

[54] DIE CASTING APPARATUS

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[51] Int. Cl. **B22d 17/12**

[58] Field of Search **164/113, 312, DIG. 10, 164/109, 112, 119, 306, 332, 342, 343**

[56] References Cited

UNITED STATES PATENTS

2,060,224	11/1936	Lannert	164/312
2,807,844	10/1957	Hemphill	164/312
3,315,315	4/1967	Triulzi	164/113 X
3,584,345	6/1971	Beastrom	164/DIG. 10

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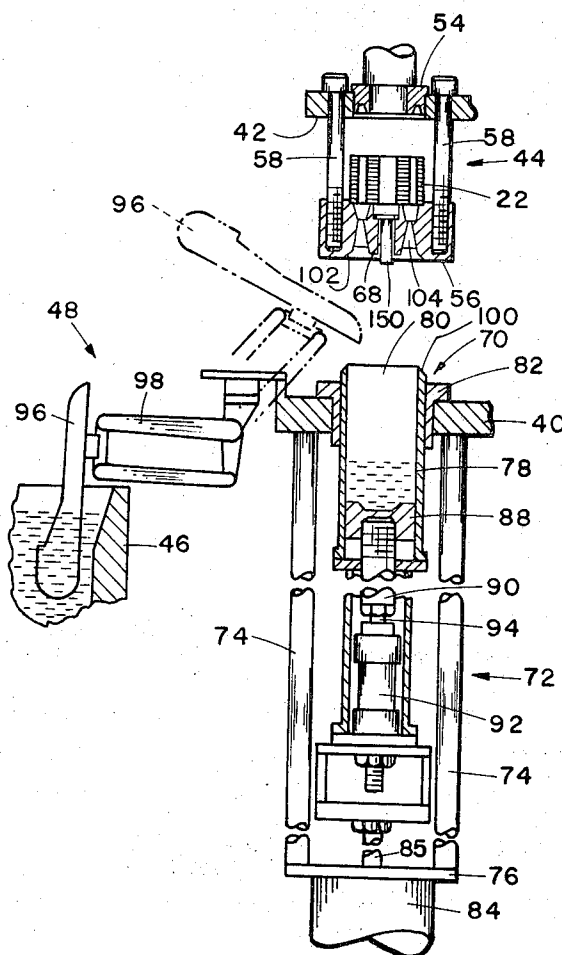
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[57]

ABSTRACT

Apparatus for automatically casting articles and particularly the end rings and conductor bars in a rotor. A mold having interconnected ends adapted to receive the body of the product into which the liquid material to be cast is injected, can be clamped, is movably seated over a chamber, reservoir or shot sleeve for the injectable material. By movement of either the mold, the reservoir or both, the mold and chamber can be separated sufficiently to permit free access to the reservoir for introduction of a charge of the liquid injectable material. In a more automated phase of the invention, a single injection station is provided with a plurality of molds movable between the injection station and other stations at which the mold is opened, sprue removed, finished product removed and the mold prepared for the next casting cycle.

6 Claims, 12 Drawing Figures



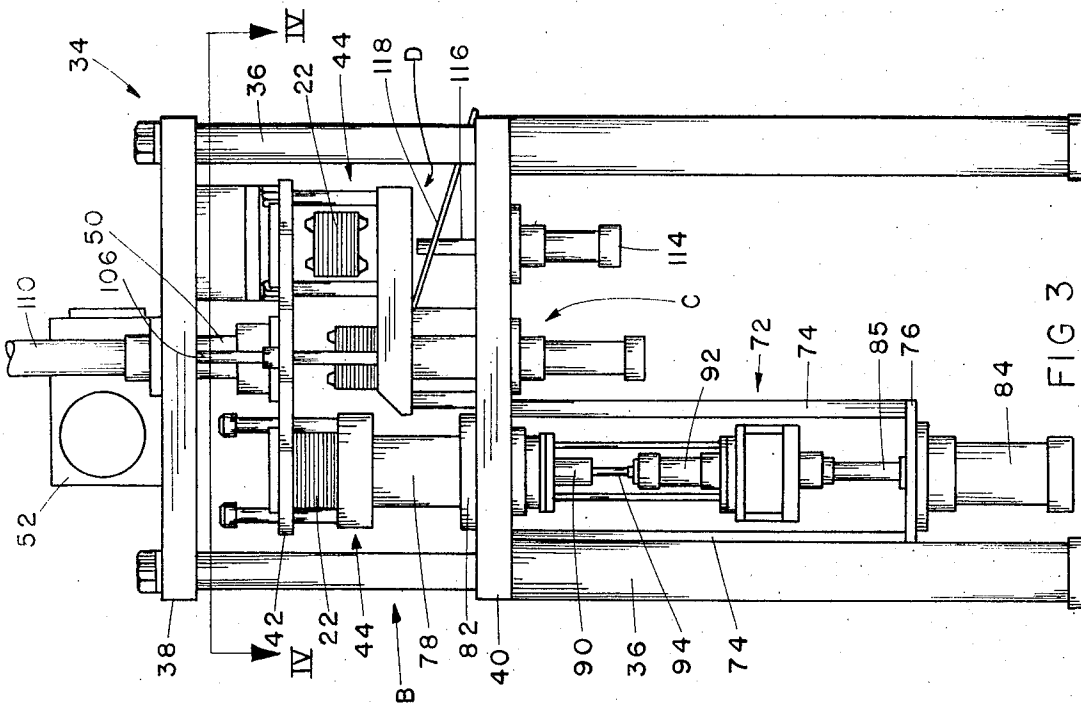


FIG 3

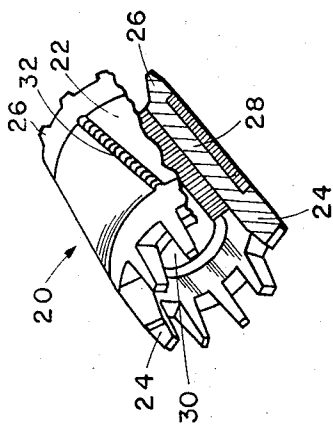


FIG 1

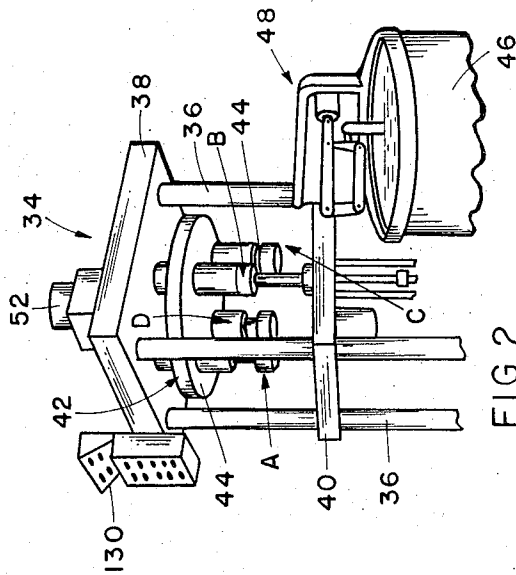


FIG 2

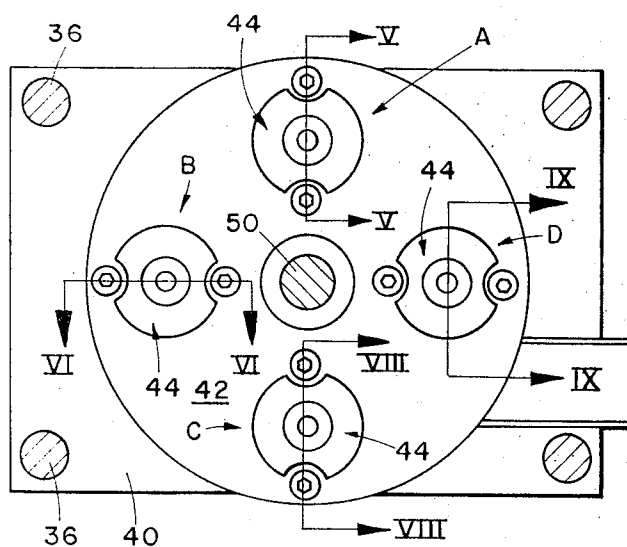


FIG 4

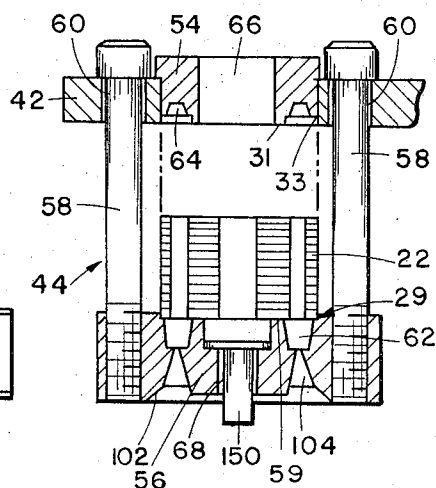


FIG 5

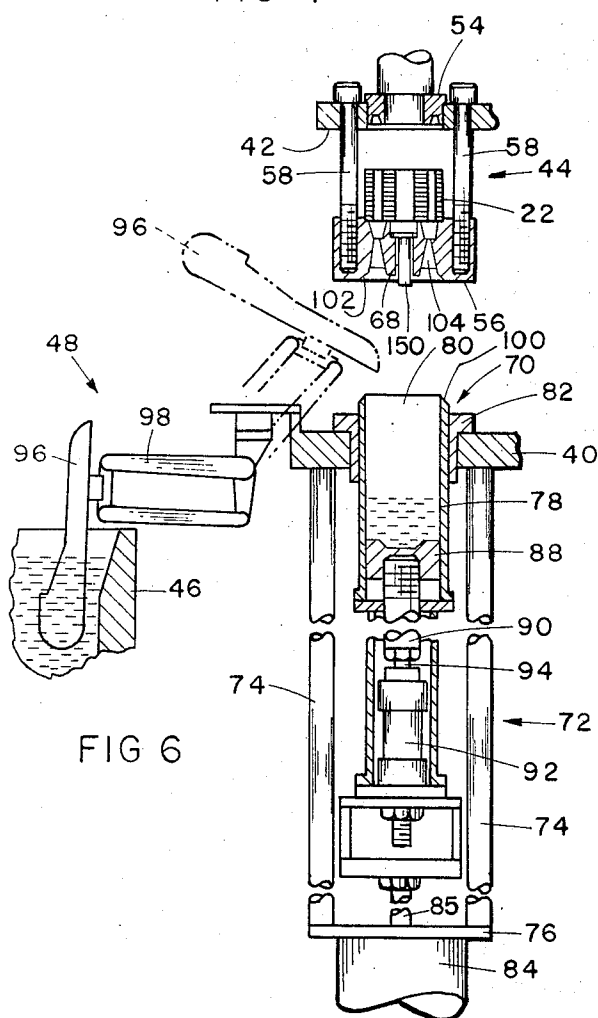


FIG 6

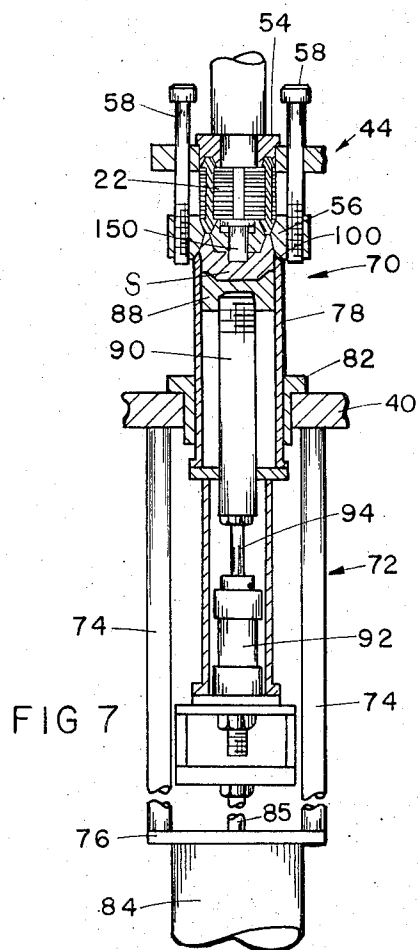


FIG 7

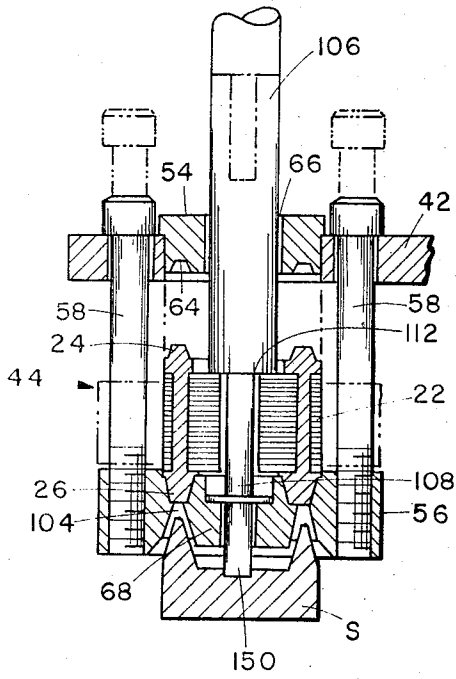


FIG 8

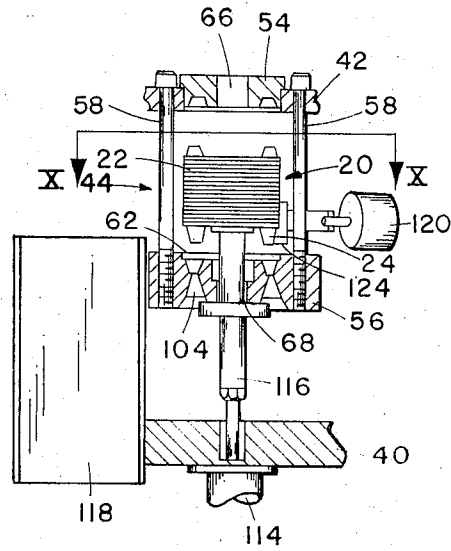


FIG 9

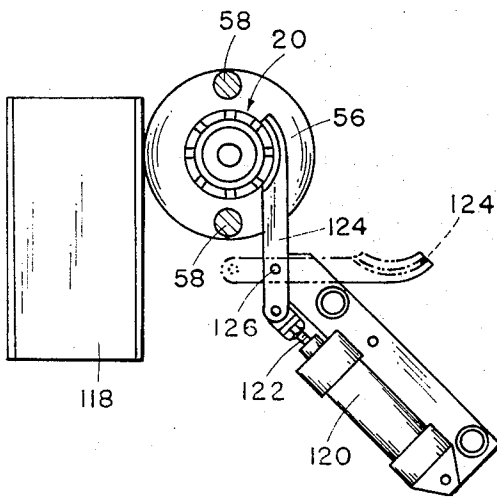


FIG 10

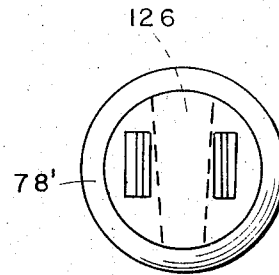


FIG 12

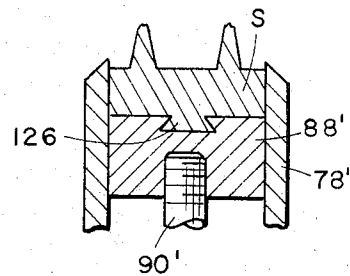


FIG 11

DIE CASTING APPARATUS

BACKGROUND OF THE INVENTION

The present invention relates to die casting wherein a shot sleeve for introducing a quantity of molten metal into a die cavity and a mold are mounted for movement such that the entire mold is separated from the open end of the shot sleeve to expose it whereby the shot sleeve is readily accessible for refilling. In a preferred embodiment of the invention, the apparatus and a method for die casting is illustrated as employed to cast the conductor bars and end rings in the rotor of a synchronous motor. The apparatus includes a plurality of mold members mounted on an indexing table. The mold members each include an upper die member having a cavity therein and a lower die member provided with a similar cavity which is mounted with respect to the upper die member for clamping engagement with the rotor lamination assembly between them. The mold members are fixed to and rotatable with an indexing means such that the molds may be sequentially positioned in operative relationship with a plurality of tool elements forming various work stations where die casting and removal operations may be simultaneously performed. The work stations to which the molds are indexed include a loading station, a clamping, casting and sprue removal station, a first removal station wherein the cast part is released from the upper die and a final station wherein the cast part is released from the lower die and removed from between the dies. Each station operates nearly simultaneously such that extremely high production is attained through the use of the automatic die casting machine of the present invention.

It is a primary object of this invention to provide a machine of this type in which the charged mold as an assembly and the shot sleeve are capable of separation to provide free and open access to the shot sleeve for recharging.

It is another object of the invention to provide a die casting apparatus for performing a number of die casting and removal operations simultaneously and automatically.

It is another object of the invention to provide a casting apparatus for automatically casting the conductor bars and end plates in a rotor.

It is yet another object of the invention to provide a charging means for a die casting apparatus for automatically clamping the die members while simultaneously inserting a predetermined quantity of molten material into the die.

It is another object of the invention to provide an apparatus for automatically removing the sprue from a cast part in an automatic die casting apparatus.

And, it is yet another object of the present invention to provide an apparatus for removing the cast parts automatically from between the die members in a die casting machine.

These and other objects of the invention are attained in a die casting apparatus including a mold member having a casting or die cavity formed therein and a gate forming an entrance to the cavity. A means for charging the mold includes a shot sleeve and a piston axially movable in the sleeve for forcing the molten material through the gate into the cavity. The shot sleeve is mounted for vertical movement into communicating relationship with a mold member positioned there-

above. Means are also provided for moving the piston axially through the shot sleeve to force the molten material through the gate into the cavity.

Other important features, objects, and the many advantages of the present invention will become readily understood to those skilled in the art upon reading the following description and with reference to the accompanying drawings illustrating a preferred embodiment thereof.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a perspective view partially broken away to illustrate details of a die cast rotor assembly fabricated in accordance with the present invention;

FIG. 2 is a perspective view of the die casting apparatus of the invention;

FIG. 3 is a side elevational view of the die casting apparatus shown in FIG. 2;

FIG. 4 is a cross-sectional view taken along the plane IV—IV of FIG. 3 illustrating the various work stations in the die casting apparatus;

FIG. 5 is a cross-sectional view taken along the plane V—V of FIG. 4 illustrating a die assembly having a rotor loaded therein for subsequent operation at a second operating station;

FIG. 6 is a cross-sectional view taken along the plane VI—VI of FIG. 4 illustrating the shot sleeve of the present invention positioned in charge-receiving position;

FIG. 7 is a view similar to FIG. 6 depicting the shot sleeve vertically raised to clamping and injection position;

FIG. 8 is a cross-sectional view taken along the plane VIII—VIII of FIG. 4 illustrating the release mechanism for the cast rotor from the upper die and the removal of sprue from the lower die structure;

FIG. 9 is a cross-sectional view taken along the plane IX—IX of FIG. 4 illustrating the removal of the cast rotor from the lower die;

FIG. 10 is a view partially in cross section, illustrating the mechanisms for removing the rotor from between the upper and lower die sections taken along the plane X—X of FIG. 9;

FIG. 11 is a fragmentary view of a modified piston head in the shot sleeve utilized to facilitate the removal of the sprue and the completed cast part from the upper die structure; and

FIG. 12 is a top, plan view of the modification shown in FIG. 11.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now to the drawings, in FIG. 1 the numeral 20 designates a partially completed rotor assembly produced in accordance with the present invention. The rotor assembly includes a plurality of rotor laminations 22 which are punched from thin sheet steel or other suitable material and which are held assembled between end rings 24 and 26 by a plurality of circumferentially arranged conductor bars 28 cast integrally with the end rings and laminations. The laminations are punched with a central bore 30 for mounting on an armature shaft or the like as is well known to those skilled in the art. In the practice of this invention, the stack of laminations 22 are conventionally assembled to a predetermined axial length. The laminations are skewed or twisted along their axial length and placed in compression where several welds 32 are made along the length

of the outer periphery. As will more fully described hereinafter, the end rings 24 and 26 and the conductor bars 28 are then cast through and on the ends of the lamination stack. As will also become apparent to those skilled in the art, the welds 32 serve only as a temporary holding fixture for maintaining the lamination stack under compression prior to and during the casting process. When casting is completed and the end rings and conductor bars are formed as an integral part of the lamination stack 22, they are machined from the peripheral surface in a conventional manner.

The casting apparatus utilized in the practice of this invention to produce the rotor or like part illustrated in FIG. 1 is illustrated in perspective view in FIG. 2. Basically, the apparatus of the present invention includes a supporting framework 34 having a plurality of vertical legs 36 upon which are mounted an upper support surface 38 and a lower supporting surface 40. A turntable or indexing means 42 is rotatably attached to the upper supporting surface 38 and is adapted to carry a plurality of molds 44 thereon simultaneously and sequentially through a plurality of work stations where various operations are performed on the work piece. A suitable supply of molten material, as for example aluminum, is provided in a temperature-controlled crucible 46 which is positioned adjacent the supporting framework 34. A ladle assembly 48 fixed on the crucible is provided to deliver a predetermined quantity of molten material for casting purposes as will be more fully described hereinafter.

As illustrated additionally in FIGS. 3 and 4, the indexing turntable 42 is mounted for rotation to the upper support 38 by means of a shaft 50 which is journaled in the upper support. Conventional drive means 52 is connected to the shaft and advances the turntable and the molds 44 carried thereon into an operating position with respect to each of the work stations. As illustrated in FIG. 4, for convenience, the various work stations are labeled with the letters A through D. A represents the first work or loading station while D represents the final work station where the completed cast part (as shown in FIG. 1) is removed from the apparatus. Station B includes provision for operating on the work piece by clamping and casting while station C is provided to remove the sprue and to release the cast part from the mold.

Referring briefly to FIG. 5, each of the molds 44 carried by the turntable 42 are identical in construction. Each mold or die assembly 44 includes an upper die section 54 and a lower die section 56. The lower section is mounted on a pair of shoulder screws 58 which are slidably received in openings 60 in the indexing plate 42. The lower die 56 is vertically movable with the shoulder screws with respect to the upper die assembly 54. Each die assembly 44 has a mold cavity formed therein conforming in configuration to the end rings 24 and 26 on the completed rotor assembly 20 as illustrated in FIG. 1. Preferably, the end ring 24 is formed in the cavity 62 provided in the lower die assembly while the end ring 26 is formed in the cavity 64 in the upper die assembly. The lower die has a circular recess 29 and the upper die a similar recess 33. These recesses are very shallow and receive the ends of the product body 22. The die cavities and die assemblies themselves are formed in a generally conventional manner well known to those skilled in the art. A detailed discussion, therefore, is not believed necessary to

describe the exact configuration of the die. It is, however, important to the practice of this invention that the facing die surfaces be shaped so as to receive a lamination assembly 22 between their facing portions and, as will be more fully described hereinafter, clampingly received between the upper and lower die sections in a manner such that molten material forced therein under pressure will not escape between the rotor and the die sections to form flash. In the loading station A, the die members 54 and 56 are positioned as shown in FIG. 5 that is, the lower die section is at maximum separation from the upper section and in position to have a lamination stack 22 placed between the dies and resting on the lower die 56. It is also noted that in the preferred embodiment of the invention, each of the upper and lower die assemblies 54 and 56 include central openings 66 and 68 respectively formed therein. The upper die has an annular depending ridge 31 and the lower die a similar upstanding ridge 59. These surround and seal the openings 66 and 68, respectively, and prevent entry of the casting material into these openings. Seated in the opening 68 is a knockout pin 150 having an enlarged head and a stem extending through the bottom of the opening — preferably even when the mold is charged extending slightly below the lower face of the mold. The thickness of the head of this pin is less than the depth of the enlarged upper portion of the opening 68, permitting the pin to reciprocate in the opening.

Referring now to FIGS. 6 and 7, the second operational station "B" is illustrated in greater detail. As previously mentioned, station B provides two functions, i.e., clamping and casting. To perform the clamping and casting functions, the mold is positioned vertically over the injection apparatus 70 at the station B. Injection apparatus 70 is vertically movable into and out of engagement with the mold assembly 44 and is fixed in a secondary support framework 72. The supporting framework 72 is formed of a plurality of support struts 74 fixed to and depending from the underside of the lower support 40 (FIGS. 3 and 7). A lower mounting plate 76 is at the lower end of the supporting struts 74.

The injection apparatus includes a shot sleeve 78 fixed for vertical movement with respect to the mounting plate 40 and the secondary supporting framework 72. The shot sleeve is basically an elongated metallic cylinder open at its upper end 80 and mounted for vertical movement perpendicular to the support plate 40 through a bushing 82 fixed in the support 40. Vertical movement of the shot sleeve is accomplished by means of a hydraulic cylinder 84 secured to and depending beneath the bottom plate 76. A piston rod 85 is extendable and retractable within the cylinder 84 to move the shot sleeve and its associated mechanisms vertically within the apparatus for engagement and disengagement with the lower die assembly.

The injection apparatus also includes a plunger 88 mounted for movement with the shot sleeve. The plunger is mounted for reciprocal movement within the shot sleeve by means of a rod 90 and hydraulic cylinder or actuator 92 mounted on the piston rod 85 and movable therewith.

The plunger 88 reciprocates the length of the shot sleeve 78. The rod 90 extends through the lower end of the shot sleeve 78.

As best illustrated by a comparison of FIGS. 6 and 7, when the shot sleeve is retracted as shown in FIG. 6, the piston 88 is also retracted to the bottom of the shot sleeve. The mold 44 is supported well above the end of the shot sleeve creating a substantial space between them (FIG. 6). This arrangement provides easy access to the open end of the shot sleeve.

The shot sleeve 78 is loaded with a measured quantity of molten metal from the crucible 46 by means of ladle assembly 46. The ladle assembly includes a ladle 96 pivotally mounted on a linking mechanism 98 such that it is shiftable between a molten metal receiving position in the crucible 46 and a pouring position (shown in phantom in FIG. 6) where a quantity of the molten metal is poured into the shot sleeve. As will be more fully described hereinafter, once the molten metal has been poured into the shot sleeve, the ladle automatically returns to its original position in the crucible 46 and refills.

OPERATION OF THE CASTING CYCLE

The casting cycle is illustrated in FIGS. 5, 6, and 7. A product body such as the rotor body 22 is placed in the open mold. It is seated in the recess 29. The loaded mold is positioned over the end of the retracted shot sleeve 78. A measured charge of the material to be cast, such as molten aluminum is poured into the shot sleeve by the ladle 96 and the ladle retracted. Actuation of the cylinder 84 raises the hot sleeve until its beveled edge 100 seats into the chamfered opening 102 in the lower face of the lower die half 56. Continued upward movement of the sleeve forces the lower die half 56 upwardly until the product body 22 seats against the upper die half 54. The cylinder 84 provides sufficient clamping force to effect a tight seal between the sleeve and the lower die half as well as between the product body and both die halves. The upper end of the product body seats in the cavity 33 (FIG. 5) in the upper die half 54 against the annular ridge 31. A seal is formed between the sidewalls of the cavity 33 and the product body as well as between the ridge 31 and the product body. A similar seal is formed between the product body and the ridge 59.

As soon as the product body has been clamped as described, the piston 88 is actuated, injecting the charge of material into the mold. The force of the piston is such as to force the material into the upper die half 56, through the product body 22 and fill the cavity in the upper die half 54. As the charge of material hits the knockout pin 150, the pin is forced upwardly against the product body 22 (FIG. 7). The stem of the knockout pin 150 provides a seal preventing the material from entering the central opening in the product body. The time lapse between charging the shot sleeve 78 from the ladle and completion of filling the mold is very short to prevent chilling of the material. This is particularly true in the case of materials having a high melting point and a high coefficient of thermal conductivity, such as aluminum.

Gates 104 provide passages for the material permitting it to enter the mold (FIG. 5). The gates 104, as is well known to those skilled in the art, form the entrance to the die cavities 62 and 64 through which the molten material is introduced. As the material solidifies, the end rings 24 and 26 (FIG. 1) and conductor bars 28 are formed in and on the product body 22. The cylinder 84 is then actuated in the opposite direction to

withdraw the shot sleeve 78 and piston 88 returning it to its lowered retracted position as shown in FIG. 6.

The excess casting material or sprue S formed between the gate 104 and the top of the piston 88 is then exposed below the lower die section. Normally, because of the bond between the solidified material and the upper and lower die sections, the two die sections remain closed even though the shot sleeve has been retracted. The present invention, therefore, also provides a mechanism for removing the sprue and for releasing the case part from between the die sections.

Referring to FIG. 8, the die sections are shown in position for operation at work station C where the sprue is removed and the cast part is released from the upper die section 54. At station C, a hydraulically operated piston rod 106 having an extended end 108 of reduced diameter is actuated by cylinder 110 mounted on the upper support surface 38 (FIG. 3). The piston rod extends through the opening 66 in the upper die section 54, through the center opening of the product body into the opening 68 in the lower die section when the cylinder 110 is actuated. The piston rod 106 has an upper portion of a greater diameter than the opening in the product body and a lower portion 108 of reduced diameter to pass through the product body. The length of the lower portion 108 is such that it will contact the knockout pin 150 before the upper portion of the rod contacts the product body. The rod forces the knockout pin down either disengaging the finished product from the upper die half or separating the sprue S from the casting and dropping it free of the mold or die. Should the force of breaking the sprue S from the casting be insufficient to separate the casting from the upper die half, the contact of the larger diameter portion of the piston 106 will strike the product body forcing it out of the upper die half. When the cast part has been released from the upper die and the sprue is removed, piston rod 106 is retracted and the turntable advances the mold assembly 44 to the next work station D.

At station D, as illustrated in FIG. 9, a cylinder 114 (see also FIG. 3) mounted on the lower supporting surface 40, has an extendable rod 116. The rod 116, when extended, raises the knock-out pin 150, lifting the casting 22 out of the lower die half. Simultaneously with the lifting of the casting out of the lower die section, an ejection mechanism as shown as FIG. 10 removes the completed rotor 20 from the casting apparatus and deposits it on a slide 118. The ejection mechanism includes a cylinder 120 having an extendable piston rod 122 connected to one end of a pivoted arm 124. With extension and retraction of the piston rod 122, the arm is free to pivot about a pivot pin 126 swinging the arm into position to push the completed cast rotor 20 from between the die members and into the removal slide 118.

The various simultaneous clamping, casting, and removal operations performed at the several work stations are programmed to operate in a timed sequence. The actuation and operation of various hydraulic cylinders to effect these functions as well as operation of the rotating mechanism 52 for effecting movement of the indexing means 42 are operative through suitable hydraulic and electrical circuits (not shown) which may be operated from a main control panel 130 (FIG. 1). The control panel is situated in a convenient operating position preferably near the loading station A. The in-

terconnection and operation of the control circuits will be readily apparent to those skilled in the art. Since the circuits are conventional and form no part of the present invention other than to ensure the proper sequential operation of the same, they will not be described in greater detail.

Depending upon the particular part being cast, it is sometimes not possible to remove the sprue and to release the casting from the upper die section as hereinabove described. This would occur, for example, when the cast part is solid and an opening cannot be provided in the upper and/or the lower die sections. An alternate arrangement for accomplishing this purpose is shown in FIGS. 11 and 12 wherein a modified piston 88a is provided in the shot sleeve 78. The modified piston 88a is provided with a tapered dove-tail mold cavity 126. When the molten material solidifies on the upper face of the piston, it conforms to the dove tail 126 so that as the shot sleeve and piston is moved to a retracted position as shown, for example, in FIG. 6, the cast part is pulled away from the upper die while the lower die section moves downwardly. When the lower die section reaches its lower limit of travel by the abutment of the head and the shoulder screws 58 against the top surface of the turntable 42, downward movement of the piston 88a will break the sprue away from the cast part at the gate 104. After the shot sleeve 78 is completely retracted, the piston 88a may be raised just slightly above and extend through the opening at the leading edge of the shot sleeve such that the sprue is exposed whereupon force exerted against the sprue from the narrow tapered portion of the dove-tail mold 126 toward the wide portion will result in the sprue sliding along the mold whereupon it will release from the piston 88a. This piston 88a is then retracted into the shot sleeve 78 in readiness to receive molten material via the ladle as previously described.

It will be recognized that those of the various components of this invention which have been stated to be hydraulically operated could, without departure from this invention, be operated pneumatically. It will also be recognized that while this invention has been described as applied to casting the conductor bars and end rings on an electrical rotor, the invention can be applied to various other applications. It is applicable to any casting situation in which the casting is applied to an existing body of sufficient strength to withstand the clamping pressures between the upper and lower dies necessary to effect a seal at the injection pressures produced by the piston 88. The injected material can be metallic or non-metallic.

The construction of the machine so that free access to the open end of the shot sleeve is provided is an important facet of the invention. It will be recognized that this can be accomplished by moving the mold toward and away from the shot sleeve as well as moving the shot sleeve as shown.

The invention, however, is particularly advantageous when the casting material is one having a high coefficient of thermal conductivity and, therefore, subject to rapid cooling once it has been discharged from the ladle. By separating the shot sleeve and die sufficiently to permit ready access to the shot sleeve, the charging of the shot sleeve can be accomplished rapidly and this operation can be fully automated. Once the ladle has been retracted, the shot sleeve and die can be joined and the casting material injected. Since this cycle can

be accomplished in a fraction of the time required by existing devices, the problem of chilling is eliminated. Further, by so reducing the cycle time, the necessity for installation of special thermal insulating liners in the shot sleeve is eliminated further reducing cycle time, cost and permitting automation of the equipment.

The apparatus is relatively simple in construction and in operation and when operated as hereinabove described, performs a variety of die-casting and removal operations simultaneously. Extremely high production rates are achieved resulting in the corresponding cost reduction. The novel vertical positioning movement of the shot sleeve adapted to receive the charge of molten material when combined with a novel clamping and simultaneous casting operations provides a method of die casting which is extremely reliable in its operation.

While a preferred embodiment of this invention has been illustrated and described, it will be recognized that other embodiments and modifications incorporating the teachings hereof may readily be made in the light of this disclosure. All modifications embodying the principles of this invention are therefore considered as included in the appended claims unless these claims by their language expressly state otherwise.

The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:

1. In a die casting apparatus having a mold and shot sleeve, an element supporting said mold in vertical alignment with the top of said shot sleeve, the improvement in said die casting apparatus comprising:

said shot sleeve having an open upper end; said mold having an upper die and a lower die movable with respect to each other for opening and closing said mold;

a member connecting said dies and restraining said lower die against downward travel below a predetermined position; and

means mounting one of said mold and said shot sleeve for movement toward and away from each other, said means in one position holding the top of said shot sleeve and the bottom of said mold in engagement and in another position holding said entire mold and said shot sleeve in spaced-apart relationship to provide access to the open top of said shot sleeve and permitting introduction of a measured quantity of casting material into said shot sleeve.

2. The die casting apparatus described in claim 1 wherein said shot sleeve is mounted on said means for vertical movement with respect to said mold.

3. The die casting apparatus described in claim 2 wherein a piston is mounted in said shot sleeve and an actuator for said piston for injecting casting material in said shot sleeve into said mold; said piston and actuator connected to said shot sleeve for simultaneous vertical movement with said shot sleeve.

4. In a die casting apparatus including a mold member having a casting cavity formed therein; means for charging said mold with a predetermined quantity of molten metal, said charging means including a shot sleeve and a piston axially movable in the sleeve for forcing molten metal into said cavity, the improvement comprising:

means mounting and moving said shot sleeve vertically into and out of communicating relationship with said mold;

said mold member including spaced-apart upper die and lower die sections adapted to receive an apertured product body therebetween, said lower die section being mounted for vertical movement by said mounting and moving means with respect to said upper die section to thereby vertically shift said shot sleeve into communicating relationship with said mold and shift said lower die section and clamp the product body between said die sections; and

means for driving said piston axially through said shot

sleeve to thereby force the molten metal into said cavity.

5. The die casting apparatus as defined in claim 4 and further including:

means for vertically shifting said shot sleeve between communicating and noncommunicating positions with said mold; and

means for placing a predetermined quantity of molten metal in said shot sleeve when said shot sleeve is in said noncommunicating position.

6. The apparatus of claim 1 in which said means includes means for causing said dies to move relative to each other to open and close said mold.

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