United States Patent [19]

Chandley et al.

[11] **3,900,064**

[45] **Aug. 19, 1975**

[54] **METAL CASTING**

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[73] Assignee: **Hitchiner Manufacturing Co., Inc.,** Milford, N.H.

[22] Filed: **Feb. 1, 1974**

[21] Appl. No.: **438,692**

Related U.S. Application Data

[62] Division of Ser. No. 312,138, Dec. 4, 1972, Pat. No. 3,863,706.

[52] **U.S. Cl.** **164/51;** 164/129; 164/306; 164/363; 164/361; 164/62; 164/66; 164/136; 164/335

[51] **Int. Cl.** **B22d 27/02**

[58] **Field of Search** 164/361, 363, 129, 306, 164/257, 337, 135, 136, 309, 61, 62, 63, 65, 77, 262, 119, 253, 256, 257, 255, 120, 133, 254, 350, 351, 48, 49, 51, 335; 249/109, 110, 118, 126

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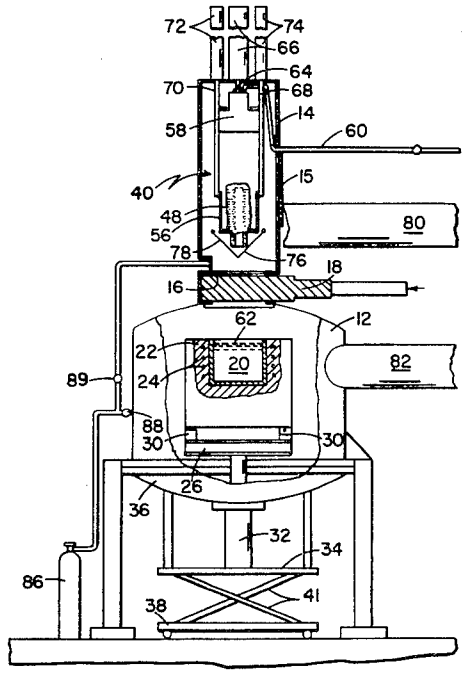
Primary Examiner—Francis S. Husar
Assistant Examiner—V. K. Rising

[57] **ABSTRACT**

Apparatus, methods and molds for casting metal in an evacuated-inert gas atmosphere. The apparatus comprises a sealable melting and mold pouring chamber having a sealable loading compartment mounted thereon with a conduit having a valve communicating therebetween and a sealable mold container having a bottom opening for sealing around the lower open end of a gas permeable refractory shell mold sealingly supported therewithin and extending downwardly therebeyond. Power means supports the container from above for movement between the chamber and compartment through the conduit to a melting crucible within the chamber directly beneath the container. The mold is loaded and unloaded with the container in raised position within the compartment while maintaining the chamber in evacuated condition by closure of the valve. A movable drip guard is mounted within the loading compartment between the valve and the container in its raised position. The refractory, gas permeable, shell mold preferred has a lower open end with a central vertical riser passage and may have a plurality of overlapping mold cavities clustered thereabout connected to the riser passage by gate passages. The cross section area dimension of the riser passage is at least one inch and five times as great as the cross section area dimension of a gate passage, so that molten metal can be drained from the riser passage to provide discrete unconnected cast parts from a single mold after the mold is separated from them.

1 Claim, 9 Drawing Figures



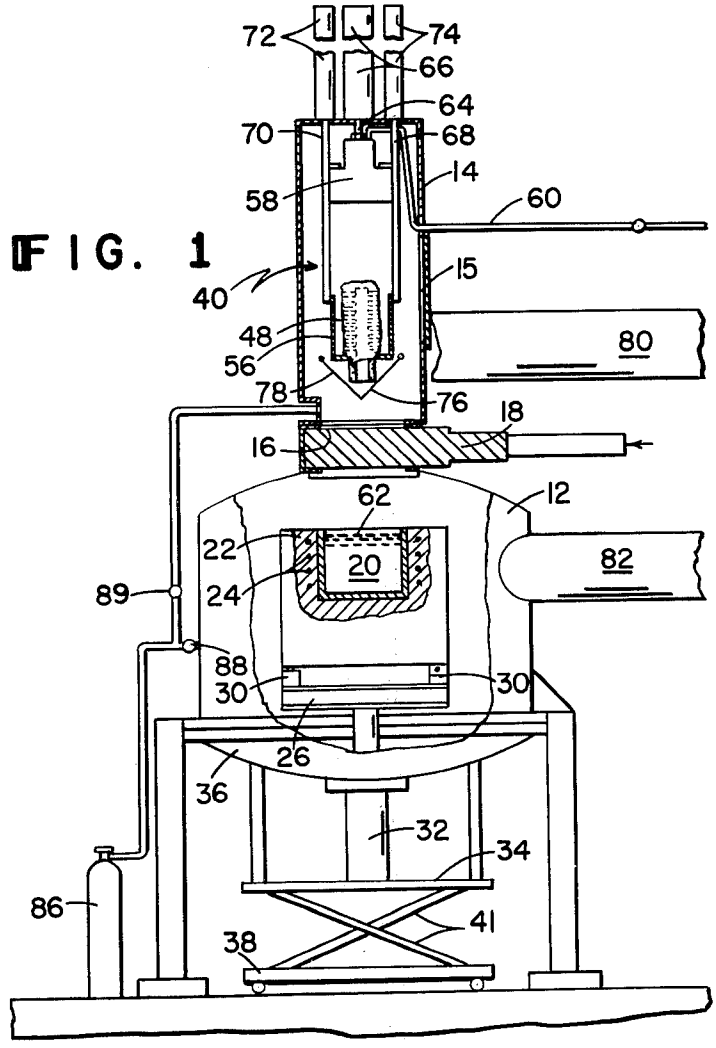


FIG. 1

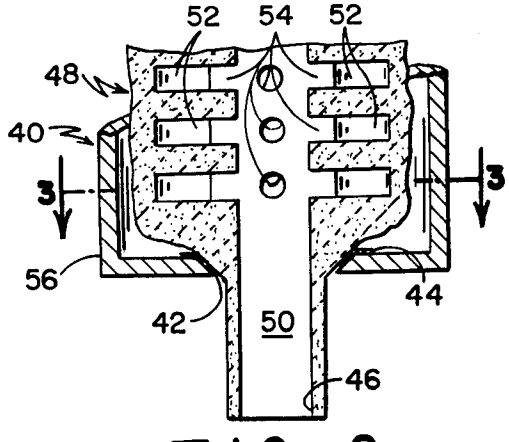


FIG. 2

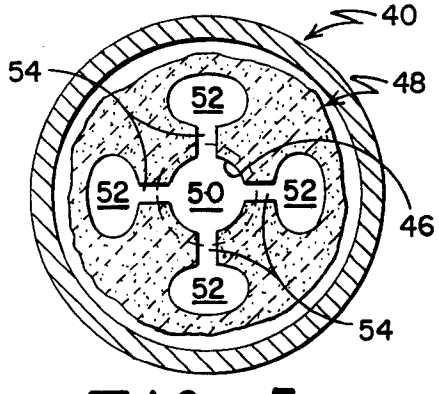
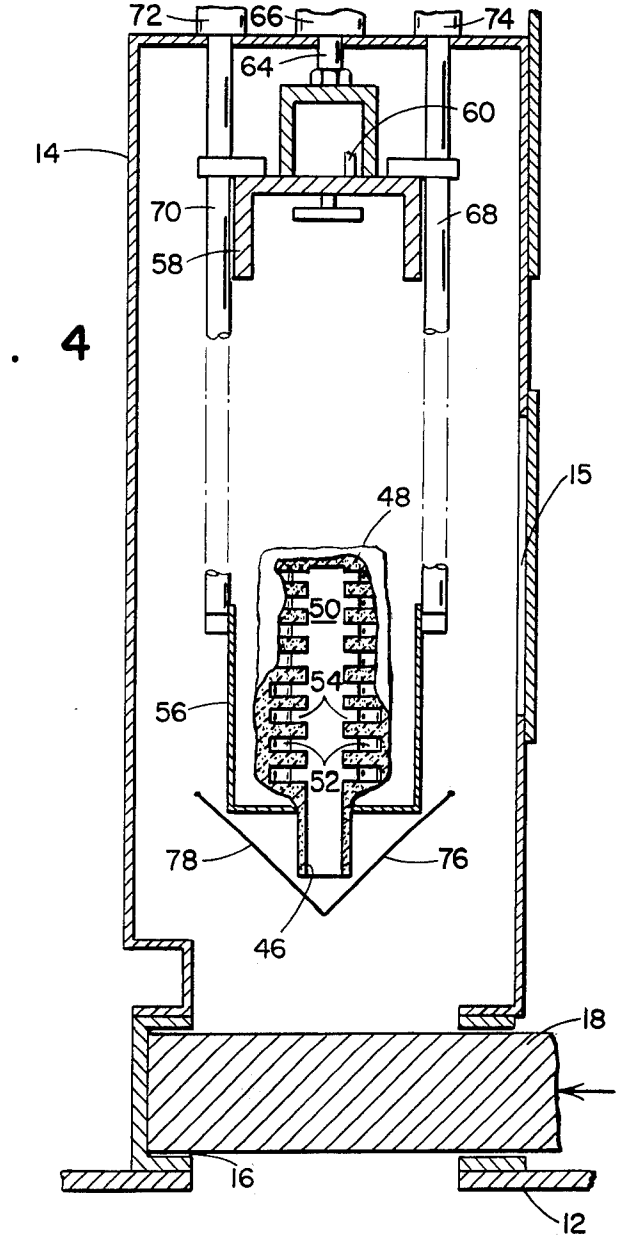


FIG. 3

FIG. 4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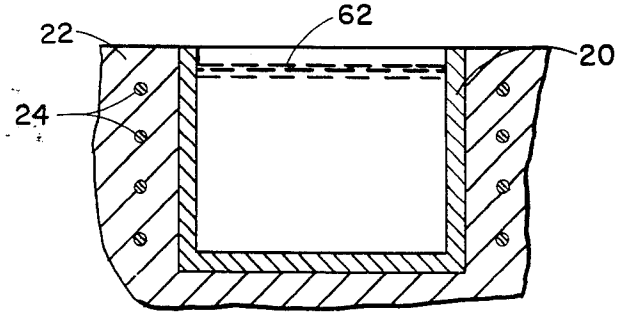
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FIG. 5

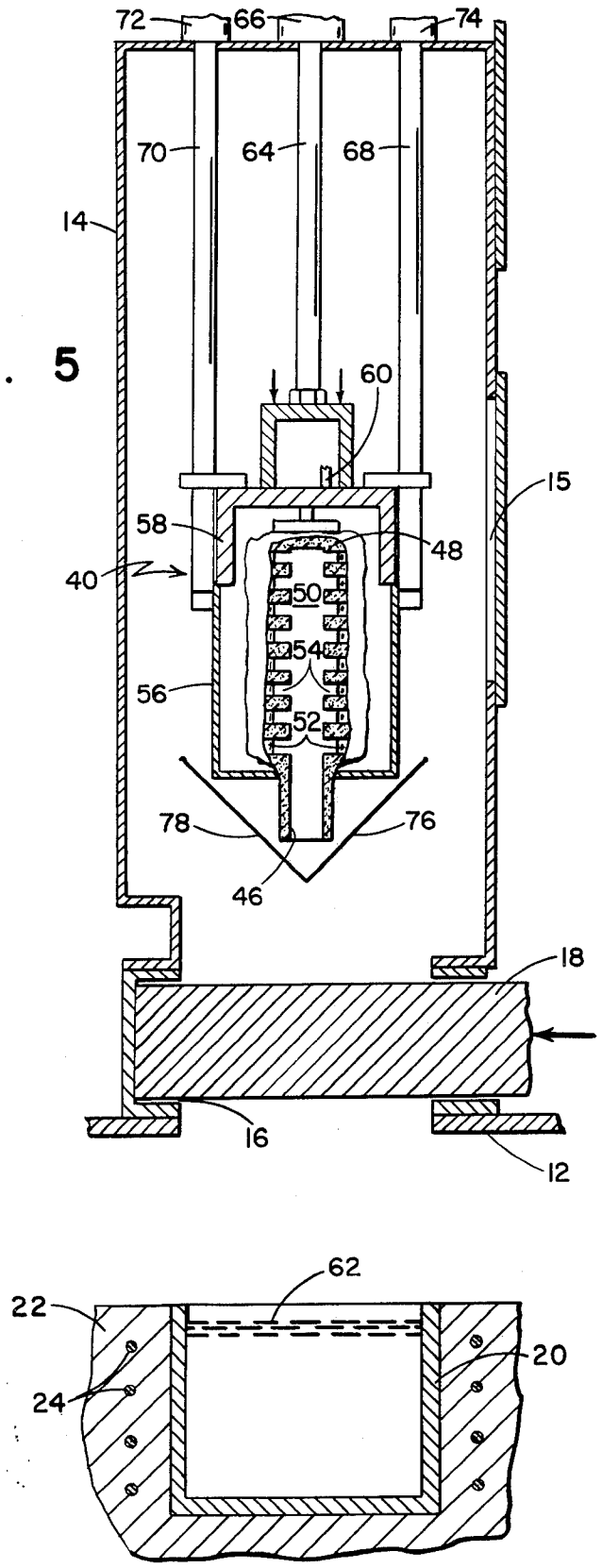
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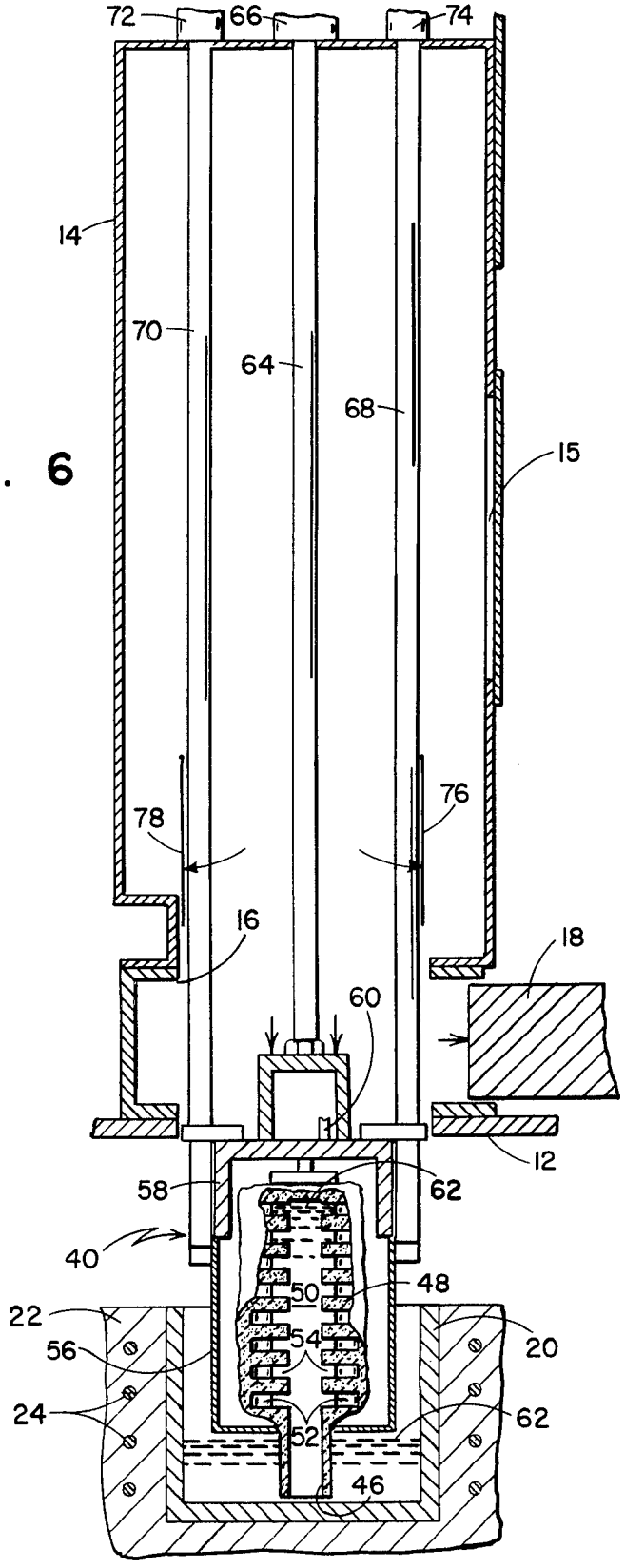
FIG. 6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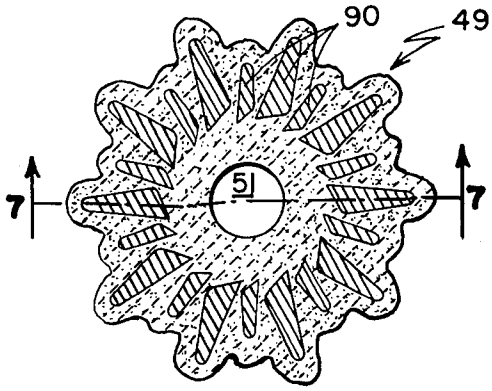

FIG. 8

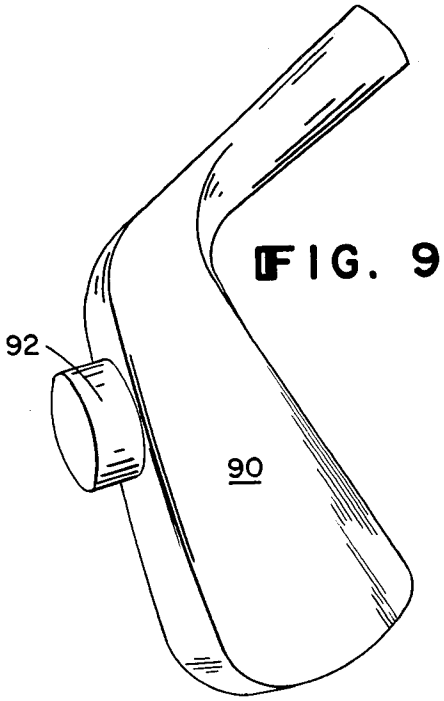

FIG. 9

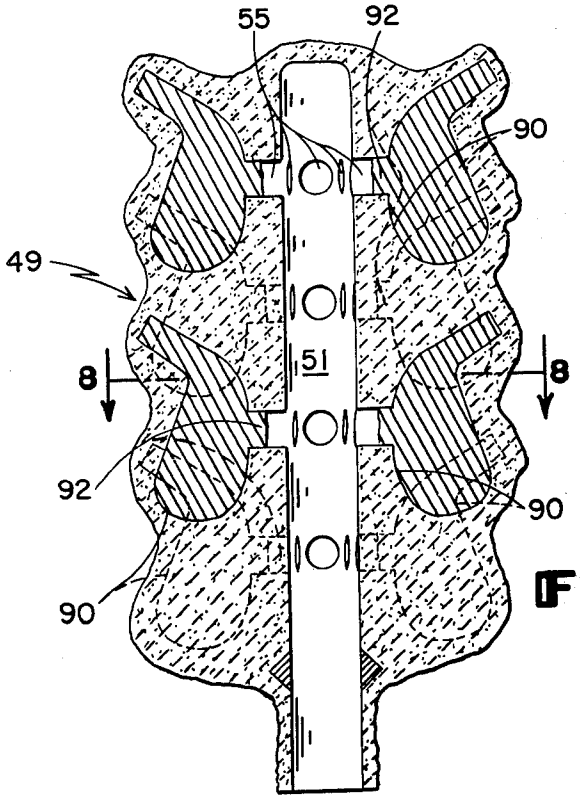

FIG. 7

METAL CASTING

This is a division of application Ser. No. 312,138, filed Dec. 4, 1972, and now U.S. Pat. No. 3,863,706.

This invention relates to metal casting apparatus, methods and molds and more particularly to the casting of metal in an evacuated-inert gas atmosphere and the casting of a plurality of discrete unconnected parts in a single mold.

The precision casting on a high production basis of metals which must be cast in an evacuated or inert gas atmosphere has long been a problem. In part, this is due to the time necessary to establish the required seals and to evacuate the apparatus, especially insofar as the relatively large melting and pouring chamber is concerned. There are also problems caused by the inclusion in the cast parts of dross or other impurities present on the surface of the molten metal. Additionally there are problems in separating the cast parts from the solid metal riser connecting them, which make necessary relatively wide separation between the mold cavities.

Accordingly, it is a major object of the invention to provide much improved apparatus, methods and molds for casting metal in an evacuated-inert gas atmosphere and one capable of operating in much reduced cycle times.

It is another object of the invention to provide a dross and impurity free molten metal surface for introduction into the mold.

It is still another object of the invention to provide novel methods and molds which provide automatic separation of the cast parts from one another and so make possible greatly increased part packing within the mold.

This is accomplished, according to one aspect of the invention, by providing, preferably in combination with a sealable melting and mold pouring chamber having a sealable loading compartment mounted thereon and valve and conduit means communicating therebetween,- that improvement which consists of a sealable mold container having a bottom opening for sealing around the lower open end of a gas permeable mold supported therewithin and extending downwardly therebeyond and power means supporting the container from above for movement between the chamber and compartment through the valve and conduit means. Preferably, the mold container has independent upper and lower relatively movable cup elements supported by suitable fluid actuated pistons for vertical movement. A melting crucible for holding molten metal is mounted within the chamber directly beneath the container. Means are provided for selectively varying the pressure of the chamber, compartment and container to fill the mold after lowering the container with the lower open end of the mold beneath the surface of molten metal in the crucible. The mold is loaded and unloaded with the container in raised position within the loading compartment while maintaining the chamber in evacuated condition by closure of the valve means. A movable drip guard may be mounted within the loading compartment between the valve and conduit means and the mold container in its raised position.

In another aspect, the invention provides dross and impurity free molten metal by inductive stirring in the crucible to cause outward surface movement to carry impurities away from the central area of the crucible to which the mold opening is introduced.

The invention, in still another aspect, provides a novel mold and method of casting in a refractory, gas permeable, shell mold comprising providing a mold having a lower open end with a central vertical riser passage having a plurality of preferably overlapping mold cavities clustered thereabout and connected to the riser passage by gate passages. The cross section area dimension of the riser passage is at least about one inch and five times as great as the cross section area dimension of a gate passage, so that molten metal can be drained from the riser passage after solidification in the mold cavities to provide discrete unconnected cast parts from a single mold after the mold is separated from them.

For the purpose of more fully explaining the above and further objects and features of the invention, reference is now made to the following detailed description of preferred embodiments thereof, taken together with the accompanying drawings, wherein:

FIG. 1 is a side view, partly broken away and in section, illustrating apparatus according to the invention;

FIGS. 2 and 3 are, respectively, detail side and top sectional views of a gas permeable shell mold of the invention mounted in the apparatus of FIG. 1;

FIGS. 4 through 6 are sectional side views of the operating elements of the apparatus of FIG. 1 showing successive steps in the operation of the methods of the invention;

FIGS. 7 and 8 are, respectively, detail side and top sectional views of another gas permeable shell mold of the invention such as may be mounted in the apparatus of FIG. 1; and

FIG. 9 is an isometric view of a cast part from the mold of FIGS. 7 and 8.

Referring to the drawings, and especially to FIG. 1 thereof, there is provided a sealable melting and pouring chamber 12 with a sealable loading compartment 14 mounted thereabove having a door 15. A conduit 16 having a slide valve 18 provides selective communication therebetween.

In chamber 12 is provided a melting crucible 20 having surrounding induction coils 24 which form part of an induction melting furnace 22. Furnace 22 is mounted on vertically movable platform 26 by means of interposed load cells 30 to permit the measuring of the weight of furnace 22 and hence that of the molten metal in crucible 20. Platform 26 is moved vertically by hydraulic cylinder and piston 32 mounted on support plate 34. Chamber 12 may be provided with a bottom closure 36 mounted on support plate 34, and the latter may be mounted on dolly 38 by scissors legs 41 for removal of furnace 22 from chamber 12.

More specifically as to the present invention, within chamber 12 and compartment 14 is mounted a sealable mold container, generally designated 40, having a bottom opening 42 including an annular seal 44 for sealing around the lower open end 46 of a gas permeable mold, generally designated 48, supported therewithin and extending downwardly therebeyond (FIG. 2). Mold 48 is of the precision refractory, gas permeable, shell type utilizing the "lost-wax" technique and is well known and widely used in the art for casting a wide variety of ferrous and non-ferrous metals and alloys, such as steel, aluminum and nickel-chromium alloys, for example.

As shown in FIGS. 2 and 3, the novel mold of the invention includes, connected to its open end 42, a central vertical riser passage 50 with a plurality of mold cavities 52 clustered thereabout and connected to riser passage 50 by gate passages 54, the transverse cross section area dimension of the riser passage, as seen in FIGS. 3 and 8, for example, being at least about one square inch and preferably no greater than about ten square inches in cross section area dimension and at least about five times as great as the transverse cross section area dimension of a gate passage, as seen in FIGS. 2 and 7, for example. Mold 49, shown in FIGS. 7 and 8, is similar in its construction and dimensional relationships to mold 48. It includes a central riser passage 51 and a plurality of longitudinally and circumferentially spaced gate passages 55 connecting the riser passage to a plurality of mold cavities circumferentially clustered thereabout, both in longitudinally and transversely radially overlapping relationship with regard to riser passage 51. In FIGS. 7 and 8, the mold spaces are shown as containing separated discrete cast parts 90 with short gate stubs 92 (FIG. 9) in accordance with the methods of the invention as hereinafter more fully explained.

Mold container 40, as best shown in FIGS. 4 through 6, includes a lower cup element 56 with bottom opening 42 and seal 44 (FIG. 2) and an upper cup element 58 with a gas communicating pipe 60. Each of said elements is independently supported from above for movement into sealing relationship with one another and for bodily vertical movement directly between an upper position within loading compartment 14 through conduit 16 to a lower position in chamber 12 with the lower end 46 of mold 48 beneath the central area of the surface 62 of molten metal in crucible 20. To this end, upper cup element 58 is suspended by piston rod 64 of central hydraulic cylinder 66 centrally mounted on the upper end of container 14 and lower cup element 56 is suspended by side piston rods 68, 70, respectively, of hydraulic cylinders 72, 74 mounted on the upper end of container 14 at the sides of central hydraulic cylinder 66. Hydraulic cylinders 66, 72 and 74 are operated in the conventional manner to provide power for moving piston rods 64, 68 and 70 as required.

A pair of pans 76, 78 forming a movable drip guard are mounted within loading compartment 14 above conduit 16 and are moved between their open and closed positions as shown in FIGS. 1, 4, 5 and 6 by suitable air cylinders (not shown).

Suitable vacuum pumps (not shown) are provided for evacuating loading container 40 through pipe 60, mold compartment 14 through pipe 80 and chamber 12 through pipe 82. A supply of inert gas, such as argon, is provided in bottle 86 for controlling the vacuum pressure in container 40 through pipe 60, chamber 12 through valve 88 and loading compartment 14 through valve 89 as desired.

In operation, with door 15 of loading compartment 14 and slide valve 18 open, and with lower container element 56 raised, crucible 20 may be charged by passing ingots directly through open drip guard doors 76, 78. Alternatively, cup element 56 may be removed and suitable tongs or the like may be used for carrying ingots to crucible 20 by downward movement of piston rods 68, 70. Slide valve 18 is then closed and chamber 12 evacuated through pipe 82 to a suitable high vacuum (about 10 microns) at which time the ingots may be melted by supplying power to induction coils 24.

After melting is completed, according to another aspect of the invention, the induction coils 24 surrounding crucible 20 holding the molten metal operate to stir it by moving it axially of coils 24 upwardly in the center of the crucible to cause outward surface movement to carry dross and other impurities away from the central area of crucible 20.

A molding cycle may be begun with the apparatus positioned as shown in FIG. 1. That is, with container cup elements 56, 58 separated, a mold 48 is placed in bottom opening 42 of bottom cup element 56 with its open end 46 therebelow (FIG. 2). Door 15 of loading compartment 14 is then closed, and the upper element 58 of container 40 moved downwardly into sealing relationship with its lower element 56 (FIG. 5). Container 40 and compartment 14 are then evacuated through pipes 60 and 80 to a high vacuum of about 10 microns. Then container 40, compartment 14 and chamber 12 are backfilled with argon to a suitable low vacuum (about 25 inches Hg).

After all three are at the same vacuum pressure, according to the methods of the invention, as shown in FIG. 6, slide valve 18 is opened and sealed container 40 lowered by piston rods 64, 68 and 70 past open drip guard doors 76, 78 until its open end 46 is below the surface 62 of the dross and impurity free molten metal in the central area of crucible 20. Lower cup element 56 is kept above the surface 62. The molten metal is then caused to enter vertically positioned mold 48 by lowering the pressure in container 40.

According to another important aspect of the invention, after the metal has solidified in mold cavities 52 and in at least part of their gate passages 54, the still molten metal in riser passage 50, preferably while open end 46 is kept below the molten metal surface 62, is caused to drain back by gravity flow into the molten supply of metal in crucible 20 by raising the pressure in container 40 by admitting argon through pipe 60. Thus, before open end 46 is moved above surface 62, the only metal left in the mold (FIG. 7) except near its open end 46, are the desired solidified cast parts 90 with short gate stubs 92 (FIG. 9) which it will be noted do not extend for the full length of the gate passages 55.

After molding is completed, container 40 is raised into compartment 14, drip doors 76, 78 are closed, and slide valve 18 is then closed. Thereafter, compartment 14 is raised to atmospheric pressure, its door 15 opened, container cup elements 56, 58 separated and mold 48 or 49 removed to complete the molding cycle. The mold 48 or 49 is then separated from the contained parts by conventional methods, providing a plurality of discrete, unconnected parts (FIG. 9).

This aspect of the invention can perhaps best be understood in connection with FIGS. 7 and 8 in which the cast parts (FIG. 9) are shown as present in the mold in the form of a plurality of discrete, unconnected parts 90 with short gate stubs 92, as is made possible by the dimensional relationships of the central riser and gate passages as set forth above. The elimination of the solid metal riser which in heretofore conventional practice connected all the parts together makes possible uniquely high density packing of the mold cavities to the extent that it would be impossible as a practical matter to separate the parts were they connected to a solid metal central riser. Such is the case with the mold

of FIGS. 7 and 8, which illustrates the actual practice of the invention in the casting of golf iron heads (FIG. 9).

When it is desired to replenish the supply of metal in crucible **20**, such may be done while maintaining the pressure in chamber **12** by placing an ingot in an appropriate pair of tongs in place of lower container element **56**, evacuating and pressurizing compartment **14** with argon, opening slide valve **18** and lowering the ingot into crucible **20** by piston rods **68, 70.**

What is claimed is:

1. A method of casting in a refractory, gas permeable, shell mold comprising the steps of

providing a mold having a lower open end with a central vertical riser passage having a plurality of mold cavities clustered thereabout connected to said riser passage by gate passages, the cross section area dimension of said riser passage is at least five times as great as the cross section area dimension of a gate passage,

providing a crucible having surrounding induction coils for holding molten metal,

stirring said molten metal by means of said coils causing outward surface movement thereof along its surface to carry impurities away from the central area of said crucible,

lowering the lower open end of said mold beneath the surface of the central area of said crucible,

causing molten metal to fill said riser passage and said mold cavities through said gate passages and

draining molten metal from said riser passage after solidification thereof in said mold cavities.

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