Sept. 28, 1954 W. J. TRETHEWAY ET AL 2,689,989

CASTING APPARATUS

Filed Sept. 12, 1951 2 Sheets-Sheet 1

FIG. 1

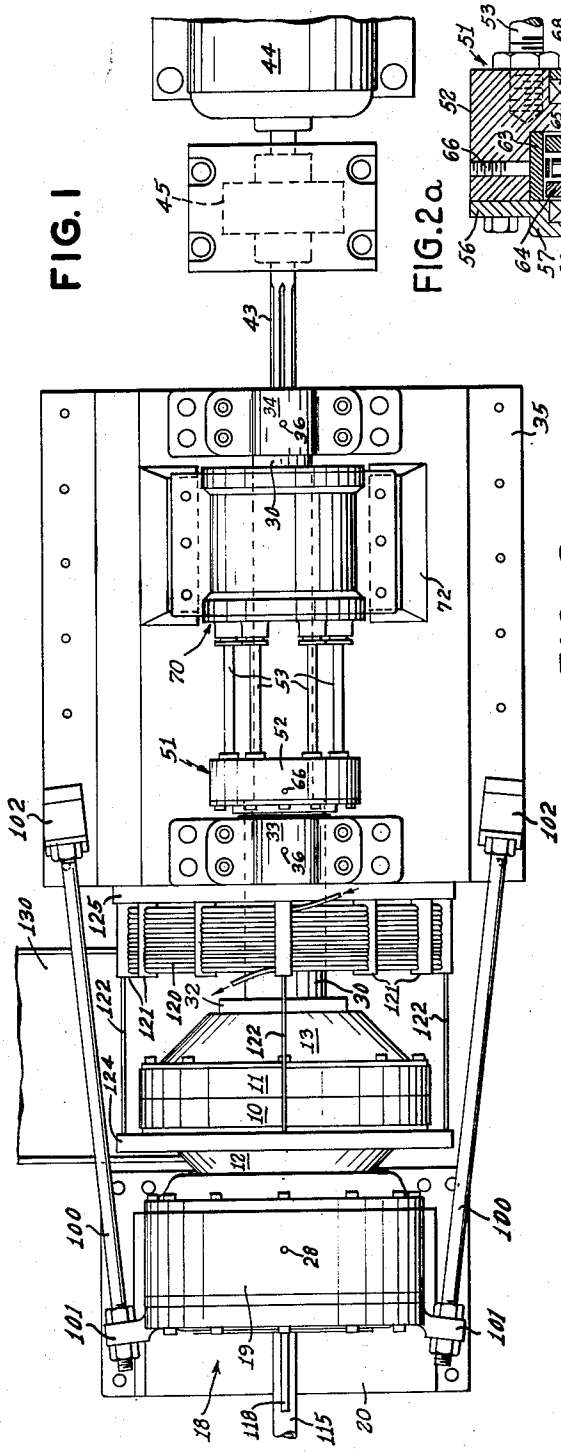


FIG. 2a

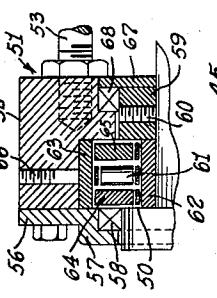
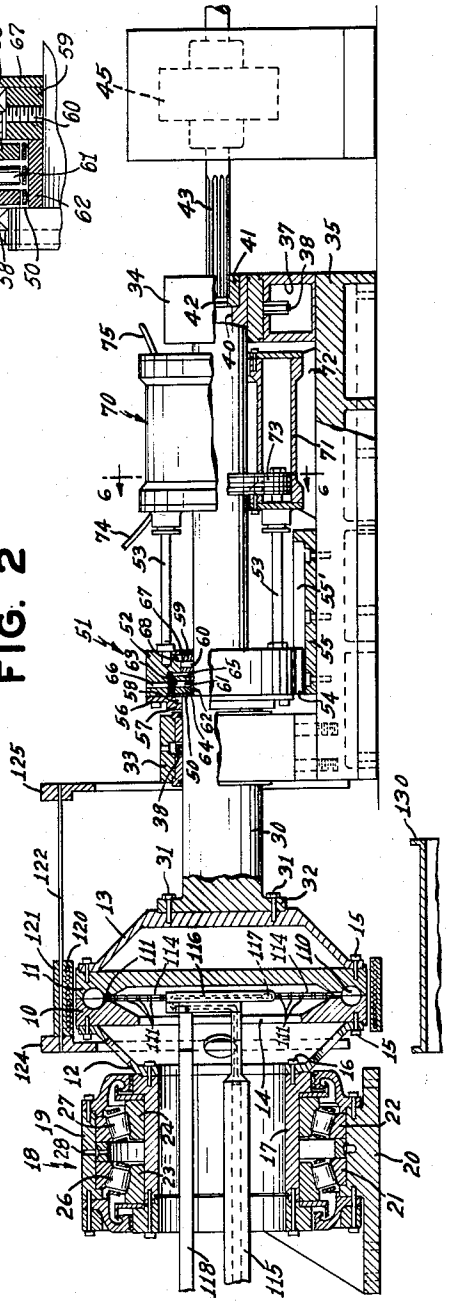


FIG. 2



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CASTING APPARATUS

Filed Sept. 12, 1951 2 Sheets-Sheet 2

FIG. 3

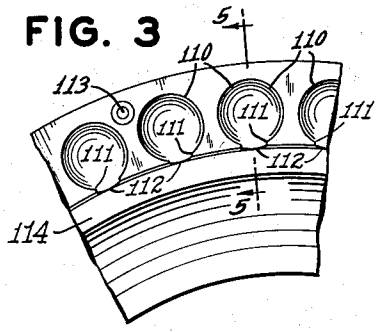


FIG. 4

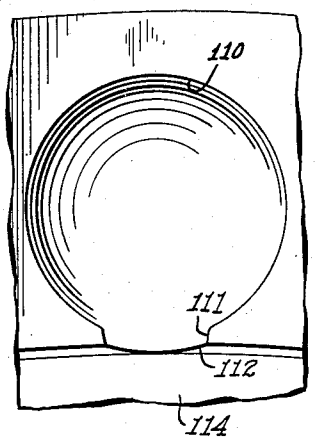


FIG. 5

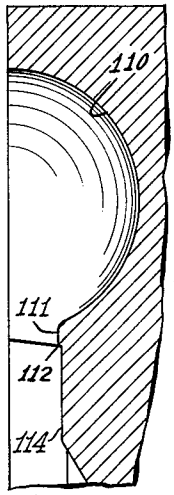


FIG. 7

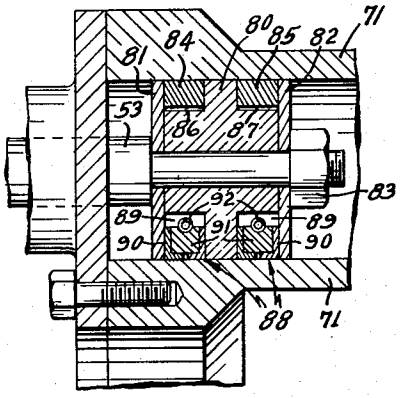


FIG. 6

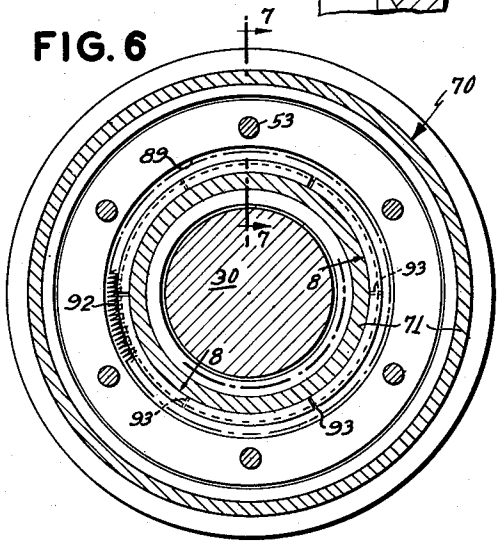


FIG. 8

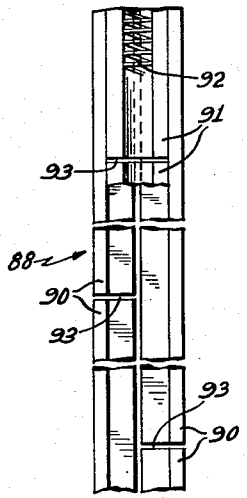
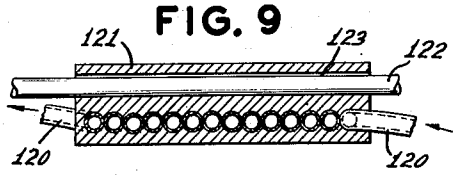


FIG. 9



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UNITED STATES PATENT OFFICE

2,689,989

CASTING APPARATUS

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Application September 12, 1951, Serial No. 246,272

5 Claims. (Cl. 22—65)

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This invention relates to the casting of metals, and more particularly is concerned with a centrifugal casting apparatus for casting cadmium. About 90% of the substantially pure cadmium sold today is sold in the form of ball-shaped castings. Our invention is therefore more specifically directed to a centrifugal casting apparatus for making ball-shaped cadmium castings.

Cadmium is a relatively difficult metal to cast; first, because it is readily oxidized whereby, unless proper care is taken, castings made therefrom will contain substantial amounts of dross; and secondly because, unless it is carefully handled during the casting operation, the castings are apt to contain holes or have undesirably rough surfaces. Heretofore the majority of cadmium castings have been made by employing hand casting operations, that is, the molten metal has been poured into a stationary mold by a hand operation. The object of this invention is to provide an apparatus by which cadmium balls may be cast substantially automatically without requiring any manual operations, such as manual pouring of the molten metal, and by which desirable dense castings, free of holes and dross and having relatively smooth surfaces, may be obtained.

Accordingly, the invention contemplates a centrifugal casting apparatus comprising a pair of mold halves adapted when in face-to-face contact with each other to form a mold. One mold half is supported on a hollow shaft which is in turn supported in a thrust bearing which permits rotation of the shaft and the mold half supported thereby but does not permit substantial longitudinal movement of either. The hollowness of the supporting shaft provides ready access to the interior of the mold for introducing molten cadmium which is to be cast therein. The other mold half is supported in face-to-face relation with respect to the first mold half by a drive shaft by which it is adapted to be rotated, the drive shaft being supported in turn in at least one bearing. The drive shaft may move both longitudinally and rotationally in its supporting bearing. Means for rotating the drive shaft, advantageously an electric motor, is provided and has a splined shaft which is adapted to be connected to the drive shaft by a splined connection which permits relative longitudinal movement between the drive shaft and the motor shaft. Additionally, means is provided for moving the drive shaft and its supported mold half in one longitudinal direction to bring the faces of the mold halves into contact with each other and for moving the drive shaft and its supported mold half in the opposite direction to permit removal of a casting from the mold. This means is advantageously hydraulic in nature whereby it is somewhat more flexible in use than would be a strictly mechanical means for the same purpose.

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In the preferred form of apparatus the face of each mold half is provided with a plurality of hemispherical cavities arranged in a circle and a plurality of radially extending channels, one channel leading to each hemispherical cavity. For a casting operation, the mold halves are urged together so that their faces abut and so that the cavities and channels in one mold half coincide with those in the other mold half.

The invention also contemplates the provision of means for preheating the mold halves to prepare them for a casting operation. Such heating of the mold halves is extremely important if it is desired to use the apparatus most efficiently. However, in view of the relatively large size of the mold halves and the other adjacent portions of the casting apparatus, the preheating of the mold halves presents various problems due both to the fact that long periods of time are not available, in efficient operation, for performing the preheating operation and to the fact that some of the adjacent portions of the apparatus may be damaged by excessive heating or by even what might otherwise be considered low temperatures with respect to casting operations. In order to avoid both of the aforementioned objectionable results, the preheating of the mold halves is accomplished by electrical induction and the heating means therefore comprises an induction coil of novel design. A further feature of the preheating means is the provision for movement thereof to a position surrounding the mold halves, when they are in contact with each other, for the preheating operation and provision for the movement of the preheating means away from the mold halves during a casting operation, whereby it will be out of the range of any flying metal by which it might otherwise be damaged.

The manner in which the cadmium to be cast in the apparatus of this invention is prepared for casting and the manner in which it is delivered to the casting apparatus at the proper temperature and free from dross, form no part of this invention but are fully disclosed and claimed in our application Ser. No. 251,024, filed October 12, 1951.

Further novel and advantageous features of the casting apparatus of this invention may be derived from and will be described in connection

with one form of casting apparatus according to my invention and illustrated in the accompanying drawings, in which:

Fig. 1 is a plan view of the casting apparatus;

Fig. 2 is an elevation in section of the apparatus of Fig. 1;

Fig. 2a is an enlarged sectional view of the thrust bearing of the casting apparatus;

Fig. 3 is a fragmentary view of a portion of the face of one mold half;

Fig. 4 is an enlarged fragmentary view of a smaller portion of the face of a mold half illustrating in more detail one hemispherical cavity therein and the channel leading thereto;

Fig. 5 is an enlarged sectional view on line 5—5 of Fig. 3;

Fig. 6 is a sectional view on line 6—6 of Fig. 2;

Figs. 7 and 8 are sectional views on lines 7—7 and 8—8, respectively, of Fig. 6; and

Fig. 9 is an enlarged cross sectional view of the induction coil of the mold preheating means.

The casting apparatus, as may be seen most clearly in Figs. 1 and 2, comprises a pair of mold halves 10 and 11 supported with their faces opposite one another by cone-shaped supporting members 12 and 13, respectively. The mold halves 10 and 11 have substantially identical faces as will be more fully pointed out subsequently, the only difference between the two mold halves being that mold half 10 has a centrally located circular opening 14 extending through it. Each mold half is secured to its supporting cone by a plurality of bolts 15.

The supporting cone 12, which supportes mold half 10, is itself secured by bolts 16 to one end of a hollow shaft 17 which is, in turn, supported within a combination radial and thrust bearing 18, the outer casing 19 of which is fixedly mounted on a base or pedestal 20 which may be bolted to the floor, or to the bed or crib of the machine. The thrust bearing 18 comprises the housing 19 to the inner face of which are secured two outer bearing races 21 and 22. A second pair of bearing races 23 and 24 are supported on the periphery of the hollow shaft 17 and secured thereon against relative longitudinal movement and are separated from the bearing races 21 and 22 by two sets of roller bearings 26 and 27, respectively. The faces of the bearing races lie in planes angularly disposed with respect to the longitudinal axis of the hollow shaft 17, as do also the axes of the bearings 26 and 27. An oil hole 28 is formed through the upper wall of the casing 19 whereby lubricating oil may be supplied to the interior of the thrust bearing. It will be clear from the above and from Fig. 2 that the thrust bearing 18 permits rotation of the hollow shaft 17, the supporting cone 12 and mold half 10, but prevents any longitudinal movement thereof. Thus mold half 10 is longitudinally stationary.

The supporting cone 13 which carries the other mold half 11 is supported by a drive shaft 30 by being secured to one end thereof by bolts 31 which extend through a flange 32 formed on said end of the drive shaft 30. The drive saft 30 is, in turn, supported in a pair of bearings, namely, a forward bearing 33 and a rear bearing 34. The bearings 33 and 34 are of conventional form and are fixedly supported in any desirable manner upon a crib or bed 35. Each of these bearings is provided with an oil inlet 36 and includes a lubricating oil reservoir 37 through which an oil ring 38 resting on drive shaft 30 is

adapted to be rotated by the drive shaft 30, whereby the shaft surface is continually lubricated in the bearings. From the above it will be understood that the drive shaft may be both rotated in bearings 33 and 34 and moved longitudinally therethrough.

At its rear end the drive shaft is provided with a bore 40 into the outer end of which is non-rotatably set a coupling member 41 provided with annular spaced teeth 42. The coupling member 41 and bore 40 of the drive shaft 30 receive in a relatively non-rotatable connection a splined shaft 43 connected to the shaft of an electric motor 44 by a coupling 45, the splines of the shaft 43 entering the spaces between the teeth 42 of the coupling member 41. The splined connection, while preventing relative rotation of the drive shaft 30 and the shaft 43, permits longitudinal relative movement therebetween. Thus the motor 44 drives the drive shaft 30 and rotates the mold half 11 supported by the supporting cone 13. In place of coupling the motor directly to the splined shaft 43 by the coupling 45, as shown, this shaft may be driven by a V-belt drive or by any other desired type of drive.

To provide for longitudinal movement, the drive shaft 30 is provided with a shoulder 50 against which a thrust bearing indicated generally at 51 is adapted to act to urge the drive shaft 30 to the left, as viewed in Fig. 2, so that the mold half 11 will contact the longitudinally stationary mold half 10 face-to-face. An enlarged sectional view of the thrust bearing 51 is shown in Fig. 2a. The thrust bearing 51 comprises an outer ring member 52 supported non-rotatably on the outer ends of a plurality of piston rods 53. A key 54 extends from the lower portion of the periphery of the ring member 52 into a longitudinal keyway 55' in a member 55 bolted or otherwise secured to the crib or bed 35. A flanged ring 56 is bolted to the forward face of the ring member 52, the flange 57 thereof having an inner diameter substantially equal to the outer diameter of the drive shaft 30 and enclosing an oil retaining gasket 58. The ring member 52 of the thrust bearing 51 also surrounds a collar 59 which is secured by one or more set screws 60 to the drive shaft 30. Between the collar 59 and the shoulder 50 of the drive shaft 30 there are located a plurality of roller bearings 61 supported by spaced annular rings 62 and 63 and flanked on opposite sides by bearing races 64 and 65. A second oil-retaining gasket 68 is provided to surround a portion of collar 59 and is maintained in place by an annular plate 67 secured to the rear face of the ring member 52.

The operation of the thrust bearing 51 to move the shaft 30 in either longitudinal direction will, it is believed, be clear from the above description thereof but briefly, when the piston rods 53 are urged to the left as seen in Fig. 2, force is conveyed through ring member 52, bearing race 65, bearings 61 and bearing race 64 to the shoulder 50 of the drive shaft 30 thereby urging the drive shaft 30 to the left. When piston rods 53 are withdrawn to the right, the withdrawing force is conveyed through ring member 52 to the flanged ring 56 and thence through the bearing races 64 and 65 and rollers 61 to the collar 59 which is secured to the shaft. To maintain thrust bearing 51 continually well lubricated, an oil hole 66 is provided through ring member 52 for the admission of a lubricating oil.

A hydraulic means 70 is provided to move piston rods 53 and thrust bearing 51 longitudinally

to thereby urge mold half 11 into face-to-face contact with mold half 10 or to move mold half 11 out of contact and away from mold half 10. The hydraulic means comprises an annular cylinder 71 connected through a base 72 to the crib or bed 35 of the apparatus. The annular cylinder 71 surrounds the drive shaft 30 but is not in any way in contact therewith. An annular piston 73 (Fig. 2) is contained within the annular cylinder 71 and is connected to the rear ends of the connecting rods 53 which extend through the forward wall of the annular cylinder 71. Packing (not shown) prevents leakage of fluid from the annular cylinder 71 around the piston rods. Hydraulic fluid is supplied to opposite ends of the cylinder 71 through supply lines 74 and 75, the fluid entering through the supply line 75 being adapted to urge the piston 73 to the left, as seen in Fig. 2, and the fluid supplied through the supply line 74 being adapted to urge the piston 73 to the right.

The structure of the annular piston 73 and the piston rings employed in connection with it are illustrated in more detail in Figs. 6, 7 and 8. The annular piston comprises an annular member 80 flanked on either side by ring-shaped plates 81 and 82 secured thereto by reason of the reduced cross sectional area of the inner end of piston rods 53 which extend through the member 80 and the plates 81 and 82 and are secured thereto by nuts 83. To provide for a close fit between the piston and the outer wall of cylinder 71, a pair of conventional expanding piston rings 84 and 85 are provided and are located in channels 86 and 87, respectively, formed in the outer surface of the ring member 80 and partially defined by ring-shaped plates 81 and 82.

To provide for a close fit between the piston and the inner wall of the annular cylinder 71, however, a novel type of contracting piston ring has been designed. Two such piston rings 88 are illustrated and are located in channels 89 formed on the inner face of the ring member 80 and partially defined by the ring-shaped plates 81 and 82.

Each of the contracting piston rings 88 comprises a plurality, preferably 6 in number, of arcuately curved angle elements 90, and a plurality, preferably 3 in number, of arcuately curved filler segments 91. The angle segments 90 are arranged in two side-by-side groups of three each to form a channel-shaped ring; and the filler segments 91 are laid end-to-end in the channel defined by the thus assembled angle segments. The outer peripheral edges of the filler segments 91 are grooved to receive a coil tension spring 92. When the resulting composite ring is in place against the inner wall of the annular cylinder 71, narrow spaces 93 exist between the adjacent ends of the segments 90 and 91. These spaces are staggered in the composite ring so that no two of them lie in substantially the same radial plane. The coil tension spring 92, which lies in the peripheral groove formed in the filler segments 91, urges the segments 90 of the composite ring toward each other to form an uninterrupted ring and so into tight contact with the inner wall of the annular cylinder 71.

In the piston rings above described, the filler elements 91 are simply three in number, each extending substantially one third of the distance about the periphery of the inner wall of the cylinder 71. Each of these segments may however be divided into two by being cut lengthwise, so that in the assembled ring the filler segments, like the angle segments, are divided into two symmetrical halves arranged on opposite sides of a plane normal to the axis of the ring. In such a structure, the coil spring 92 not only urges the ring halves against the inner wall of the cylinder 71, but also urges them to spread apart, into engagement with the side walls and the annular ring grooves 89. Of course, in this latter structure, the filler elements and the angle elements may just as well be integral with each other, in which case each ring will consist of six segments, three forming the half of the ring abutting against that side wall of the channel 89 formed by one or the other of the plates 81 or 82, and the other three forming the half of the ring which abuts against the opposite side wall of said channel.

In view of the fact that relatively large forces are employed in operation of the thus far, above-described casting apparatus whereby the mold halves 10 and 11 are urged together under relatively great force, it is desirable and even necessary to provide means for additionally supporting the upper end of the thrust bearing 18 supporting the hollow shaft 17. Such support is provided by a number of tie rods 100 (Fig. 1) adjustably secured between outwardly extending portions 101 of the casing 19 of the thrust bearing 18 and brackets 102 secured in any desirable manner to the crib or bed 35 of the casting apparatus.

The present casting apparatus, as stated, is adapted to be used in the casting of ball-shaped cadmium castings. The faces of each of the molds 10 and 11 are thus formed with a plurality of hemispherical cavities 110 (Figs. 3 through 5). These hemispherical cavities 110 are arranged in a circle around the outer portions of the faces of each mold half. A plurality of channels 111 are also formed in each mold face, each channel leading to a hemispherical cavity and being adapted to convey molten metal thereto. In order that the metal to be cast flows outwardly into the cavities without substantial turbulence and consequent oxidation, the former by itself causing rough-surfaced casting and the latter impure ones, the sides of the channels 111 are tapered to diverge slightly toward the hemispherical cavities. This may be seen by reference to Fig. 4. Additionally the base of each channel 111 is provided with a small ridge 112 as may be seen in Fig. 5. The purpose of this ridge is to decrease the amount of labor involved in separating the cadmium ball castings from the sprue which is formed by the excess cadmium employed which hardens or solidifies within a common annular central cavity 114 radially inwardly of channels 111 and inwardly of said cavity 114 in the immediately adjacent portion of the mold. This is because the presence of the ridge causes the shrinkage cracks which form upon solidification of the metal to break off the sprue whereby it need not be subsequently broken off either manually or mechanically.

Additionally the face of each mold half 10 and 11 is provided with a plurality of spaced dowel pins 113 extending outwardly therefrom, and a plurality of holes (not shown) to receive the dowel pins of the other mold half when the mold halves are in face-to-face contact. The dowel pins serve two functions; first, they properly position the mold halves 10 and 11 with respect to one another so that the hemispherical cavities

110 and the channels 111 in one coincide with those in the other, and, second, they provide for transferring rotational driving forces from the mold half 11 to the mold half 10.

The manner in which molten metal is prepared for casting and delivered to the mold of the present casting apparatus is fully described and claimed in our aforementioned application Ser. No. 251,024. A portion of the apparatus employed for this purpose is illustrated in Fig. 2 and comprises an insulated stainless steel delivery pipe 115 provided at its discharge end with a removable gooseneck member 116 at the lower end of which is formed a molten metal delivery spout 117 adapted to discharge molten metal into the composite mold formed by mold halves 10 and 11. A stainless steel bar 118 is connected to the end of the stainless steel delivery pipe 115 to supply electric current thereto for the purpose of maintaining the molten metal therein heated to a desired temperature as fully disclosed and described in our aforementioned application. To obtain desirable dense ball castings of cadmium in the present apparatus, the temperature of the mold must be from 400° to 450° F., preferably about 430° F. If it is lower the castings are not smooth but tend to be rough surfaced, whereas if the temperature of the mold is substantially greater, expansion may cause the mold to crack open between the halves, permitting escape of molten metal. As set forth in our aforementioned application, the temperature at which molten cadmium is delivered to the mold of this apparatus should be between 700° and 800° F., and preferably about 760° F.

It will be apparent from the above that in order to start casting with the present apparatus, the composite mold, comprising the mold halves 10 and 11, must be preheated to the temperature of about 400°–450° F. Two factors are involved in preheating the mold, the first being the length of time required in view of the relatively great weight of the mold and the second being that the parts of the apparatus surrounding the mold, and particularly the thrust bearing 18, must not be overheated. In order to preheat the mold in a reasonable length of time and yet not overheat the surrounding parts of the apparatus, we have designed a novel preheating means. This preheating means (Figs. 1, 2 and 9) comprises an induction coil made up of a number of turns of copper tubing 120 held together at spaced intervals by a plurality of blocks of material 121 in which they are embedded. The composite coil is supported by a plurality of rods 122 which are adapted to extend through openings 123 in a number of the blocks 121, the rods 122 being supported at opposite ends by appropriate supports 124 and 125. This supporting means for the coil permits movement of the coil longitudinally of the casting apparatus so that it may be positioned to surround the abutting mold halves 10 and 11, as in Fig. 2, or be positioned rightwardly thereof as seen in Fig. 1. Suitable electrical connections (not shown) are provided for the induction coil. In view of the relatively great weight of the mold, relatively high currents must be employed and in order that the tubing of the induction coil and its insulation be not damaged thereby, water or some other coolant may be passed through it. By this heating means the mold can be uniformly heated and brought up to temperature (400°–450° F.) in a relatively short time without overheating of the surrounding parts of the apparatus.

After several casting operations, it will be understood that the mold will tend to become overheated by repeated charges of molten cadmium and thus means is usually provided to cool the mold. This means may comprise an exhaust fan to remove the hot air and smoke from around the motor as well as a fan to provide cool air thereto. In order to maintain and properly control the temperature of the mold, a small thermocouple may be embedded in a brush adapted to continuously engage the periphery of the mold. This thermocouple may be electrically connected to the above-mentioned fans to cause their operation when necessary if the mold becomes too hot (above 450° F.) and may be further employed to discontinue the supply of current to the induction coil during the preheating operation when the temperature of the mold has been raised to about 430° F. This control apparatus is not shown.

It will be understood that the induction coil is used only for preheating and is maintained otherwise in its righthandmost position (Fig. 1) as during casting operations. Desirably a shield (not shown) is provided to surround the mold during casting operations to catch any metal thrown off by the mold. A chute 130 (Figs. 1 and 2) is also provided below the mold to receive newly cast balls from the mold and to carry them away.

There are many features of the apparatus of this invention which are critical because of the nature of the metal being cast. Thus fine temperature control as well as proper metal handling is required if desirable, dense, smooth, dross-free and non-porous castings are to be obtained. Aside from the criticality of the temperature of the mold as above discussed, it should be pointed out that the molten metal must be introduced very quickly into the mold if proper castings are to be obtained. With one particular casting apparatus constructed in accordance with this invention, it has been found that the entire charge of molten metal must be introduced into the mold within from four to six seconds. If this period of time is longer, the castings formed are apt to be undesirably rough.

In the aforementioned particular casting apparatus, the following are specific characteristics. The mold halves are made of Mehanite, a particular form of cast iron, and together weigh about 480 pounds. Each mold half is provided with 36 hemispherical cavities by which 36 ball castings may be formed in one casting operation, their total weight being approximately 46 pounds. About 20 additional pounds of molten metal are supplied to the mold to form the sprue whose purpose is to keep the mold full during the cooling and solidifying period and to absorb the shrinkage effects of cooling. As stated above, it has been found that the 66 pounds of molten metal must be supplied to the mold in about 4 to 6 seconds to obtain desirable castings. In addition, it has been found that in this particular apparatus the molds must be rotated at such a speed that the centers of the mold cavities have a linear speed of about 75 feet per second. If the speed is lower, the successive increments of metal entering the cavities are too large and one increment may solidify before the next is added. Thus an undesirable, stratified ball, which is not solid, may result. From this it will also be clear that the rate of rotation of the mold must be sufficiently great to give the previously set forth linear speed prior to admission of any molten metal into the mold.

In this specific apparatus it has been found that

the pressure of the oil or other fluid supplied through conduit 75 to the cylinder 70 must be about 280 pounds per square inch in order that the mold shall be held together with sufficient force during casting. The resulting force between the mold halves when the aforementioned oil pressure is employed is equal to about 12½ tons.

The specific induction heater of the aforementioned specific apparatus has a 14 turn coil which with water cooling permits the application thereto of at least 600 amperes and 115 volts, the current being a 60 cycle alternating one. This current will cause the composite mold to be heated to 400°–450° F. in a period of about 40 minutes without raising the temperature of the surrounding parts, and particularly the thrust bearing 18, of the apparatus substantially above 200° F.

It should be understood, however, that by reason of our setting forth specific characteristics of a specific apparatus according to our invention, our invention should not be limited thereby but rather it should be considered to be as broad as are the appended claims.

The operation of the apparatus of this invention may be substantially fully automatic by providing certain controls which are not here disclosed but which are conventional in themselves. To initiate casting with the apparatus, the mold halves must first be heated to the above prescribed temperature and this may be accomplished by moving the mold halves into contact with each other and then moving the induction coil into position to surround them as illustrated in Fig. 2. As stated, about 40 minutes is required to bring the temperature of the molds up to 400° to 450° F. Yet during this preheating operation, the surrounding parts of the apparatus, and particularly the thrust bearing 18, are not heated to above 200°. When the mold halves are at the proper temperature, the preheating operation is discontinued and the induction coil moved to the position illustrated in Fig. 1. The motor 44 is then energized and sufficient time permitted to elapse to permit the mold to be brought up to the proper rotational speed. Molten metal is then admitted to the mold through the stainless steel delivery pipe 115 and removable gooseneck 116 in the manner set forth in our aforementioned application Ser. No. 251,024. All of the molten metal required for a single casting operation is discharged into the mold preferably in from 4 to 6 seconds. If desirable, and as above indicated, a carbon dioxide atmosphere may be maintained within the mold to shield the molten metal discharged thereinto from air. An automatic timer, not shown, deenergizes the electric motor after the lapse of a predetermined period of time and the mold is brought to rest. Mold half 11 is then retracted to the right as seen in Fig. 2 and the castings therein discharged into the carry-off chute 130. The mold halves may also be cleaned at this time and periodically may be sprayed with a special oil which breaks down with heat, leaving a carbon deposit thereon.

Successive batches of ball castings may be formed by repeating the above-described operation over and over again. It will be clear, however, that the mold preheating step of the operation need be performed only at the beginning of a series of operations after the apparatus has had a period of disuse and the mold permitted to become cool. Actually, during a series of operations the mold tends to become too hot by reason of the repeated batches of molten metal cast therein, and for this reason, as previously stated, cooling fans may be employed. These fans may be energized automatically whenever the mold temperature approaches a predetermined maximum value.

It will be understood that various changes and modifications may be made in the apparatus described above without departing from the scope of our invention as set forth in the appended claims.

We claim:

1. In a centrifugal cadmium casting apparatus including a pair of mold halves adapted when in face-to-face contact with each other to form a mold, the face of each mold half containing a plurality of circumferentially spaced hemispherical cavities, means contained on the opposing faces of the mold halves for rotationally positioning the mold halves with respect to each other so that the rims of the cavities in one mold face will coincide with the rims of the cavities in the other mold face when the mold faces abut each other, a horizontal hollow shaft for supporting one mold half and providing access to the entrance of the mold for molten metal delivery means, a thrust bearing supporting said hollow shaft and mold half for rotation about the longitudinal axis of said shaft and mold but preventing substantial movement of the shaft or mold half longitudinally of said axis, a horizontal drive shaft supporting the other mold half, the longitudinal axes of the mold halves and shafts being aligned and the mold halves facing each other, at least one bearing supporting said drive shaft and permitting both rotational and longitudinal movement thereof, means for rotating said drive shaft, means for moving said drive shaft longitudinally to urge said other mold half supported by the drive shaft into face-to-face contact with the mold half supported by the hollow shaft, said means also being adapted to move the drive shaft in an opposite direction to separate the mold halves, and means for preheating and maintaining the mold halves within a predetermined temperature range when said mold halves are in said face-to-face contact, the combination therewith of a plurality of channels in the face of each mold half, each of said channels leading radially from a common central cavity to a hemispherical cavity, each channel having side walls which diverge slightly toward its corresponding hemispherical cavity and each channel being provided with a sharp ridge spaced a short distance from its point of juncture with said cavity.

2. An improved centrifugal cadmium casting apparatus according to claim 1 in which the heating means for preheating the mold halves prior to a casting operation comprises a number of turns of copper tubing, and which includes means movably mounting said copper tubing to surround said mold halves in any position of rotation thereof when the latter are in face-to-face contact and for movement to a position completely out of the plane of rotation of the mold halves when in face-to-face contact, whereby when a charge of molten cadmium is contained in the composite molds and the latter is rotated the heating means will lie out of the path of travel of any flying metal.

3. An improved centrifugal cadmium casting apparatus according to claim 1 in which the means for moving the horizontal drive shaft longitudinally comprises an annular cylinder surrounding a portion of said drive shaft, an annu-

lar piston mounted in said cylinder, expanding piston rings mounted in and completely encircling the outer peripheral face of said annular piston, contracting piston rings mounted in and completely encircling the inner face of said piston adjacent the inner wall of said annular cylinder, a thrust bearing supported on said drive shaft between said annular cylinder and the mold half supporting end of said drive shaft, a plurality of connecting rods connecting said annular piston to said thrust bearing, a fluid conduit connected to one end of said annular cylinder and adapted to supply fluid under pressure thereto, and a fluid conduit connected to the opposite end of said annular cylinder and adapted to supply fluid under pressure to said opposite end of said cylinder.

4. An improved centrifugal cadmium casting apparatus according to claim 3 in which the drive shaft is provided with a rearwardly facing shoulder between said thrust bearing and said mold half and in which said thrust bearing comprises a ring collar secured to said drive shaft but spaced from said shoulder, a plurality of roller bearings surrounding said drive shaft between said shoulder and said collar and extending radially from said drive shaft, said roller bearings being flanked on either side by a bearing race, and a non-rotatable ring member surrounding said roller bearings, said bearing races, and said collar.

5. An improved centrifugal cadmium casting apparatus according to claim 3 in which each contracting piston ring comprises a plurality of arcuate segments assembled in the form of a ring with adjacent ends of each adjoining pair of segments spaced from one another, and spring means surrounding said segments and urging them into contact with each other to form an uninterrupted ring.

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