

Aug. 18, 1925.

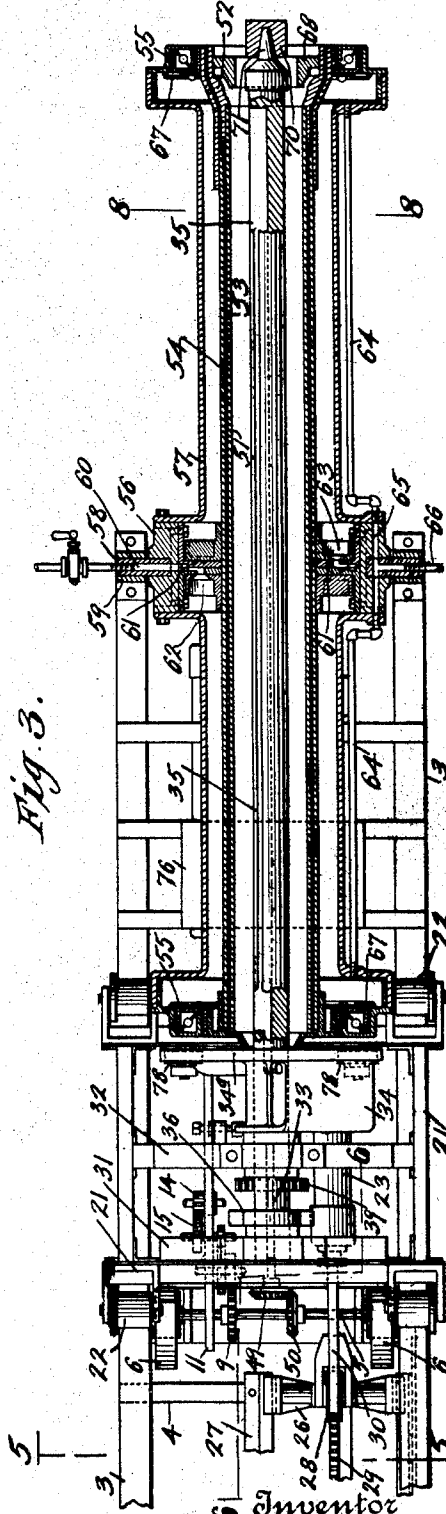
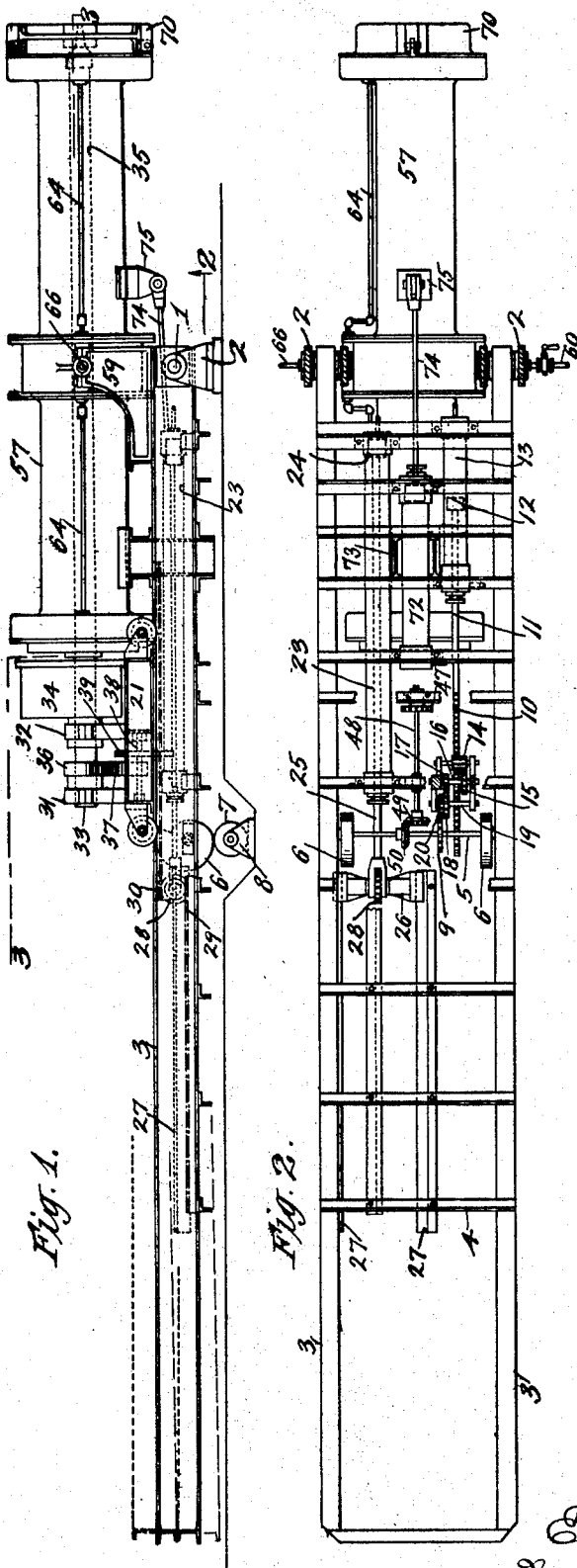
E. DE V. TOMPKINS

1,550,126

PROCESS OF AND APPARATUS FOR CASTING METAL IN A ROTARY MOLD

Filed March 31, 1923

5 Sheets-Sheet 1



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5 Sheets-Sheet 2

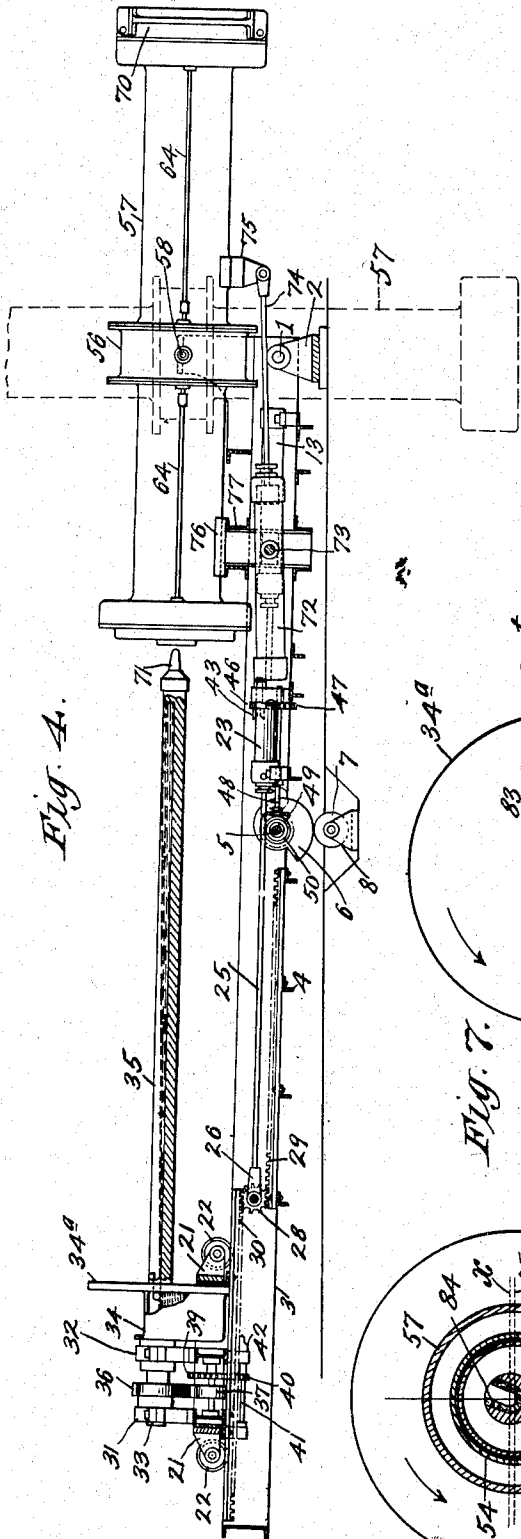


Fig. 4.

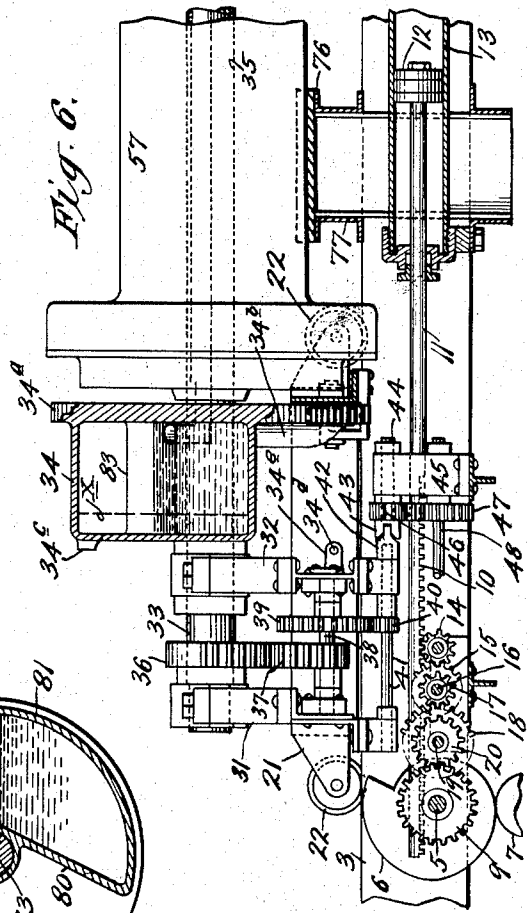


Fig. 6.

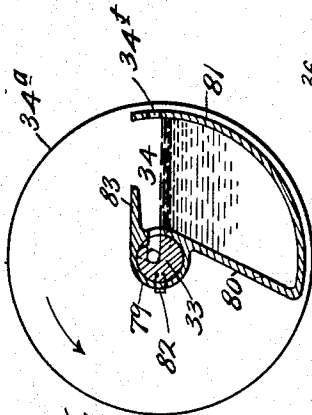


Fig. 7.

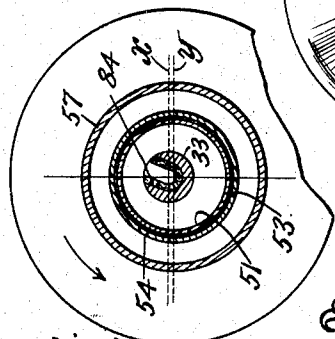


Fig. 8.

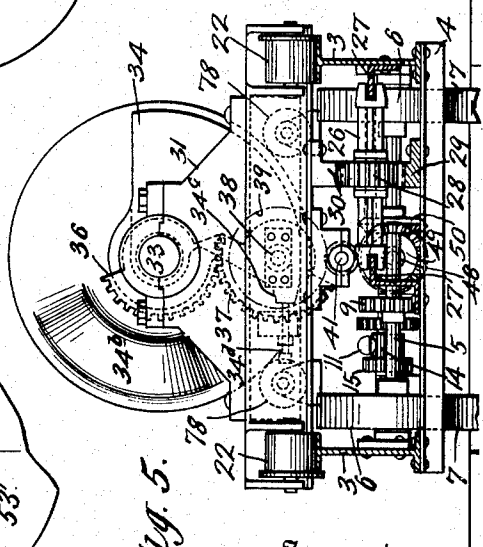


Fig. 5.

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Fig. 9.

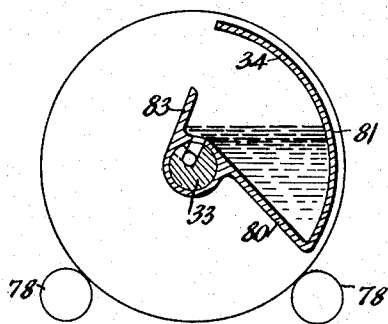


Fig. 10.

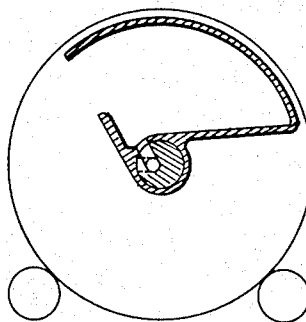


Fig. 11.

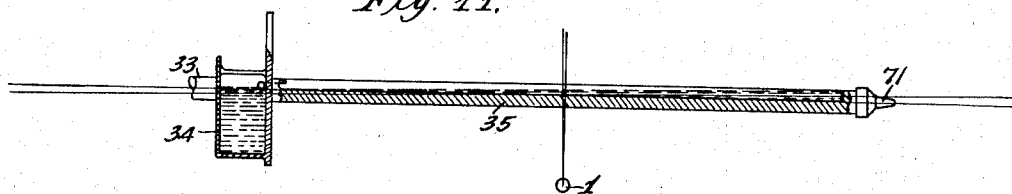


Fig. 12.

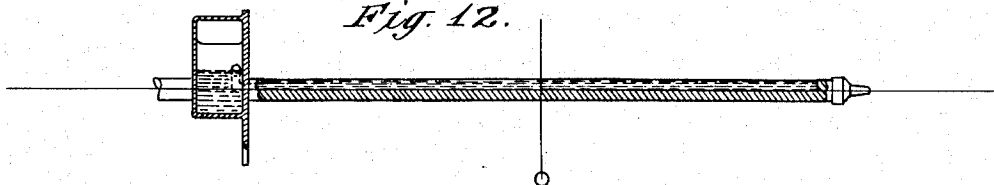
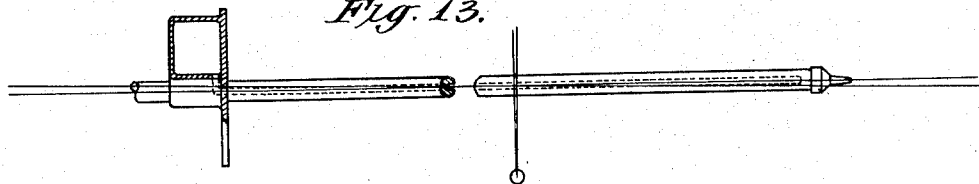


Fig. 13.



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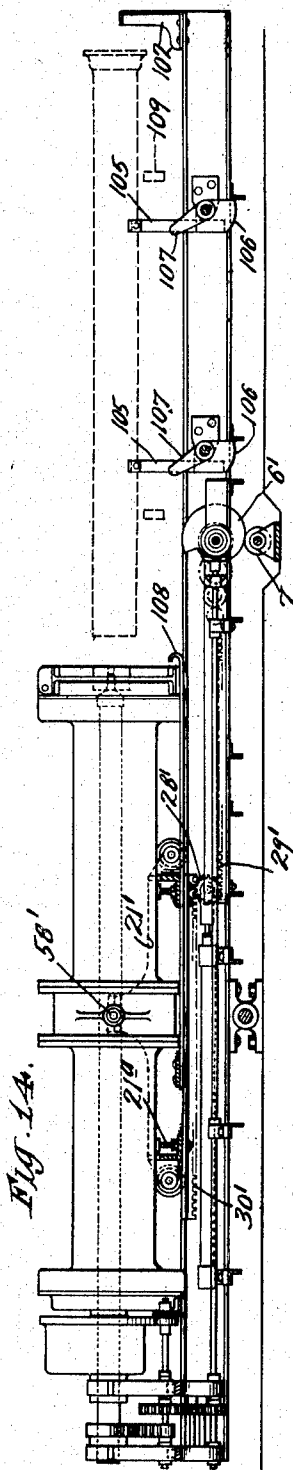


Fig. 14.

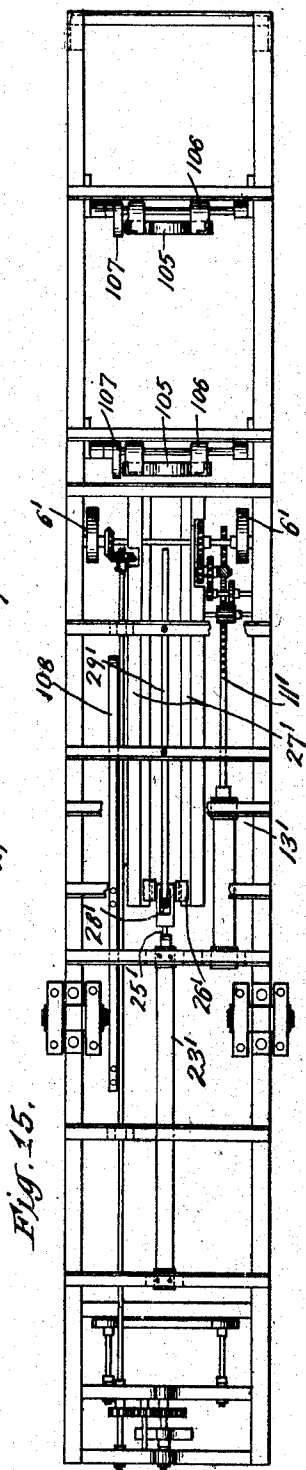


Fig. 15.

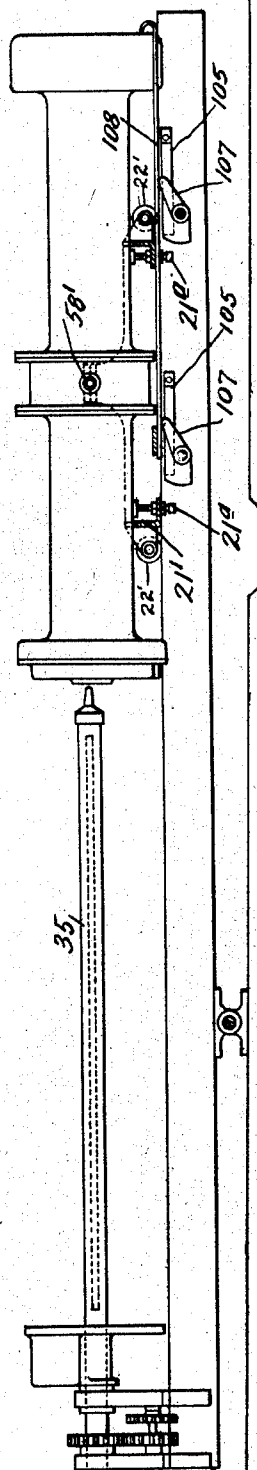


Fig. 16.

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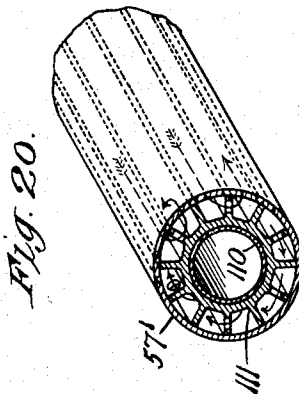
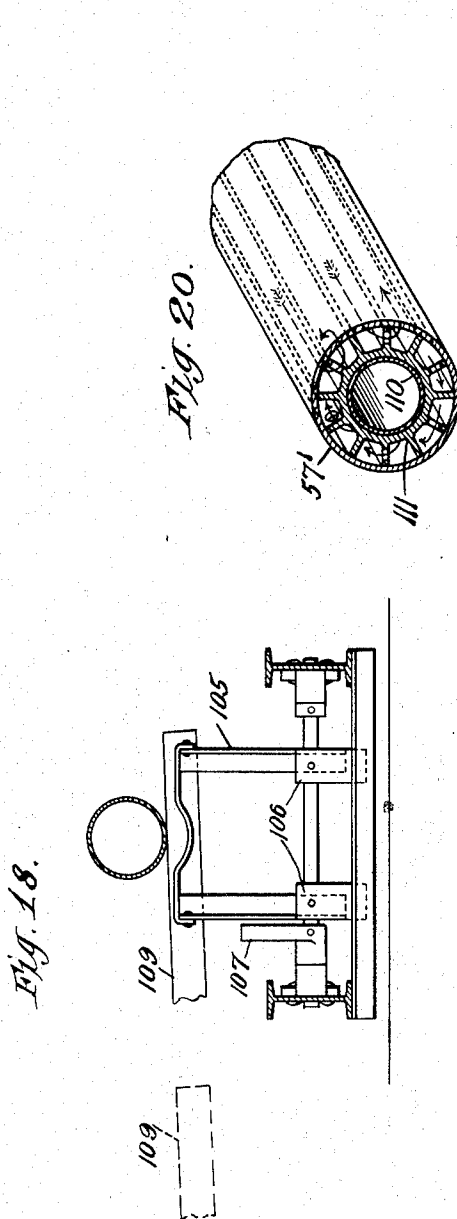
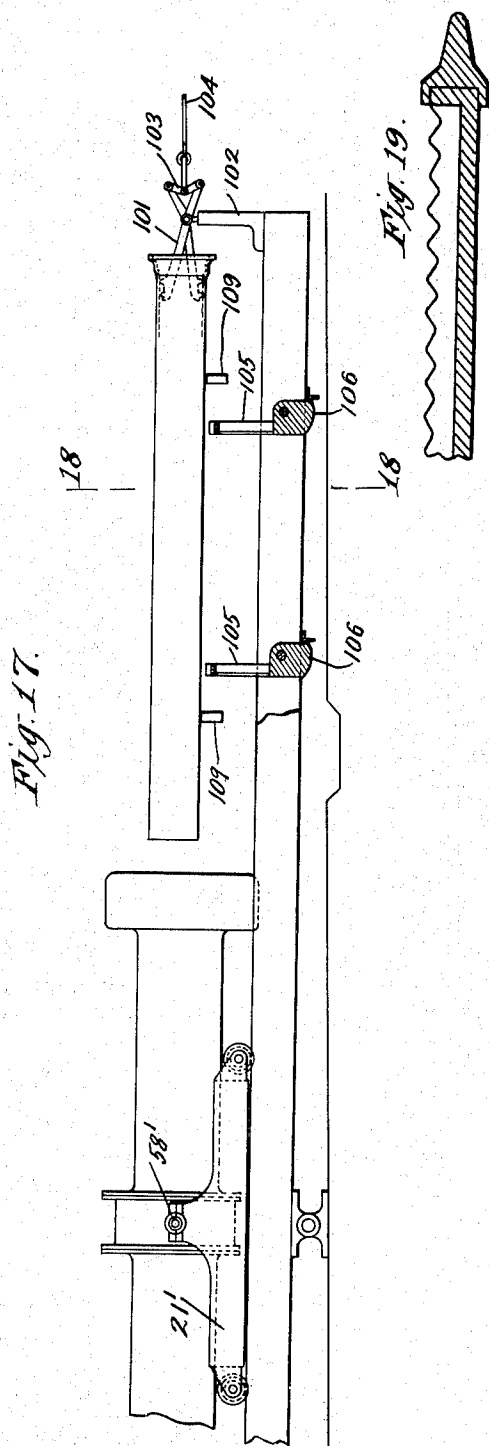
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Filed March 31, 1923

5 Sheets-Sheet 5



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UNITED STATES PATENT OFFICE.

EDWARD DEVOE TOMPKINS, OF NEW YORK, N. Y.

PROCESS OF AND APPARATUS FOR CASTING METAL IN A ROTARY MOLD.

Application filed March 31, 1923. Serial No. 629,074.

To all whom it may concern:

Be it known that I, EDWARD DEVOE TOMPKINS, a citizen of the United States, residing at 17 East 38th Street, New York city, county of New York, and State of New York, have invented certain new and useful Improvements in a Process of and Apparatus for Casting Metal in a Rotary Mold, fully described and represented in the following specification and the accompanying drawings forming a part of the same.

This invention relates to a process of and apparatus for casting metal in a rotary mold.

The object of the invention is to so cast the metal as to keep at a minimum the stresses due to temperature differences in the mold, thereby rendering the mold more durable; to sweep gases from the mold as much as possible so as to avoid the production of blowholes in the casting; to deposit the metal in a series of relatively thin layers coiled one within the other, rather than to deposit the full amount at once, thereby avoiding the rolling of the particles of metal on each other and the trapping of gases which will occur where the metal is deposited at once of the full thickness of the casting, and, finally to deposit the metal as nearly as possible at the place where it is to stay so that there will be a minimum amount of spreading of the metal longitudinally by centrifugal force, because such spreading by centrifugal force, if relied upon to distribute extensively metal deposited with great irregularity, will cause a rolling of the particles and working of the metal which renders the casting non-homogenous and also is likely to cause a considerable trapping of the gases, with consequent formation of blowholes.

A further object of the invention is to provide a durable and highly efficient apparatus, which is capable of simple and rapid operation for the production of annular castings, and particularly those having a considerable length compared with their diameters, as, for example, cast pipes.

A still further object of the invention is to provide a new type of mold member for use in any process of rotary casting.

The invention will first be described in connection with the drawings and then more particularly pointed out.

In the drawings,—

Fig. 1 is a side elevation of an apparatus embodying one part of the invention;

Fig. 2 a bottom plan view of the same;

Fig. 3 a sectional view on the line 3, Fig. 1;

Fig. 4 a side elevation, partly in section, showing the distributor mechanism retracted from the mold;

Fig. 5 a vertical section on the line 5—5, Fig. 3, showing an end view of the carriage and distributor mechanism with the reservoir in position to be filled;

Fig. 6 a detail view partly in section, showing the gearing for tilting and rocking the distributor mechanism;

Fig. 7 a detail sectional view of the reservoir or pot for molten metal in the position when it is about to commence pouring metal into the trough;

Fig. 8 a section on the line 8—8, Fig. 3, with the trough in a position corresponding to Fig. 7;

Figs. 9 and 10 views similar to Fig. 7, showing the pot at its half-emptied position and completely emptied position, respectively; and

Figs. 11, 12 and 13 diagrammatic views illustrating the rocking and tilting of the distributor trough.

Fig. 14 is a side elevation of another embodiment of the invention;

Fig. 15 a bottom plan view of the same;

Fig. 16 a side elevation showing the mold device withdrawn from the distributor;

Fig. 17 a diagrammatic detail view showing the manner in which the cast pipe is withdrawn from the rotary mold in a machine of this kind, and

Fig. 18 a transverse view on the line 18—18, Fig. 17;

Fig. 19 is a detail view on an enlarged scale showing a modified form of trough with a serrated edge;

Fig. 20 is a transverse view showing a modified form of mold device.

Referring to the drawings, and particularly to Figs. 1 to 13 inclusive, there is shown a main frame having trunnions at one end, as indicated at 1, these trunnions being journaled in bearings carried by pedestals 2 secured to suitable foundations. The main frame comprises side members 3 connected by suitable cross members, as in-

indicated at 4, secured to the bottoms of the side members. The main frame carries a suitable cam-shaft 5 suitably journaled in the side members 3. To this cam-shaft 5 are fixed two bearing cams 6 which run in contact with bearing rollers 7 revolubly mounted in pedestals 8 secured to suitable foundations. It will be seen that the main frame is supported by its trunnions 1 and cams 6, and that by the rotation of the cams 6 the main frame will be swung up or down about the axis of the trunnions 1, as indicated by the dotted lines in Fig. 1.

For the purpose of rotating the cam-shaft 5 and its cams 6 to elevate and depress the main frame, the said shaft is provided with a gear-wheel 9 fixed to it, and arranged to be driven by a train of gears, more specifically referred to hereinafter, from a rack 10 driven by a piston rod 11 and piston 12 movable in a cylinder 13. The rack 10 meshes with a pinion 14, in mesh with a gear wheel 15 on a shaft 16 which carries a gear-wheel 17 in mesh with a gear wheel 18 on a shaft 19 which carries a gear wheel 20 in mesh with the gear-wheel 9. The piston 12 is reciprocated in the cylinder 13 as desired, by a suitable pressure fluid, for example, compressed air, which may be admitted to either end of the cylinder through suitable pipes, not shown, as will be fully understood by those skilled in the art.

On the main frame is mounted a mechanism which may be termed the distributor mechanism, as it serves to distribute the charge of molten metal to the mold. This distributor mechanism comprises a carriage 21 having flanged wheels as indicated at 22 arranged to run on the upper faces of the side members 3. For the purpose of moving the carriage along the track, suitable mechanism is provided. In the present example, this consists of a cylinder 23 arranged to receive pressure fluid at either end and provided with a movable piston 24 and piston rod 25. The latter is provided with a cross-head 26, sliding in guides 27 secured to the main frame, and carrying a rotatable gear wheel or idler 28, which meshes with a bottom rack 29 secured, with its teeth upward, to the main frame, and with a top rack 30 secured to the bottom of the carriage 21, with its rack teeth facing downward. By suitably admitting fluid to the proper end of the cylinder 23, while allowing fluid, if any, to exhaust from the opposite end of the cylinder, the carriage may be moved in the desired direction. Furthermore, because of the racks 29 and 30 and the gear wheel 28, the carriage will move twice as far and twice as rapidly as the piston 24.

The carriage 21 carries a plurality of pedestal journal boxes, for example, two, as indicated at 31 and 32, in which is journaled

a main distributor shaft 33. This distributor shaft carries a reservoir or pot indicated at 34 and a distributing trough 35, the latter forming a continuation of the distributor shaft. As the trough must sustain the weight of the molten metal which flows along the trough, it is advantageous to support the reservoir 34 and also to support the trough 35 at its end remote from the reservoir, as will be described hereinafter.

For the purpose of rotating the trough, to a limited extent, about its longitudinal axis, there is provided a suitable operating mechanism. In the present example this comprises a pair of toothed segments in mesh with each other, one being secured to the distributor shaft, as indicated at 36, and the other, 37, being fixed on a carriage shaft 38 journaled in the carriage and provided with a gear wheel 39, which meshes with a gear wheel 40 on a shaft 41 journaled in the lower part of the carriage. The shaft 41 has its forward end provided with a clutch member 42 arranged to detachably engage a coacting clutch member 43 carried by a stub shaft 44 journaled in a pedestal 45 carried by the main frame. On the stub shaft 44 is secured a pinion 46 in mesh with a gear wheel 47 fixed on a shaft 48 carried by the main frame and driven from the cam shaft through a pair of bevel wheels indicated at 49 and 50. Consequently, when the cams 6 are rotated to rock the main frame, the distributor mechanism will be rotated simultaneously to a limited extent, for a purpose more fully explained hereinafter.

The mold mechanism into which the distributing trough 35 extends when the apparatus is in condition for casting, comprises a rotary mold device, an outer shell or mold supporting member, and means for rotating the rotary mold device. The mold device comprises the mold proper which is illustrated in the drawing as a mold for pipe casting. It comprises a straight tubular portion 51 and a bell-mold portion indicated at 52, Fig. 3. An important advantage is attained by making the mold portion 51 of iron cast by the identical process for which the apparatus is to be used but without subjecting it to "annealing" or heat treatment for the elimination of casting stresses, because if any stresses are set up in the cast mold, they will be relieved as soon as the molten metal is poured into such a mold. That is to say, such a mold portion will be normally under certain initial stresses, but will be free therefrom when unequally heated up in use under the identical conditions that caused these initial stresses. This eliminates danger of mold failures due to the fatigue from temperature stresses in molds made of metal not possessing these equal and opposite initial stresses. The parts 51 and 52 are enclosed in an in-

terlining of good heat-conductive material, such as copper, as indicated at 53. The parts 51, 52, and 53 are enclosed in an outer mold-member or mold reinforcing member 54, carried by the mold-supporting member. The mold proper 51, 52, is attached to 54 at the spigot end only, so that it will be free to expand and contract. The object of the heat-conductor 53, is to rapidly transmit temperature differences that may exist throughout the length of the mold proper, so that the heat conducted to the outer mold-member 54 may be more nearly uniform throughout its length. In the particular example illustrated, the mold-supporting member is trunnioned intermediate its ends, so that it, and with it the mold, may be swung to a vertical position, in order to discharge the casting formed in the mold. As shown, the mold-supporting member comprises a trunnion ring 56 and shells 57, the latter being flanged outwardly and secured to the trunnion ring. The shells also are enlarged at the free ends to receive the ball-bearing devices. The trunnion-ring 56 carries trunnions 58 journaled in trunnion-supports 59 secured to the main frame.

Suitable means is provided for rotating the mold within its support. While this rotating means may be constructed in various ways, an important feature of the present invention consists in providing an air-turbine device for rotating the mold. With such a rotating mechanism, the turbine is driven by compressed air, which may be exhausted into the space between the rotary mold and its supporting shells, the exhaust fluid serving to cool the exterior of the mold. In the example illustrated, the compressed air is led to the turbine through one of the trunnions, as indicated at 60, and first enters an annular distributing passage formed in an annular abutment member 61 secured to the trunnion ring. This abutment member is provided with two series of oppositely discharging ports or nozzles, so as to direct the compressed air in opposite directions against a duplex rotor member comprising two turbine rotors 62 and 63 secured to the outside of the rotary mold. Each turbine rotor may be of any desired construction. The exhaust fluid from the two rotors travels to the ends of the shells, cooling the mold on the way. From the ends, the exhaust fluid is led back through pipes 64 to a transverse passage in the trunnion opposite that containing the inlet for the pressure fluid. This passage, indicated at 65, connects with an axial passage to which is connected an exhaust pipe 66. To prevent escape of air through the ball bearings, very thin hardened steel disks 67 are secured to the revolving ball-race devices carried by the mold. These disks 67 are pressed lightly against the ball-race de-

vices carried by the support, which have their faces properly finished to form tight rubbing joints with the disks. By the use of air as a means for moving and cooling the rotary mold all the dangers which could occur with water in case of leakage are avoided.

At the bell-end of the mold is removably secured a core-member 68, whose outer surface is shaped to give the desired configuration to the inner face of the bell of the casting. While this core member 68 may be of any suitable construction, it will be possible to employ a sandcore of the usual type set tightly in the bell portion of the mold, in which case a new core member will be used for each casting. As shown in the drawings, the core-member 68 has a large central opening. This permits the trough member to be journaled above the axis of the rotary mold as explained hereinafter.

To the bell end of the support is detachably secured a cross-member 70 which serves as an out-board bearing for the distributor trough, which is provided with a coned journal device 71, which enters an opening in the cross-member 70. The latter may be detachably secured to the support in any suitable way so as to be readily removed. In the example illustrated, the cross-member has forked ends which receive lugs secured to the support, the forked ends and the lugs having registering holes through which pins are inserted. By driving out the pins the cross-member may be removed.

It is an important advantage of the construction that the trough-member may be mounted with its longitudinal axis parallel to and above the axis of rotation of the mold, thereby increasing the height of fall of the molten metal, and consequently its velocity at the point where it is deposited in the mold. This non-concentric journaling of the mold is possible because the out-board bearing is carried by the mold support, instead of by the mold itself.

In order to swing the mold and its support from a prone to an erect position, indicated in dotted lines in Fig. 4, with the bell-end of the mold downward so as to discharge the pipe from the mold into a suitable pit in the floor (not shown), any desired means for swinging the support may be employed. In the present example a suitable fluid pressure mechanism is used. This comprises a cylinder 72 trunnioned at 73 in the main frame and having a piston and piston-rod, the latter indicated at 74, which is connected to an arm 75 projecting downward from the mold support, as shown in Fig. 1. By admitting a fluid under pressure, as, for example, compressed air to the front end of the cylinder, the mold and its support may be swung into

the erect position, and by admitting the compressed air to the rear of the cylinder while exhausting the air from the front end of the cylinder, the mold and its support
 5 may be swung back to the prone or normal position. When in the latter position, the rear end of the mold support rests in a cradle or shoe 76 carried by girders 77 secured to the main frame, the adjustment
 10 being such that in this position the longitudinal axis of the mold is parallel to the corresponding axis of the main frame.

The distributor pot or reservoir 34 has a peculiar construction which will now be
 15 described. Its wall adjacent the mold is extended to form a flange, indicated at 34^a having a circular periphery which may run on and be supported by anti-friction rollers secured to the carriage, these rollers being
 20 shown in dotted lines at 78, Fig. 5. The metal receiving chamber of the pot or reservoir 34 has one longitudinal wall flat and substantially tangential to the hub of the reservoir while the other longitudinal wall
 25 is curved practically concentric with the hub, as will be clear from Fig. 7, where 79 is the hub, 80 the flat wall, and 81 the curved wall.

In order to assist in counterbalancing the
 30 weight of the reservoir or pot 34 the flange or disk 34^a may carry a counterbalance weight on one face as indicated at 34^b. This is not quite sufficient to overbalance the empty reservoir or pot, and hence the latter,
 35 always tends to swing to a position when a boss 34^c, Fig. 5 will come into contact with the end of an adjustable stop-screw 34^d mounted in a projection 34^e carried by the middle cross-frame member of the carriage.
 40 See Fig. 6. This insures that clutch member 42 will always be in proper position to engage clutch member 43 when the distributor carriage rolls from its position shown in Fig. 4 to the position shown in
 45 Fig. 6.

The reservoir is provided with an overflow opening as indicated at 34^f so that it can readily be filled to the same extent without special care, the surplus running
 50 off through the opening 34^f.

In order that the pot may have its capacity adjusted to adapt it for different charges, according to the thickness of pipe which is to be cast, there may be provided
 55 removable refractory end blocks for the interior of the pot, these blocks having different thicknesses and each being arranged to be inserted in the pot, and when in place, reducing the capacity of the pot. Fig. 6
 60 shows the pot at its maximum capacity, in full lines and the dotted line at x shows how the pot would be shortened and its capacity reduced by an end block filling the end of the pot up to the line x .

65 The distributor shaft 33 extends through

the hub of the reservoir 34 and the latter is secured to the shaft in any suitable way, as, for example, by a key, indicated at 82. The shaft 33 which is a continuation of the
 70 trough is provided with a longitudinal passage arranged to conduct metal from the pot to the trough, this longitudinal passage connecting with a transverse passage opening into the metal chamber of the pot at a point just above the normal level of the
 75 molten metal when the pot is in what may be termed its starting position, as shown in Fig. 7. This discharge opening will, however, be beneath the surface of the metal at all times after casting begins, and hence
 80 will be below any slag layer which floats on the metal, thereby avoiding the clogging of the discharge opening. The pot has a lip 83 projecting from the hub and overhanging the metal to retain the metal as the
 85 pot is tilted.

The trough member 35 may be considered as an extension of the distributor shaft, and in practice may be integral therewith. It is provided with a relatively wide and deep
 90 groove lined with suitable refractory material, such, for example, as carborundum, this lining being indicated at 84, Fig. 8. In Fig. 4, which shows the distributor mechanism withdrawn from the mold, the pot and trough are shown as containing
 95 molten metal, at that stage where a further rotation of the pot and trough will start the pouring of the metal. In practice, of course, there will be no molten metal in the trough and pot when the latter are withdrawn from the mold.

In the present embodiment of the invention the longitudinal axis about which the trough member tilts to discharge the molten metal is parallel to and somewhat above the axis of rotation of the rotary mold. This is indicated in Fig. 8 where the dotted line
 100 x indicates the horizontal plane containing the longitudinal axial line of the trough and the dotted line y indicates horizontal plane containing the axis of rotation of the mold. Furthermore, in this embodiment the vertical plane through the axis of the trunnions 1 of the main frame intersects the trough
 105 about at the middle of the length of the trough. The movement of the trough about this transverse axis, will be termed the rocking of the trough. In the starting position, the trough and mold incline downward at the front end, and during the casting operation the trough and mold move to the horizontal position and then gradually change their common inclination until at the finish of the casting operation they incline downward, toward the rear end. This will be clear from Figs. 11, 12 and 13. In practice the extreme inclinations of the trough to the horizontal will be equal in both directions. Furthermore, it is advantageous to
 110

give the trough a uniform angular rocking motion from start to finish. The trough tilts to pour the metal in such a manner that the direction of flow of the stream of molten metal will be transverse to the axis of rotation of the mold, that is to say, the trough pours sidewise. The angular movement of the trough in tilting is such that it extends each side of the vertical but not to equal extents. In the construction shown in the drawings, the trough tilts to pour in a counter-clockwise direction viewed from the reservoir end and, of course, the rotary mold rotates in the same direction. The arrangement is such that the trough will tilt through a slight angle toward the vertical when first receiving its charge and at the time of reaching the vertical will be filled with molten metal just ready to overflow, so that as the trough tilts further in the same direction it commences to pour the metal into the mold.

It is advantageous to provide sufficient clearance for the fall of the molten metal from the trough to the place where the metal is deposited in the rotary mold, so that the molten metal may acquire a high velocity in the general direction of the tangent to the mold surface where the molten metal is deposited. The higher the velocity of fall the less work must be done by the rotary mold in getting the molten metal up to the velocity of the rotary mold, and therefore the less dragging or rolling of the metal occurs. For these reasons, there is an advantage in placing the trough with its tilting axis higher than the axis of rotation of the mold. That is, with the greater clearance between the trough and the mold at the bottom, the molecules of molten metal falling in planes transverse to the axis of rotation of the mold and as nearly tangential to the inside of the mold as is practicable, will have ample clearance to gather momentum and revolve with the same angular velocity as the mold, if not already moving with that velocity at the time of contacting with the mold. The diameter of the trough should be as large as the interior diameter of the mold and the above mentioned clearance will permit.

The reservoir or pot 34 is of such size that it will have a capacity at least equal to the volume of the article to be cast. Also, in the starting position, it will contain this full charge without any of its contents flowing through the discharge orifice to the trough. It must be tilted through a slight angle before this flow commences, and then through a still further angle before the molten metal has flowed into and filled the lower end of the trough to a height when it is just at the point of overflowing the lip of the trough at the extreme end. At this moment the plane of symmetry of the trough

should be vertical and should contain the axis of rotation of the mold and the axis of tilting of the trough. Soon after the reservoir or pot starts to tilt, the molten metal therein covers the discharge orifice, which from that time on is below the level of the molten metal. This insures that the orifice will not be clogged by slag, which, as it floats on the molten metal, is kept away from the orifice very soon after the tilting of the reservoir commences. The passage from the discharge orifice to the trough is so sloped that it will drain off all the molten metal when the trough has tilted 90 degrees.

In order to prevent the molten metal from overflowing at the end of the trough or sloping over on the right hand side of the trough (viewed from the reservoir end) the end and said right hand side either for its full length or at least near the front end may be made higher than the left hand side which serves as the discharge edge or lip of the trough.

The shape of the reservoir chamber for receiving molten metal is such that it will maintain about the same head of metal during the tilting of the reservoir and trough until near the end of the pouring operation. Furthermore, the shape and capacity of this reservoir chamber, in the best embodiment of the invention, is such that when the trough has rocked to its mid-position the reservoir chamber will still contain nearly one half the charge to be cast. Theoretically the contents should be one half the charge to be cast minus the amount of metal which was required to fill the trough.

Assuming the apparatus in condition for casting, with its rotary mold rotating at the proper speed, a charge of molten metal is supplied to the pot or reservoir 34. At this time the main frame, and consequently the trough and the rotary mold, slope downward toward the front of the machine, and the front end of the trough is tilted away from its poring position so that its right hand edge, viewed from the reservoir end of the trough, will be lower than the left hand edge. See Fig. 8. The charge of molten metal in the reservoir chamber is not quite sufficient to cause the molten metal to overflow through the discharge orifice of the pot, but should be approximately up to that level. Compressed air is now admitted to the front end of the cylinder 13 which forces out the rack 10 and through the gearing rotates the cam-shaft 5 and thereby also rotates the distributor shaft 33 to tilt the pot or reservoir 34 and trough 35. This causes the molten metal to be discharged through the discharge orifice to the trough down which it flows until it reaches the lower front end of the trough. It then rapidly accumulates at this lower end, until by the

time the trough has tilted in the direction of the arrow, Fig. 8, to a position where the plane of symmetry of the trough is vertical, the lower end of the trough is filled just ready to overflow. During this time the cams 6 have been revolving in contact with the rollers 7, but this part of the periphery of each cam is circular so that the main frame has not lifted and hence no rocking of the trough about its transverse central axis has occurred. From this point on, however, the periphery of each cam 6 is such as to lower the back end of the main frame at a uniform rate, thereby rocking the trough toward a position where the discharge side will be horizontal. During this rocking action the trough is tilting to pour the molten metal. The stream will first overflow at the extreme front end of the trough as a narrow and thin stream, and will first increase in thickness at the front end while also widening, so that the cross-section of the stream will be triangular. As the rocking and tilting of the trough tends to widen the stream further, the thickness of the stream at its maximum point, viz, at the front end of the trough, gradually reduces. Eventually, the width of the stream will be about equal to the length of the discharge edge of the trough. Then the stream commences to change from triangular cross section to a cross-section which may be considered as a truncated triangle or a triangle with a rectangle extending from its base. At what might be termed the true mid-overflow position of the trough the discharge lip will be truly horizontal and the stream will be truly rectangular in cross-section. From this point onward, the trough, while still tilting in pouring, will rock further so that the front end rises and the rear end lowers so that the stream of molten metal is thickest at its rear end. With the continuation of the rocking and tilting movement, the stream becomes triangular in cross-section, and then gradually narrows while first increasing in thickness and then decreasing until eventually all the metal has been poured.

During the pouring of the metal the mold has been revolving at a rate such that the molten metal is deposited in layers one within the other, the metal, of course, uniting to form a coherent mass.

In casting pipes, the bell-mold will receive a portion of the metal first poured, this portion being caused to flow into the bell-mold by centrifugal force until said bell-mold is filled, after which the metal is deposited wholly in the pipe body mold.

It is to be noted that most of the molten metal is deposited during the time that the stream has its maximum width, and during this interval the total thickness of metal deposited is uniform in every plane per-

pendicular to the axis of rotation of the mold. This is true because the triangular portion of the cross-section of the stream, taken at any interval when the trough is tilted downward toward the front end, is identical in size, but reversely arranged, with relation to the triangular portion of the cross-section taken at the corresponding opposite slope of the trough where its rear end is lowest. The only variation from this uniformity is at the beginning of pouring before the stream has reached a width equal to the length of the discharge lip of the trough, and toward the end of the operation after the stream has narrowed below such width. The extra metal at the first of the pouring operation is used in part to form the bell, and the extra metal at the last must be distributed by centrifugal force. Since the principal part of the metal is deposited so as to form a uniform thickness, it is deposited practically at the place where it is to stay, and hence, there is little or no distributing of this metal by centrifugal force after it is deposited in the mold. Therefore, there is less opportunity for the trapping of gases and the formation of blow-holes. The result is a more nearly homogeneous product.

It will be noted that the cams 6 may have their peripheries modified as may be necessary to rock the trough in various ways to vary the manner of pouring the metal as may be required.

When all the metal has been poured from the pot and trough, the trough may be tilted back to its starting position, and the carriage run back on the main frame to retract the trough from the mold. The main frame, of course returns to its starting position simultaneously with the return of the trough to the starting position.

When the carriage has been retracted, the cross-member 70 is removed, the sand-core 68 is broken out, and then the mold and its support are swung to a vertical position to discharge the pipe from the mold. Then the mold and its support are swung back to the normal position, a new core-member is inserted at the bell-end of the mold, the cross-member 70 is replaced and the carriage returned to the normal position for casting, whereupon the apparatus is ready for another operation.

It is obvious that when the carriage moves away from the mold, the clutch members 42 and 43 disengage, and when the carriage returns to normal operative position the said clutch members will again engage with each other.

The manner of operating the apparatus by the admission of compressed air to the proper ends of the respective ram cylinders and the corresponding exhaust from the opposite ends of said cylinders will be obvious

to those skilled in the art, from the drawings and the description hereinbefore given.

In Figs. 14 to 18 of the drawings is illustrated another embodiment of the invention which is particularly advantageous in some situations, as it does not require a pit to allow the mold device to be swung vertically for the discharge of the pipe.

In this embodiment the distributor mechanism does not travel along the frame, but is mounted at one end thereof. The mold device, however, is mounted on a carriage which travels along the frame so as to withdraw the mold device from the distributor mechanism, as will appear from Fig. 16.

The frame instead of being trunnioned at the front end as in the structure shown in Figs. 1 to 13 is trunnioned towards its rear end, about one third the length of the frame from said rear end. The cam mechanism for raising and lowering the frame is located toward the front end of the frame, and preferably about one third the length of the frame from said front end. The cams are reversed as compared with those employed in the first described construction; that is, at starting, the minimum radius of each cam 6' is in contact with its pedestal roller 7 and at the finish of the casting operation the maximum radius of each cam contacts with its roller.

The mechanism for operating the cam shaft is the same as that in the first embodiment of the invention with the exception that the ram cylinder is rearward from the cam shaft instead of forward of it and consequently has its piston-rod projecting from the cylinder in the correspondingly opposite direction. In Fig. 15 the ram cylinder is shown at 13' and the piston rod at 11'.

The mold member is mounted on trunnions as indicated at 58' which are journaled in a carriage 21' having flanged wheels or rollers 22' rolling on the top surface of the side rails of the main frame. The mold member is trunnioned on the carriage merely to allow the adjustment of the mold member into parallelism with the track of the main frame. To permit this adjustment and at the same time to hold the mold member rigidly when adjusted, suitable adjusting mechanism is provided between the carriage and the mold member as, for example, the adjusting screws 21^a, Fig. 16, which are provided with suitable lock nuts. The carriage 21' which supports the mold member is moved along the track by mechanism similar to that used for moving the distributor in the first embodiment of the invention, and hence needs no special description. The corresponding racks are shown at 29' and 30'. The ram cylinder 23' is located along the longitudinal central axis of the frame and has the piston rod 25', cross-head 26'

and gear wheel 28'. The guides for the cross-head are shown at 27'.

In this embodiment of the invention, when the casting has been made, the mold member is run toward the front end of the frame. The member 70 which supports the front end of the trough member is removed, the core for the bell of the pipe is withdrawn or broken away, and a suitable holding device is secured to the pipe. In Fig. 17, this holding device comprises a pair of pivoted arms 101 whose pivot device is arranged to rest on the top end of a standard 102 secured to the main frame. The jaws of the pivoted arms are expanded to hold the pipe by means of toggle members 103 arranged to be pulled in the proper direction by a rod or cable indicated at 104 which may be pulled by suitable mechanism, not shown, or by hand.

When the pipe is thus secured, the mold member may be run backward to its normal casting position, thereby, freeing itself from the pipe, which drops onto a pair of swinging trestles, as indicated at 105, Fig. 14. These trestles are pivoted to the main frame and have counter weights 106, which tend to hold them upright. The upper member of each trestle is cranked downward to form a recess in which the pipe can lie, as shown in Fig. 18. Each swinging trestle is also provided with a crank arm 107 arranged to be struck by a striker bar indicated at 108, Figs. 14 and 16 whose front end is upturned or rounded. As the mold member is run forward, the striker bar hits the crank arms of the swinging trestles and thereby swings the latter out of the way of the mold member. When the mold member moves backward the trestles swing up into position to receive the pipe. The pipe may be removed from the swinging trestles in any suitable way as for example, by projecting a pair of slightly inclined rails 109 beneath the pipe and then lowering the front end of the frame so that the trestles will be lowered and the pipe left supported by the rails, as shown in Figs. 17 and 18. Although the holding device is shown in place in the pipe in Fig. 17, it will be understood that this holding device will be freed from the pipe and removed just before the pipe is shifted from the trestles to the rails. Consequently, the pipe is free to roll down the rails to one side of the apparatus.

In Fig. 19 is shown a portion of a trough having a pouring lip of special construction suitable for pouring metal when a very thin layer is to be deposited, as for example, when very thin pipes or the like are to be cast. In this case the lip is wavy or serrated so that the molten metal will be poured in separate streams, rather than in one integral stream, as hereinbefore described.

In Fig. 20 is shown in cross section a modified form of mold member. The mold proper, indicated at 110, is fitted into a member 111 having a series of longitudinal ribs, as shown. These ribs reach to the outer shell 57' of the mold member and divide the air jacket space into a plurality of channels for the cooling air. This materially increases the cooling surface of the mold. Where a lesser degree of cooling will suffice, the cooling air may travel in one direction through alternate passages, and return through the intermediate alternate passages, as will be fully understood by those skilled in the art.

In all the embodiments of the invention it is important to have the mold proper or inner wall member which receives the molten metal, for example, the mold portion 51, Fig. 3, or 110, Fig. 20, removable from the remainder of the mold device, so that said inner wall member may be readily replaced. Hence, in case the inner wall member or mold proper becomes scored or eroded or otherwise injured so that it is no longer satisfactory, it may be withdrawn and replaced by a new inner wall member, with a minimum of expense and delay. As the mold portion is secured only at its spigot end, as for example, by radial set-screws or the like carried by the mold-reinforcing member 54, Fig. 3, it is relatively easy to remove and replace said inner wall member. The bell-mold portion 52, Fig. 3, may also be readily removed and replaced, preferably being secured to the member 51, in any suitable way; as by radial set-screws, so that when the member 51 is released the two members, 51 and 52, may be forced out of the members 54 in a forward direction, that is, toward the front end of the apparatus.

What is claimed is:

1. The process of casting metal into a rotary mold, which consists in pouring the molten metal into the mold in a stream flowing transverse to the axis of rotation of the mold, starting said stream as a narrow stream at one end of the mold and gradually widening the stream toward the other end of the mold until the stream has a width substantially equal to the length of the mold, and at a subsequent period of the casting, narrowing the stream from the starting end of the mold toward the other end, and finally terminating the stream at said other end.

2. The process of casting metal into a rotary mold, which consists in pouring the molten metal into the mold in a stream flowing transverse to the axis of rotation of the mold, starting said stream as a narrow stream at one end of the mold and gradually widening the stream toward the other end of the mold until the stream has a width substantially equal to the length of the mold,

maintaining the stream at this width during a substantial portion of the casting time, then narrowing the stream gradually from the starting end of the mold toward the other end, and finally terminating the stream at said other end.

3. The process of casting metal into a rotary mold, which consists in pouring the molten metal into the mold in a stream flowing transverse to the axis of rotation of the mold, starting said stream as a narrow stream at one end of the mold and gradually widening the stream toward the other end of the mold until the stream has a width substantially equal to the length of the mold, maintaining the stream at this width during at least half the casting time, then narrowing the stream gradually from the starting end of the mold toward the other end, and finally terminating the stream at said other end.

4. The process of casting metal into a rotary mold, which consists in pouring the molten metal into the mold in a stream flowing transverse to the axis of rotation of the mold, starting said stream as a narrow stream at one end of the mold and gradually widening the stream toward the other end of the mold until the stream has a width substantially equal to the length of the mold, maintaining the stream at this width while varying its thickness from a maximum at the starting end and a minimum at the opposite end to a minimum at the starting end and a maximum at the other end while maintaining the cross sectional area of the stream substantially constant, then narrowing the stream gradually from the starting end of the mold toward the other end, and finally terminating the stream at said other end.

5. In a rotary casting machine, the combination, with a rotary mold, of a distributor comprising a trough arranged to project into the rotary mold and having one side arranged to serve as a discharge lip to discharge molten metal in a stream transverse to the axis of rotation of the mold, said discharge lip being substantially the length of the casting to be made, means for tilting the trough to discharge the molten metal as a stream, and means for simultaneously rocking the trough to determine the width of the stream.

6. In a casting machine, the combination, with a rotary mold, of a distributor comprising a trough arranged to project into the rotary mold and having one side arranged to serve as a discharge lip to discharge molten metal in a stream transverse to the axis of rotation of the mold, said discharge lip being substantially the length of the casting to be made, means for tilting the trough to discharge the molten metal as a stream, and

cam mechanism for rocking the trough to determine the width of the stream in a manner determined by the cam.

7. In a casting machine, the combination, with a mold-support mounted for angular-rocking motion about an axis transverse to its length, and a mold rotatably mounted in the mold support, of a trough arranged to extend into the rotary mold and having one side arranged to serve as a discharge lip to discharge molten metal in a stream transverse to the axis of rotation of the mold, means for simultaneously rocking the mold-support, the mold, and the trough, and means for simultaneously tilting the trough to discharge the molten metal.

8. A casting machine comprising a frame arranged for angular movement up and down about an axis transverse to the length of the frame, a mold-support mounted on said frame, a rotatable mold within said mold support, means for rotating the mold, a distributor trough arranged to project into the rotary mold, said trough being supported by the frame and arranged to tilt about an axis parallel to the axis of the rotary mold, said trough having one of its sides arranged to serve as a discharge lip, means for simultaneously giving the frame an angular movement up and down, and means coacting therewith for tilting the trough to discharge the molten metal.

9. A casting machine comprising a frame arranged for angular movement up and down about an axis transverse to the length of the frame, a mold support arranged to rock with the frame, a rotatable mold within said mold support, means for rotating the mold, a distributor trough arranged to project into the rotary mold, said trough being supported by the frame and arranged to tilt about an axis parallel to and higher than the axis of the rotary mold, said trough having one of its sides arranged to serve as a discharge lip, means for simultaneously giving the frame an angular movement up and down whereby the mold support is correspondingly rocked on its trunnions, and means coacting therewith for tilting the trough to discharge the molten metal.

10. A casting machine comprising a frame arranged for angular movement up and down about an axis transverse to the length of the frame, a mold support, having trunnions whose axes are in line and parallel to the said transverse axis of the frame, a saddle carried by the frame arranged to contact with the rear end of the mold support, a rotatable mold within said mold support, means for rotating the mold, a distributor trough arranged to project into the rotary mold, said trough being supported by the frame and arranged to tilt about an axis parallel to the axis of the rotary mold, said trough having one of its sides arranged to

serve as a discharge lip, means for giving the frame an angular movement up and down about its axis, thereby rocking the mold support and mold, and means coacting with the frame-moving means for tilting the trough to discharge the molten metal.

11. In a casting machine, the combination, with a frame arranged for angular movement up and down about an axis transverse to the length of the frame, a carriage arranged to move along the frame in the direction of the length of the frame, a distributor mechanism revolubly mounted in the carriage and comprising a trough, one side of which serves as a discharge lip whose length is approximately equal to the length of the casting to be made, a mold support arranged to rock when the frame is moved, and a rotary mold mounted within the mold support, of means for rotating said mold, means for rocking the frame about its axis, and means for giving the distributor mechanism a partial revolution to tilt the trough.

12. In a casting machine, the combination, with a frame arranged for angular movement up and down about an axis transverse to the length of the frame, a carriage arranged to move along the frame in the direction of the length of the frame, a distributor mechanism revolubly mounted in the carriage and comprising a trough one side of which serves as a discharge lip whose length is approximately equal to the length of the casting to be made, and a mold support arranged to rock with the frame, of a rotary mold mounted within the mold support, means for rotating said mold, means for rocking the frame about its axis, means for giving the distributor mechanism a partial revolution to tilt the trough, and means for moving the carriage along the frame.

13. In a casting machine, the combination, with a frame arranged for angular movement up and down about an axis transverse to the length of the frame, a carriage arranged to move along the frame in the direction of the length of the frame, a distributor mechanism revolubly mounted in the carriage and comprising a trough one side of which serves as a discharge lip whose length is approximately equal to the length of the casting to be made, means carried by the carriage for transmitting rotary motion to said distributor mechanism, said transmitting means comprising one member of a clutch, an operating mechanism mounted on the frame and provided with a clutch member arranged to coact with the clutch member on the carriage, said clutch members being separable, and a mold-support arranged to rock with the frame, of a rotary mold mounted within the mold support, means for rotating said mold, means for rocking the frame about its axis, means for simultaneously rocking the mold support

about the axis of its trunnions, means for giving the distributor mechanism a partial revolution to tilt the trough, and means for moving the carriage along the frame.

- 5 14. In a casting machine, the combination, with a rotary mold, and a distributor comprising a trough arranged to project into the rotary mold and having one side arranged to serve as a discharge lip to discharge molten metal in a stream transverse to the axis of rotation of the mold, and a reservoir arranged to discharge molten metal into the trough, means for simultaneously tilting the trough and the pot, of means for simultaneously rocking the trough, and means for withdrawing the trough from and returning it to its position in the mold, substantially as described.

- 15 15. In a casting machine, the combination, with a rotary mold, of a distributor comprising a pot and a trough arranged to project into the rotary mold and having one side arranged to serve as a discharge lip to discharge molten metal in a stream transverse to the axis of rotation of the mold, said pot being connected to move with the trough and being arranged to pour metal into one end of the trough, means for simultaneously tilting the trough and the pot, and means for simultaneously rocking the trough.

- 20 16. In a casting machine, the combination, with a rotary mold, of a mold support in which said mold is mounted, and an elastic fluid turbine mounted between the support and the rotary mold, said turbine having its rotor member secured to the mold, and its abutment member secured to the support, substantially as described, the dis-

charge outlet of said turbine being arranged to discharge the exhaust fluid in contact with the exterior surface of the mold cool the same.

17. In a casting machine, the combination, with a rotary mold, of a mold support in which said mold is mounted, said support forming a cooling jacket for the mold, and an air turbine mounted centrally of the support and mold and between the two, said air turbine being arranged to rotate the mold, the discharge openings from said turbine being so arranged as to discharge the air in opposite directions through the cooling jacket space, substantially as described.

18. In a rotary casting machine, a mold member to receive and give form to the molten metal, said mold member consisting of an unannealed rotary-cast casting.

19. In a casting machine, the combination, with a rotary mold, of means for pouring a plurality of streams of molten metal into said mold at different places along the length of the mold, means for rocking said pouring means whereby the commencement of the respective streams will be non-simultaneous and the terminations of the respective streams will also be non-simultaneous and means for rotating said mold.

20. In a casting machine, the combination, with a rotary mold, and means for rotating the same, of a trough member having a serrated edge constituting a discharge lip, means for rocking the mold and trough member, and means for tilting the latter.

In testimony whereof, I have hereunto set my hand.

EDWARD DEVOE TOMPKINS.