the rolls 60—60 transversely of the path of the movement by which it was brought to the receiving rolls 35—35.

While the mold is disposed on the rolls 60—60 it is cleaned and prepared for receiving a second charge of metal as hereinafter more fully described and following this preparation is translated longitudinally along a cooling table preferably comprising a series of rotatably mounted longitudinally spaced V-shaped rollers 70 and extending from adjacent the rolls 60—60 to a point or station in substantial transverse alignment with the pouring station adjacent the pouring spout; the rollers or other means forming the cooling table thus constitute a path for the empty molds extending substantially parallel to the rolls 1—1 of such character that the molds can be readily longitudinally translated therealong with a minimum of friction and consequent expenditure of power. For moving the molds along the cooling table as well as for ejecting them consecutively from the rolls 60—60, a ram R′ comprising a cylinder 71 containing a fluid actuated piston 72 carrying a piston rod 73 having adjacent the rolls a head 74 is provided and so disposed that by projecting the head of the ram toward the rolls a mold resting thereon may be translated or pushed longitudinally onto the cooling table, a stop 75 being provided to limit the movement of the leading mold along the latter.

Finally, for transferring the leading mold on the cooling table to the pouring station after it has been brought into transverse alignment therewith as determined by the stop 75, we provide suitable means such as a U-shaped skid 80 whose arms extend beneath the mold when in said position and are pivoted at their ends to suitable supports 81 carried by the platform in association with stationary skids 80′ extending toward and partially over the rolls 1—1 as well as means for elevating the skid 80, such, for example, as a vertical screw 82 extending through an internally threaded lip carried by the skid and driven through bevel gears 83 and a motor 84 disposed on the floor, or a fluid actuated piston and rod as shown in association with the other movable skids already described, whereby the skid may be lifted to first raise the ingot from the cooling table and then form an inclined plane down which it can roll to the stationary skids 80′ and thence to the rolls 1—1 on which it rests in axial alignment and frictional engagement therewith. It will of course be understood that the precise form of elevating means provided for this as well as for the other movable skids utilized in the machine is a matter of choice, and thus any means suitable for the purpose may be employed.

A series of ingot molds M are also provided, and while the machine is in operation the molds are consecutively carried therethrough in the progress of the cycle, each mold thus being subjected to the same successive operations. Desirably all of the molds in each series are of the same size and shape, and each of them, as best shown in Fig. 1, comprises a hollow relatively thick walled tube or cylinder, the internal diameter of which corresponds with the external diameter of the ingot which is to be formed. At one end, which for convenience will be termed the rear end, each mold has an inwardly directed, preferably integral web 90 surrounding a central opening of less diameter than the internal diameter of the ingot which is to be formed in the mold while at its other end a removable retaining ring 91 of less internal diameter than said ingot is seated in the mold cavity to form a dam to prevent the molten metal from running out of that end of the mold. Each ring is secured in its mold at the time the latter is prepared to receive the cast, the particular means or method of holding the ring in position forming no part of the present invention.

We will now briefly describe the operation of such a machine in the practice of our improved method of casting: Assuming that a mold has been disposed on the rolls 1—1 at M^1 with its rear or webbed end adjacent the table 12 and thus ready to receive a charge, the table is first moved across the platform to a point at which the runner of the pouring spout is aligned with the opening in the end of the mold and the spout then entered therein as shown in Figs. 1 and 2. A charge of molten metal sufficient to form the desired ingot is then poured into the mold through the spout from a ladle L suspended above the latter and, in order to measure the quantity of metal so introduced, the ladle is desirably so interconnected with a scale or other suitable means (not shown) that the weight of the metal as it is discharged from the ladle can be accurately determined by the operator, thus enabling him to cut off the flow thereof by operating the ladle valve or stopper at the proper time. Since the rolls 1—1 are continuously rotating in the same direction, the mold M is likewise axially rotating throughout the pouring of the charge with the result

that the molten metal is distributed outwardly by centrifugal force against the inner wall of the mold and compacted thereagainst, both during the pouring operation proper and for such time thereafter as the metal remains in fluid or plastic condition.

The speed of rotation of the rolls 1—1 and consequently of the mold is determined in practice by numerous factors such as the size of the mold, quantity of metal in the charge, its condition at the moment of pouring and the like, but under usual conditions of operation it is desirable that the rotational speed of the mold be as low as possible commensurate with obtaining the requisite distribution of the metal in the mold.

Where the mold is relatively short, the metal readily distributes itself lengthwise thereof when the mold is in horizontal position, but as the length of the mold is increased for the corresponding production of longer ingots, difficulty is sometimes experienced in getting the metal to properly flow throughout the length of the mold and, under such circumstances, it may therefore be found desirable to axially incline the mold downwardly from the end where the metal is introduced, a result which can be readily accomplished by suitable manipulation of the cams 6 or other mechanism provided for raising the rear end of the platform so as to incline the same sufficiently to bring about the proper lengthwise distribution of the metal in the mold.

The charge having thus been introduced to the mold, the pouring spout is retracted so as to clear the runner therefrom and the table 12 moved transversely of the platform to align ram R with the end of the mold, following which the ram is operated so as to translate the mold longitudinally along the rolls 1—1 to the position M^2 where, of course, its axial rotation through its frictional engagement with the rolls 1—1 is continued. Another mold is then brought to position M^1, charged, and then translated to the position M^2 in the manner already described, thus moving the leading or preceding mold to the position M^3, both molds still being rotated by the rolls 1—1. A third mold is then moved to M^1 and charged, with the result that three molds are now disposed on the rolls with the metal in the leading mold at M^3 in a much more nearly sodidified condition than the metal in the mold at the pouring station while the metal in the mold at M^2 is in a state intermediate of that in the others. While for convenience of illustration we have shown but three molds upon the rolls 1—1, it will of course be understood that the precise number of molds in that position when that point in the cycle to which the present description has proceeded has been reached, in other words, the number of molds on the rolls 1—1 when the leading mold is in position to be transferred to the receiving rolls 35—35, will be determined for any particular machine having rolls 1—1 of a given length by the length of the ingot molds themselves since, where the latter are quite short, a relatively larger number of them can be disposed on the rolls 1—1 than when they are of relatively greater length. But whatever be the number of molds on the rolls 1—1 under any given set of operating conditions, the time interval required for the passage of a given mold from the pouring station to the opposite end of the rolls 1—1 should be so regulated that when the leading mold is ready for transfer to the rolls 35—35, the ingot therein contained is solidified or substantially so, whereby when the mold is received on said rolls the ingot will be in condition to be stripped from the mold or will reach that condition very shortly thereafter.

The rolls 1—1 having thus been filled with charged molds, it will be apparent that the next movement of the ram R will be effective to push the leading mold from position M^3 onto the rolls 35—35 and against or substantially against the stop 41 of the stripping table. Desirably these rolls are rotating in the same direction and at the same speed as the rolls 1—1 when the mold is transferred thereto, as such rotation facilitates the transfer and also continues the application of centrifugal force to the contained ingot while the stripping plunger 45 is being run up toward the mold, now in position M^4, so as to enter the jaws 46 into the end of the ingot preparatory to expanding them therein to cause them to grip the ingot; before the jaws are expanded, however, the rotation of the rolls is arrested so as to permit the jaws to properly grip the ingot, after which the plunger is retracted so as to strip the ingot from the mold, the retaining ring of course being stripped out ahead of the ingot. When the ingot has been moved far enough to align with the skid 52, the jaws are disengaged and the plunger retracted a little farther so as to permit the retaining ring to be recovered for subsequent use; the skid is then raised so as to roll the ingot transversely across the table and onto the stationary skids 52′ down which it moves to some suitable point for storage or further treatment, and as soon as the ingot has cleared the movable skid, the latter is lowered to normal position.

The empty mold is now resting in position M^4 on the receiving rolls and is immediately transferred by elevating the skid 65 to the rolls 60—60 and, while resting on these rolls (which may be either rotated at any suitable speed or not as desired) is cleaned and otherwise prepared to receive a second cast, this preparation including the insertion of the same or a fresh retaining ring in the end of the mold. The adjacent ram R′ is now

operated so as to move the prepared mold axially from the rolls 60—60 to the adjacent end of the cooling table where it rests in position M^5 until the following molds are successively ejected from said rolls, thus progressively moving the leading mold to positions M^6 and M^7 in which it is transversely aligned with position M^1 which it initially occupied at the pouring station. Consequently as soon as the last mold in the series is cleared from that station, the mold at station M^7 is transferred thereto by suitable elevation of the skid 80, thus placing that mold in condition to receive a second charge and completing the cycle.

Mention has been made of the desirability under certain conditions of inclining the axes of the molds to facilitate lengthwise distribution of the molten metal as it is being poured, and the machine to which we have referred is therefore preferably arranged to effect this result by suitable adjustment of the platform supporting the rolls 1—1, but as these rolls are thereby inclined throughout their length, all of the molds while resting on them are likewise similarly axially inclined with the result that the metal therein during its gradual solidification tends to flow toward their lower ends; in consequence the wall thickness of the ingots produced under these conditions frequently progressively increases from one end to the other, being thinner at what was the upper end of the ingot during its period of solidification and thicker toward that which was the lower. Ingots of this character are unsuitable for certain purposes though entirely satisfactory for others and therefore, for the purpose of producing ingots having walls of constant thickness from one end to the other under conditions of operation which dictate or at least make desirable the maintenance of the ingot molds with their axes inclined while being poured, a slightly modified form of machine such as is illustrated in Figs. 6 and 7 and which will now be described may be employed.

In this machine the molds at the charging station, that is, in the position M^1, are supported on a pair of rolls 100—100 which are journaled in pedestals 101 mounted on a frame 102 which is pivoted at 103 on a horizontal pivot or trunnion exceeding transversely of the machine; the frame is thus capable of being raised and lowered vertically about said pivot by operation of suitable means such as fluid actuated pistons contained in cylinders 104 disposed beneath the frame at the end thereof remote from the pivot and connected with piston rods 105 extending vertically upward to the frame and so arranged that the frame may be held in any desired position of vertical adjustment. Instead of fluid actuated pistons and rods, screw jacks or other similar means may be employed for the purpose. These rolls 100—100 are independently driven so as to rotate in the same direction by any suitable driving means such as silent chains 106 and a motor 107 supported from the frame and are thus operative to impart axial rotation to the mold when imposed thereon during the charging operation in the manner already described. It will thus be apparent that by suitable operation of the frame elevating means, any desired angular inclination of the roll axes, within limits, may be attained with corresponding inclination of the superposed mold at M^1 while the metal is being poured and for the purpose of enabling a corresponding adjustment of the height of the pouring spout and runner, the former may be disposed at the upper end of a vertically disposed screw 110 extending through an internally threaded collar 111 seated on a block 112 adapted for longitudinal reciprocation on the table 12 and connected with the piston rod 19, piston 20 and actuating cylinder 21 carried by the table as heretofore described; thus, by revolving the collar 111, the spout may be raised or lowered to bring the runner into alignment with the opening in the adjacent mold in accordance with its degree of elevation.

The rolls 1—1 along which the molds are translated while the ingots are cooling, as already described, are thus in this form of the machine independent from the rolls 100—100 and are independently driven. They may therefore be made correspondingly shorter and are permanently mounted in a horizontal position so that as the molds pass along these rolls the mold axes are also horizontal, thus negativing any tendency for the contained metal to flow toward one end or the other of the molds while it is solidifying, said metal because of the angular disposition of the molds while the metal was being poured having been properly distributed lengthwise in the molds with approximate accuracy; additionally, the further continued rotation of the molds while their axes are horizontal and after they have been transferred to the rolls 1—1 tends to equalize any slight inequalities in the previous lengthwise distribution of the metal with resultant production of ingots of uniform wall thickness throughout their length.

Since the molds when in position M^1 on the rolls 100—100 are axially inclined downwardly toward the rolls 1—1, there is some tendency for the molds to move away from the pouring spout during the pouring operation and we therefore provide means for preventing such movement, said means desirably comprising a roller 115 disposed at the end of a plunger 116 and reciprocable by a piston 117 in a cylinder 118 suitably supported in such position that the plunger extends transversely of the line of movement of the rolls between the molds at M^1 and M^2 so

as to bring the roller 115 against the end of the mold at the pouring station when the plunger is projected and to withdraw the roller from alignment with the mold when the plunger is retracted.

In this form of machine the principal elements, except the frame 102 supporting the rolls 100—100, may preferably be disposed, as shown in the drawings, on suitable pedestals or bases fixed on the floor of the building in which the machine is located instead of mounting some of them on a platform vertically movable relatively to the floor as heretofore described, and the rear end of the pedestal which carries the rolls 1—1 employed as a point of support for the hinged frame 102.

It will of course be understood that the machine now being described is also provided with rolls 35—35 for receiving the molds from the rolls 1—1, with stripping means, means for transferring the empty molds to a station where they are prepared for the succeeding cast, cooling table and means for transferring the molds therefrom to the charging station similarly to the machine illustrated in Figs. 1 to 5 inclusive, all preferably of the character of those referred to in connection therewith and operating in a substantially similar way; said means therefore require no further description and for convenience of illustration certain of them have been omitted from Figs. 6 and 7.

It is thought that the operation of the said machine will be readily apparent without extended description, but it may be mentioned in passing that where the axial inclination of the rolls 100—100 is considerable, it will usually be found desirable to lower the frame 102 to substantially horizontal position before withdrawing the retaining roller 115 preparatory to translating the charged mold to the rolls 1—1, and to thereafter maintain the frame in such position until the succeeding mold is disposed on the rolls 100—100, but where the axial inclination of the molds during the pouring of the metal is relatively slight the frame, after being once angularly adjusted, can usually be kept in the same position throughout the cycle. It will furthermore be apparent that in both of the machines to which we have referred, the molds can be disposed during the pouring operation horizontally where it is found that suitable lengthwise distribution of the metal in the molds will take place under such condition or in inclined position where required or desirable for effecting such distribution, and that ingots of different sizes and wall thickness may be cast in either machine by employing different sizes of molds either of the same or of different external diameters, although in the latter case some vertical adjustment of the pouring spout and runner may be required.

Thus, in accordance with our cyclic or continuous method of centrifugal casting as performed by means of machines such as we have described, or by other machines suitable for the purpose, we are enabled to rapidly and economically produce shapes or ingots of satisfactory character for the further uses for which they are intended and at a minimum of expense.

As we believe our invention constitutes a distinct advance in the art, it is our purpose to claim the same broadly and we therefore do not desire or intend to limit or confine ourselves to the use of any specific mechanism or instrumentalities for the performance of our said method or to any precise details of design, construction and arrangement of the various elements which we have chosen to illustrate and describe as component parts of the machines herein disclosed as suitable therefor, for the same may be modified in numerous particulars as dictated by the varying conditions of operation under which the machines are to be employed or for such other reasons as may be desired without departing from the spirit and scope of the invention as defined in the appended claims.

Having thus described our invention, we claim and desire to protect by Letters Patent of the United States:

1. A cyclic method of producing castings centrifugally, which comprises the steps of rotating a mold, pouring molten metal into said mold, translating the mold while continuing its rotation until the metal reaches a predetermined state of solidification, pouring molten metal into another rotating mold disposed in substantial axial alignment with said first mentioned mold during said solidification, consecutively stripping the solidified castings from the molds, and finally successively returning the molds to initial position to receive other charges of molten metal.

2. A cyclic method of producing castings centrifugally, which comprises the steps of rotating a mold, pouring molten metal into said mold, translating the mold while continuing its rotation until the metal reaches a predetermined state of solidification, stripping the solidified casting from the mold, moving the empty mold out of alignment with its former path, and finally returning the mold to initial position to receive another charge of molten metal and successively performing like steps with relation to another mold during the absence of the first mentioned mold from said initial position.

3. A cyclic method of producing castings centrifugally, which comprises the steps of rotating a mold, pouring molten metal into said mold, translating the mold longitudinally while continuing its rotation until the metal reaches a predetermined state of solidification, stripping the solidified casting from

the mold, moving the empty mold out of alignment with its former path, translating the mold in the opposite direction until substantially aligned with its initial position, and finally moving the mold to such position to receive another charge of molten metal.

4. A cyclic method of producing castings centrifugally, which comprises the steps of consecutively positioning each of a series of molds at a pouring station, rotating the mold at said station, pouring a charge of molten metal into the mold, translating the mold away from the station while continuing its rotation until the metal has reached a predetermined state of solidification, stripping the solidified casting from the mold, moving the mold out of alignment with its prior path of movement, translating the mold in the opposite direction substantially parallel to its said prior path, and finally returning the mold to the pouring station to receive another charge of metal.

5. A cyclic method of producing castings centrifugally, which comprises the steps of consecutively supporting each of a series of molds at a pouring station, rotating the mold, pouring a charge of molten metal into the rotating mold, continuing the rotation of the mold and translating it with a step-by-step motion until the metal has reached a predetermined state of solidification, stripping the solidified casting from the mold, moving the mold transversely out of alignment with its prior path, translating the mold in the opposite direction by a step-by-step motion, and finally returning the mold to the pouring station to receive another charge of metal.

6. A cyclic method of producing castings centrifugally, which comprises the steps of consecutively supporting each of a series of molds at a pouring station, rotating the mold, pouring a charge of molten metal into the rotating mold, continuing the rotation of the mold and translating it with a step-by-step motion until the metal has reached a predetermined state of solidification, arresting rotation of the mold, stripping the solidified casting from the mold, moving the mold transversely out of alignment with its prior path, translating the mold in the opposite direction by step-by-step motion, cooling the mold during said translation, and finally returning the mold to the pouring station to receive another charge of metal.

7. A cyclic method of producing castings centrifugally, which comprises the steps of supporting a mold at a pouring station, rotating the mold, introducing a charge of molten metal to the mold through one end thereof, translating the mold with a step-by-step motion while continuing its rotation until the metal therein has reached a predetermined state of solidification, arresting rotation of the mold, stripping the casting from the mold, moving the empty mold to a cleaning station, preparing the mold at such station to receive a second cast, translating the mold in a direction opposite to its prior movement of translation, cooling the mold during said movement, and finally moving the mold transversely to the pouring station to receive a second charge of metal.

8. A cyclic method of producing castings centrifugally, which comprises the steps of supporting a mold at a pouring station with its axis inclined to the horizontal, rotating the mold, introducing a full charge of molten metal to the mold through the upper end thereof while restraining the mold from longitudinal movement, then translating the mold while continuing its rotation until the metal therein has reached a predetermined state of solidification, stripping the casting from the mold, and finally returning the mold to the pouring station to receive another charge of metal.

9. A cyclic method of producing castings centrifugally, which comprises the steps of supporting a mold at a pouring station with its axis inclined to the horizontal, rotating the mold, introducing a charge of molten metal to the mold through the upper end thereof, translating the mold with a step-by-step motion while continuing its rotation until the fluid metal therein has reached a predetermined state of solidification, arresting rotation of the mold, stripping the casting from the mold, moving the mold out of alignment with its prior path, then translating the mold substantially parallel to said path but in the opposite direction, and finally returning the mold to the pouring station to receive another charge.

10. A cyclic method of producing castings centrifugally, which comprises the steps of supporting an ingot mold at a pouring station with its axis in horizontally inclined position, axially rotating the mold, pouring a charge of molten metal through the upper end of the mold, intermittently longitudinally translating the mold while continuing its rotation until the metal therein has reached a predetermined state of solidification, stripping the ingot from the mold, moving the empty mold to a position laterally disposed with respect to its prior path, preparing the mold when in said position to receive a second charge of metal, intermittently longitudinally translating the mold to a position substantially aligned with the pouring station, and finally moving the mold to the pouring station to receive a second charge of metal.

11. A cyclic method of producing castings centrifugally, which comprises the steps of supporting an ingot mold at a pouring station with its axis in horizontally inclined position, axially rotating the mold, pouring a charge of molten metal through the upper end of the mold, intermittently longitudinal-

ly translating the mold while continuing its rotation until the metal therein has reached a predetermined state of solidification, stripping the ingot longitudinally from the mold, moving the empty mold transversely of its prior path to a position laterally disposed with respect thereto, preparing the mold when in said position to receive a second charge of metal, intermittently longitudinally translating the mold along a path substantially parallel to that of its prior movement of translation but extending in the opposite direction to a position substantially aligned with the pouring station, and finally moving the mold transversely of said path to the pouring station to receive a second charge of metal.

12. A method of centrifugal casting which comprises the steps of rotating a mold in a longitudinally fixed position while pouring a full charge of metal into the mold, and thereafter translating the mold longitudinally while continuously rotating it.

13. A method of casting centrifugally which comprises the steps of rotating a mold, pouring metal into said mold, removing said mold from the rotating mechanism permanently located at the pouring station, and rotating said mold until the requisite degree of solidification has been obtained.

14. A method of centrifugal casting which comprises the steps of rotating a hollow cylindrical mold in a longitudinally fixed position, pouring a full charge of molten metal into the rotating mold while in said fixed position, and thereafter moving the mold away from the pouring station so that the axis of the mold moves in a substantially horizontal plane and continuing its rotation until the molten metal therein has solidified.

In witness whereof, we have hereunto set our hands this 5th day of May, 1930.

RICHARD H. EURICH.
BENJAMIN F. ANTHONY.