

March 12, 1940.

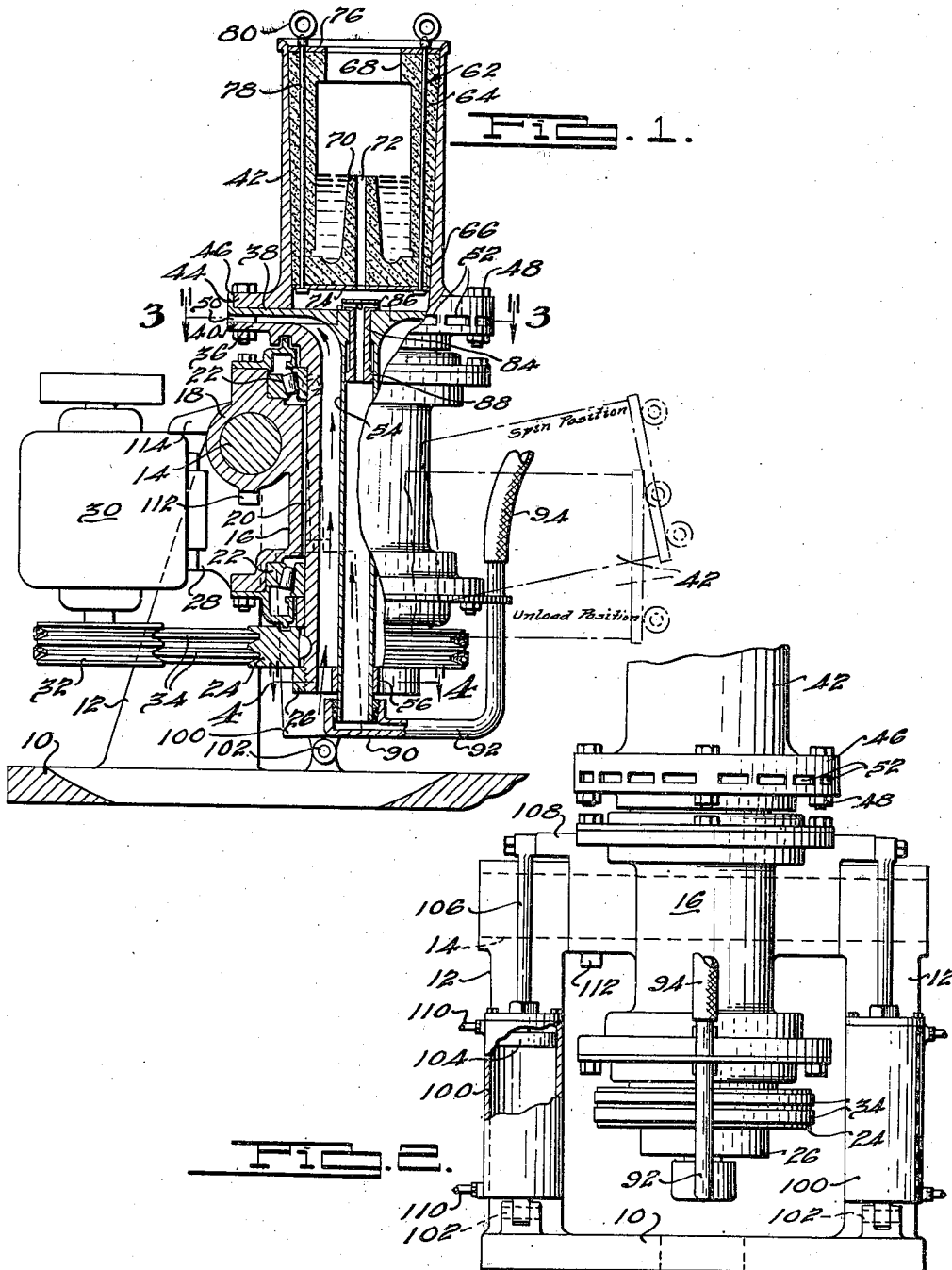
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2,193,537

CENTRIFUGAL CASTING METHOD

Filed Nov. 13, 1937

2 Sheets-Sheet 1



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2 Sheets-Sheet 2

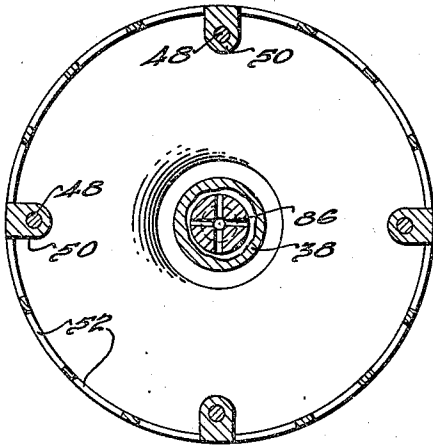


FIG. 3.

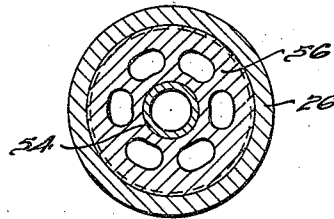


FIG. 4.

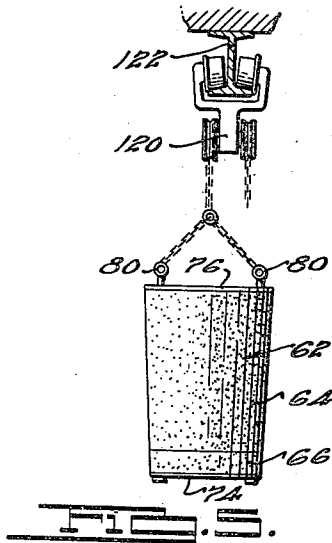


FIG. 5.

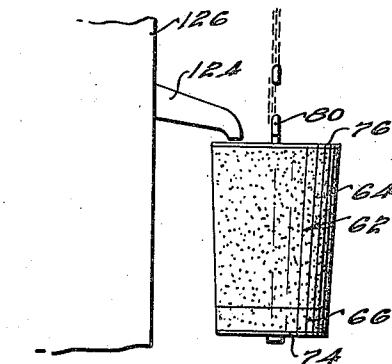


FIG. 6.

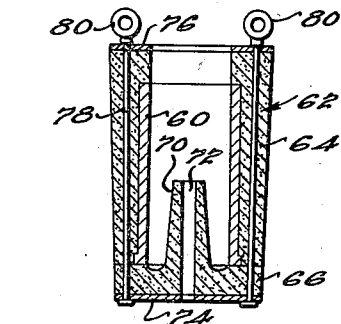


FIG. 7.

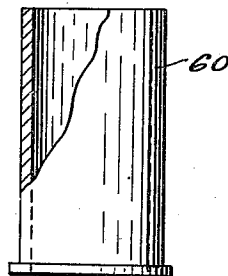


FIG. 8.

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CENTRIFUGAL CASTING METHOD

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Application November 13, 1937, Serial No. 174,296

1 Claim. (Cl. 22—200)

This invention relates to the centrifugal casting of molten metal, to certain novel steps of operation in the centrifugal casting of molten metal.

5 Objects of the invention include a method of centrifugally casting molten metal by means of a mold which acts to measure its own charge; the method of centrifugally casting in which the molten metal is first introduced into the mold and the mold is then introduced into the molding machine and spun; the method of centrifugally casting a hollow body comprising conveying a mold to a cupola, furnace, ladle, or other source of supply, filling the mold with a predetermined amount of metal at such source, and then conveying the mold directly to the casting machine, inserting the mold in position in the machine and then causing the mold to be spun by the machine; the method of centrifugally casting a metallic article including forming a peripherally unsupported mold, charging the mold with molten metal, inserting the charged mold into a centrifugal molding machine and then causing the mold to be spun in the machine while peripherally supported thereby; the method of centrifugally casting a hollow article including the steps of charging a mold while in approximately vertical position, spinning the mold, moving the spinning mold to a position with its axis substantially out of perpendicular and continuing the spinning of the mold until the molten contents thereof have solidified; and the method of centrifugally casting a hollow article including the steps of charging a mold with molten metal, placing said mold with its axis vertical in the molding machine, setting said mold in rotation while its axis is in vertical position, and then moving said spinning mold to bring its axis out of vertical position and continuing the spinning of the mold in the last mentioned position until its molten contents have solidified.

In the accompanying drawings which illustrate a suitable embodiment of the present invention and in which like numerals refer to like parts throughout the several different views:

Figure 1 is a partially broken, partially sectioned side elevational view of a centrifugal molding machine constructed in accordance with the present invention;

Figure 2 is a fragmentary, partially broken front elevational view of the machine shown in Fig. 1;

Fig. 3 is an enlarged transverse sectional view taken on the line 3—3 of Fig. 1;

Fig. 4 is an enlarged transverse sectional view taken on the line 4—4 of Fig. 1;

Fig. 5 is a more or less diagrammatic view illustrating one of the molds for the machine shown in the previous figures suspended by means of a chain fall from an overhead mono-rail track;

Fig. 6 is a more or less diagrammatic view illustrating a mold suspended in the manner illustrated in Fig. 5 in the position it assumes when being charged with molten metal from a cupola or furnace;

Fig. 7 is a sectional view taken axially through a mold such as shown in Figs. 5 and 6 after a part has been cast therein;

Fig. 8 is an enlarged partially broken, side elevational view of the part shown cast in the mold in Fig. 7.

As is generally understood in the art it is customary practice in connection with the centrifugal casting of metals and particularly where the article to be cast has a material axial dimension as compared to its diameter, to position the mold with its axis in horizontal or substantially horizontal portion, and a machine is provided to support and to rotate it while in such position. Particularly where such machines are used in quantity production, in order to conserve metal and to limit the amount of machining required to bring the article to finished condition after casting, it is necessary to carefully predetermine the charge of metal which is to be placed in the mold and to be distributed around the inner walls thereof by centrifugal force during the actual casting operation. In accordance with conventional practices molten metal in a cupola or furnace is tapped into a relatively large ladle, an estimated desired quantity of the metal is then poured into a smaller or pouring ladle, the smaller ladle and its contents are hurriedly weighed and metal is either added or discharged from the pouring ladle until approximately the required amount remains therein, the pouring ladle is then transported to the centrifugal casting machine, and the molten metal is then poured from the pouring ladle through a pouring spout into the interior of the mold which has previously been set in rotation. Thus in conventional practice the metal has an opportunity to cool while it is in the large ladle, also when it is in the small pouring ladle, and also when it passes through the pouring spout into the mold. Considerable time elapses in conventional practice between the time the metal is actually discharged from the cupola or furnace before it enters the mold and, accordingly, loses a considerable amount of its heat before it is finally in the position to be acted upon by centrifugal force in the mold proper.

Particularly the small or pouring ladle and the spout leading to the mold proper are relatively cold and contact with these is responsible for a considerable loss of heat in the molten metal. It will be realized that the maintenance to the proper heat of the molten metal is important in centrifugal casting operations if a final product of a desired high quality and texture of material is to be obtained and, accordingly, any loss of heat because of the above mentioned reasons is important.

In filling the pouring ladles and attempting to weigh them to obtain an accurate amount of metal therein, the need for speed in getting the molten metal into the mold is so great that the actual error in the final charge in the mold varies considerably, with the result that an undesirable variation in the thickness of the final product is common and results in a disadvantage in the subsequent machining operation which the article cast must usually undergo. Attempts at more accurately weighing the molten metal to be charged has usually resulted in an excessive heat loss from the molten metal resulting in the formation of blow holes and the like in the final product more detrimental than the variation in thickness of the same.

The present invention is designed to avoid the above described difficulties in the prior art. The avoidance of excessive heat loss of the molten material is accomplished preferably by filling the centrifugal molds directly from the cupola or furnace although they may be charged from a relatively large ladle. In carrying out this feature of the present invention it will be realized that it eliminates at least the heat loss occurring in conventional practices in the pouring ladle and in the pouring spout, the bulk of any heat lost by the molten metal being transferred directly to the mold which is a necessary loss in any case and this, accordingly, aids in conserving the heat in the metal between the time it is actually poured and the time at which it is subjected to centrifugal force.

In accordance with a further phase of the present invention in order to accurately predetermine the charge of metal in the mold in a quick and accurate manner, the mold is so constructed and arranged as to predetermine the amount of metal which may be charged into it. This is accomplished by so constructing and arranging the mold as to provide it with an overflow means which becomes effective when a predetermined amount of metal has been introduced into the mold. By this means the mold is charged with molten metal until the molten metal begins to be discharged from the overflow at which time the charging is discontinued with the assurance that the amount of metal remaining in the mold accurately coincides with the mass desired therein. In carrying out the last mentioned step it will usually be found desirable to fill the mold when the mold is positioned with its axis in a vertical position and the overflow means in such case will usually take the form of a standpipe positioned axially of the mold with the corresponding end of the mold closed except for the opening through the standpipe.

Where the mold is so constructed and arranged as to be charged when its axis is in a vertical position, due to the fact that it is desirable to effect or at least complete the spinning operation of the mold when the axis of the mold is in a horizontal or approximately horizontal position, it will be found necessary to insert the

charged mold in the machine and commence the spinning of the same while the axis of the mold is in vertical or approximately vertical position and after the mold has reached a sufficient rate of speed to insure throwing of the molten metal to the radial walls thereof, moving the mold so as to bring its axis into the desired position for completion of the casting operation. While this may obviously be accomplished in a number of different ways, in accordance with a further phase of the present invention the machine is so constructed and arranged as to provide a rotatable spindle for supporting and rotating the mold and a support for rotatably supporting the spindle, the support and spindle together with the mold carried thereby being capable of being moved as a unit from a position in which the mold is positioned with its axis vertical to a position in which the mold is positioned with its axis at a material angle to the vertical or even to a horizontal position where such position is desired. Furthermore as will be readily appreciated the positioning of the mold with its axis in the horizontal position makes it easier to remove the mold and the article cast therein from the machine after the material from which the article is made has solidified. In some instances, however, particularly to conserve floor space, it may be desirable to remove the mold and article when the mold is positioned with its axis vertical and this is readily possible in accordance with the present invention.

Referring now to Figs. 1 to 4, inclusive, the centrifugal casting machine itself is indicated as being provided with a base 10 which is provided with a pair of spaced upstanding arms 12 between the upper ends of which extends a horizontal shaft 14 supported thereby. A hollow generally cylindrical housing member 16 positioned with its axis in offset relation with respect to the axis of the shaft 14 is exteriorly provided with a laterally offset boss portion 18 which embraces the shaft 14 between the arms 12 thereby to provide a pivotal support for the housing 16 upon the shaft 14. When the machine is in loading position the axis of the housing 16 extends vertically but as will be apparent its axis may be positioned horizontally by causing the housing 16 to swing about the shaft 14. As a matter of convenience only, in the following description it will be assumed unless otherwise specified in describing the construction of the machine that reference to direction is intended to mean when the machine is positioned as indicated in full lines in Figs. 1 and 2, namely with the axis of the housing 16 vertical.

Rotatably mounted within the housing 16 is a hollow spindle 20 positioned with its axis coincident with the axis of the housing 16 and projecting both above and below the housing 16. The spindle 20 is supported in the housing 16 by means of anti-friction bearing assemblies 22 located adjacent the top and bottom surfaces of the housing 16. A pulley 24 is suitably keyed to the projecting lower end of the shaft 20 and is followed by a nut 26 which acts through the pulley 24 to adjust the clearance of the bearings 22 and to hold the spindle 20 against axial movement in the housing 16. A bracket 28 fixed to the housing 16 supports an electric motor 30 provided with a driving pulley 32 which is connected with a pulley 24 through belts 34 for the purpose of providing a drive for the spindle 20.

The upper end of the spindle 20 is outwardly flared to form a relatively large diameter flange

36 whose upper face is normal to the axis of the spindle 20. Seated upon the upper face of the flange 36 is a disc-like member 38 which is peripherally provided with a downwardly or axially extending flange 40 which is piloted over the periphery of the flange 36 and, therefore, serves to center the member 38 with respect to the spindle 20. A cylindrically shaped mold support 42 provided with a radial flange 44 at its lower end rests upon the upper face of the member 38 and is concentrically piloted with respect thereto by the periphery of the flange 44 fitting within the upwardly extending axial flange 46 formed at the periphery of the member 38. Bolts 48 extending downwardly through the flange 44, member 38 and flange 36 serve to secure all of these parts together rigidly in assembled relationship.

The lower face of the member 38, as best illustrated in Figs. 1 and 3 is formed to provide a plurality of downwardly projecting lugs 50 which serve to separate the main body portion of the member 38 from the upper face of the flange 36. Additionally the periphery of the member 38 is in radial alignment with the space between the member 38 and the flange 36 is cut away as at 52 around the periphery of the member 38 so as to provide open communication between the space afforded between the member 38 and the flange 36, and the outside air. The member 38 centrally thereof is provided with an axially extended concentric tube portion 54 which extends downwardly in axially concentric relation with respect to the spindle 20 and projects below the lower end thereof. A spider 56, best shown in Figs. 1 and 4 is interposed between the lower end of the spindle 20 and the tube 54 so as to center the tube 54 at this end and yet permit the flow of air through the spider to the space between the exterior of the tube 54 and the interior wall of the spindle 40. With this construction it will be apparent that upon rotation of the spindle and its associated mechanism including the member 38, the air in the upper portion of the spindle and between the flange 36 and the member 38 will be thrown centrifugally outwardly through the openings 52 and fresh air will be drawn upwardly through the spider 56 to replace such discharged air. This provides a constant flow of air up through the center of the spindle and over the upper face of the spindle which feature, in combination, with the limited area of contact between the member 38 and the flange 36, limits the flow of heat from the molten metal in the mold to the spindle during a casting operation and thereby eliminates certain difficulties which otherwise might arise.

Referring now to the mold proper which is best illustrated in Figs. 1 and 7 it will be understood that the actual construction of the mold, that is whether it is made up of an assembly of a plurality of separately formed parts or is made up as an integral structure is of no moment as far as the present invention is concerned. In most cases it will be made up as a baked sand product although in some cases it may be desirable to form it of metallic sections provided with a suitable lining of heat insulating material such as are commonly employed in connection with permanent molds. It will also be appreciated that the interior configuration of the mold will vary in accordance with the article to be formed. As a matter of illustration only in the present instance it is assumed that the mold is intended to form cylinder liners for internal combustion or other engines which take the form of a hollow cylinder

having a radially outwardly projecting flange at one end only thereof and as specifically illustrated at 60 in Fig. 8. For the purpose of forming a cylinder liner 60 it is assumed that the mold which is indicated generally at 62 is formed from baked sand in two parts, namely an upper part 64 and a lower part 66, the upper part being approximately cylindrical and being provided with the usual flange 68 at its open end for predetermining the length of the article being cast in this direction. The lower portion 66 comprises a disc-like portion sealed to the corresponding axial face of the portion 64 and centrally provided with an upwardly projecting boss-like portion 70 provided with a central opening 72 therethrough and which opening is on the axis of the mold. A metal disc or plate 74 overlies the lower face of the portion 66 and is provided with a central aperture aligned with the opening 72. A metallic ring or annular plate 76 overlies the upper face of the portion 64 and threaded rods 78 extend through the mold and cooperate between the plates 74 and 76 to maintain the two portions 64 and 66 in properly assembled relationship. Eyes 80 on the upper ends of the rods 78 provide means by which the mold 62 and its charge of molten metal may be easily transported. It may also be noted at this point that the interior walls of the mold support 42 are slightly tapered and the outer walls of the mold 62 are tapered in a complementary manner so as to insure a proper fit between these parts under all circumstances when assembled together. As will be noted from an inspection of Fig. 1 when the mold 62 is properly assembled in the mold support 42 the disc 74 overlying the lower end of the mold 62 is positioned a slight distance above the upper face of the member 38.

In order to facilitate the removal of the mold 62 from the mold support 42 the following mechanism is provided. The member 38 is centrally provided with an opening of slightly smaller dimension than the bore of the tube 54 so as to form a shoulder therebetween. Axially slidably received within this opening is a hollow member 84 provided with an enlarged head 86 having radial passages therein communicating with the hollow interior of the member 84. As will be noted this enlarged head 86 limits downward movement of the member 84 with respect to the member 38. The lower end of the member 84 is enlarged as at 88 so as to limit upward movement of the member 84 in the member 38 but still permitting a material amount of axial movement of the member 84 in the member 38. The bottom end of the tube 54 is provided with a slip connection 90 provided with an extended tube portion 92 which connects with a flexible hose 94 extending to a suitable source of air under pressure. When it is desired to remove the mold 62 from the mold support 52, air under pressure is introduced through the hose 94 and tube 92 to the interior of the shaft 54 where such air in flowing upwardly lifts the member 84 until its imperforate upper face contacts the lower face of the plate 74 and closes the lower end of the opening 72. Thereafter the pressure of air in the hose 94 is transmitted to the space between the upper face of the member 38 and the lower face of the member 74 and exerts a pressure against the lower face of the member 74 tending to lift it together with the mold 62 so as to release the mold from the support 42.

In order to control the pivotal position of the housing 16 and parts carried thereby relative to the axis of the shaft 14, the following mechanism is provided. An air cylinder 100 is pivotally con-

5 nected by means of a pin 102 to the base 10 in front of each of the arms 12 for movement in a plane radial to the axis of the shaft 14. Each cylinder 100 is provided therein with a piston
 10 104 having a rod 106 projecting upwardly through the corresponding end of the cylinder 100 and the upper end of which is pivotally connected to a corresponding outward extension 108 on the housing 16. Means including tubes 110 communicating with the interior of the cylinders 100 at opposite ends thereof and a suitable source of fluid under pressure is employed for controlling the position of the pistons 104 in the respective cylinders. As will be readily understood,
 15 admission of air under pressure to the cylinders 100 above the pistons 104 and escape of air from the lower ends of the cylinders will move the pistons 104 downwardly in the cylinders and cause the housing 16 and parts carried thereby to rotate in a clockwise direction of rotation about the axis of the shaft 14 as viewed in Fig. 1, and pressure applied to the opposite end of the cylinders 100 will effect pivotal movement of the housing 16 and parts carried thereby in a counter-clockwise direction of rotation. In order to limit pivotal movement of the housing 16 and parts carried thereby in a clockwise direction of rotation as viewed in Fig. 1 from the position shown, co-acting lugs 112 and 114 are provided on the housing 16 and legs 12 respectively and act to limit pivotal movement of the housing 16 and parts carried thereby in a clockwise direction of rotation from that shown in Fig. 1 to a position in which the axis of the housing 16 is horizontal.

35 It is to be understood that in the broader aspects of the present invention the machine or apparatus illustrated in Figs. 1 to 4, inclusive, may be employed in accordance with conventional practice. Under such circumstances the
 40 housing 16 and all parts carried thereby will be swung over to the position indicated by dotted lines and labeled "unload position" and in which event it will be necessary to insert the mold in the mold support 42 prior to charging it and will necessitate charging of the mold by a spout in the usual manner. On the other hand it may be possible to employ a mold of the characteristics described in connection with the mold 62 and to insert it in the support while the apparatus is positioned as indicated in full lines in Figs. 1 and 2, charging the mold while in such position, and then after initiation of the spinning operation swing the housing 16 with the mold 62 downwardly to either of the two positions indicated in dotted lines for completion of the spinning operation. In the latter case advantage may be taken of the particular characteristics of the mold 62 shown except that in such case provisions not shown must be made for eliminating any
 55 overflow of the molten metal charge which may pass down the opening 72 from the machine and which provisions are not necessary when the preferred method of employment is used.

60 In the preferred method of employing the apparatus shown, the mold 62 is charged with molten metal before it is placed in the mold support 42. Because of this it will be realized that the mold 62 must be self-sustaining under a charge of metal therein when stationary and it
 65 will be readily recognized that the construction of the mold 62 as previously described in detail is such as to effect this result. Accordingly, in accordance with the preferred method of procedure a mold 62 is suspended through suitable engagement with the eyes 80 of the rods 78 from a

suitable travelling lifting device 120 suspended for movement from a mono-rail track 122 as illustrated in Fig. 5. The lifting device 120 may be of any suitable type, either actuated by air or manually, and is shown by way of illustration
 5 only as a chain fall. The mono-rail track 122 is extended past the spout 124 of a suitable cupola or furnace such as 126 illustrated in Fig. 6 so that the mold while supported from the mono-rail track 122, and preferably after it has been initially heated by a torch or the like to reduce the heat losses from the metal to it, may be moved below the spout 124 so as to receive a charge of metal therefrom. As previously mentioned instead of receiving a charge directly from a cupola or furnace molten metal from such cupola or furnace may be drawn off into a relatively large ladle and the mold 62 charged directly from this large ladle with substantially the same results as here outlined except that in such event a greater
 10 heat loss will occur in the metal than where it is charged directly from the cupola or furnace. The height of the boss 70 in each mold 62 will, of course, be so constructed and arranged that when a charge of molten metal is introduced into the mold 62 and its level reaches the height of the top of the projection or boss 70, exactly the required amount of metal for the desired finished article will have been introduced into the mold. Accordingly, in charging the mold 62 as illustrated in Fig. 6 a slight excess of metal is introduced into the mold 62, such excess overflowing the top of the boss or projection 70 and being discharged from the mold through the opening 72 therein, thus insuring in every case that exactly the required amount of molten metal remains in the mold 62.

The mold 62 and its molten contents is then moved along the mono-rail track 122 which extends over the top of one or more machines such as illustrated in Fig. 1 and when over the top of such machine the chain fall 120 is operated to lower the mold 62 and its liquid contents into the mold support 42, it being understood, of course, that during this operation the housing 16 is so positioned relative to the axis of the shaft 14 as to bring the axis of the mold support 42 into a vertical position. Because of the tapered exterior surface of the mold 62 and the complementarily tapered interior surface of the mold support 42, when the mold 62 is lowered into the mold support 42 it will finally come to rest therein in snug engagement with the inner walls thereof. The mold support 42 thus provides a reinforcement for the walls of the mold 62 against the pressure of the molten metal exerted thereagainst during the subsequent centrifugal spinning action.

It will be appreciated from the above description that in following out the preferred procedure of operations not only does it insure an extremely accurately charged amount of molten metal in each mold, but because of the fact that the metal is charged directly into the mold from the furnace or at least from a relatively large ladle the heat losses occurring in accordance with conventional practice through charging into a small ladle carrying an individual charge and in passing through a charging spout is entirely eliminated and, accordingly, that any loss of heat from the charge is to the mold itself which in any event must eventually absorb the heat from the molten metal. Furthermore, because of the fact that the time element consumed between the time the metal is passed from the fur-

nace and the time the mold is inserted in the machine in running position is substantially less than that required in following out conventional practice, the molten metal at the time it is subjected to centrifugal action in the machine is at a relatively higher temperature, consequently more fluid, and results in sounder castings free of such defects as occur in conventional practices from chilled metal.

As soon as the charged mold 62 as above described is inserted in the mold support 42 and the chain fall 120 released from it, the motor 30 is energized so as to immediately set the shaft 20 and parts carried thereby including the mold support 42 and mold 62 in rotation. As soon as the speed of rotation has increased to such an extent as to insure maintaining of the molten charge of metal in the mold 62 in contact with the outer walls thereof, suitable valves are operated to introduce air through the pipes 110 into the upper ends of the cylinders 100, thus causing the housing 16 and all parts carried thereby to pivot around the axis of the shaft 14 in a clockwise direction of rotation as viewed in Fig. 1. Preferably sufficient air is admitted into the cylinders 100 to bring the mold support 42 and the mold 62 carried thereby to the position indicated in dotted lines in Fig. 1 and labeled "spin position", short of a true horizontal position. The mold support 42 may, of course, be moved to a wholly horizontal position if desired but it has been found of advantage to move it to the inclined position shown until completion of the spinning operation when the molten metal has solidified.

As soon as the molten metal has solidified additional air may be introduced into the cylinders 110 to move the mold support 42 to a wholly horizontal position as indicated in dotted lines in Fig. 1 and labeled "unload position" and as soon as the apparatus has reached this position air under pressure is admitted to the hose 94 and pipe 92 into the interior of the tube 54 to actuate the member 84 to close the opening 72 in the mold 62 and then apply such air under pressure to the base of the mold 62 whereby to loosen it from if not entirely eject the mold and its contents from the support 52. If this last operation merely loosens the mold 62 in the mold support 42 it may, of course, then be readily removed therefrom by simply pulling it out. As soon as the mold 62 has thus been removed from the mold support 42, the air through the hose 94 is discontinued and air is admitted to the lower ends of the cylinders 100 whereby to cause the apparatus to resume the position indicated in full lines in Fig. 1 and in which position it is again ready to receive another mold 62 and its

charge of molten metal for a repetition of the above described operations.

It has been previously mentioned that it is not necessary in the broader aspects of the present invention that the mold 62 and its contained cast object be removed from the mold support 42 when the support 42 is positioned with its axis in horizontal relation, as although this may ordinarily be desirable, in some cases in order to conserve floor space, it may be desired to return the mold support 42 to vertical relation directly from spinning position before removing the mold and its contained cast object, and this is readily possible with the construction shown.

Attention is also directed to the fact that during the spinning operation above described a relatively large volume of air passes through the interior of the shaft 20 exteriorly of the tube 54 and is ejected between the upper flange 36 of the shaft 20 and the member 38 which has only a limited area of contact with the flange 36. Because of this the effects of any heat discharged from the molten metal in the mold 62 which otherwise would be carried down into the shaft 20, the bearings 22 and other parts of the mechanism is eliminated and the operating parts of the machine are thus guarded against excessive temperature effects.

From the above it will be understood that in accordance with the present invention a rugged and efficient casting means is provided in accordance with the present invention, a form of mold is provided by means of which molten charge of metal for a centrifugal casting is quickly and accurately determined, and that in carrying out the preferred mode of operation the continued and rapid production of sound centrifugal casting is assured.

Formal changes may be made in the specific embodiment of the invention described without departing from the spirit or substance of the broad invention, the scope of which is commensurate with the appended claim.

What I claim is:

In the centrifugal casting of molten metals by subjecting a mold charged with molten metals to centrifugal action in a casting machine, the steps of charging a mold of refractory material with molten metal directly from a primary source, transporting said charged mold to said machine and inserting it in said machine with its axis in approximately vertical position, operating said machine to rotate said mold and liquid contents thereof, moving said mold to bring its axis out of vertical relation prior to solidification of the molten metal therein, and removing said metal after solidification from said mold.

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