

R. J. MILLER
TEMPERATURE CONTROL MOLD

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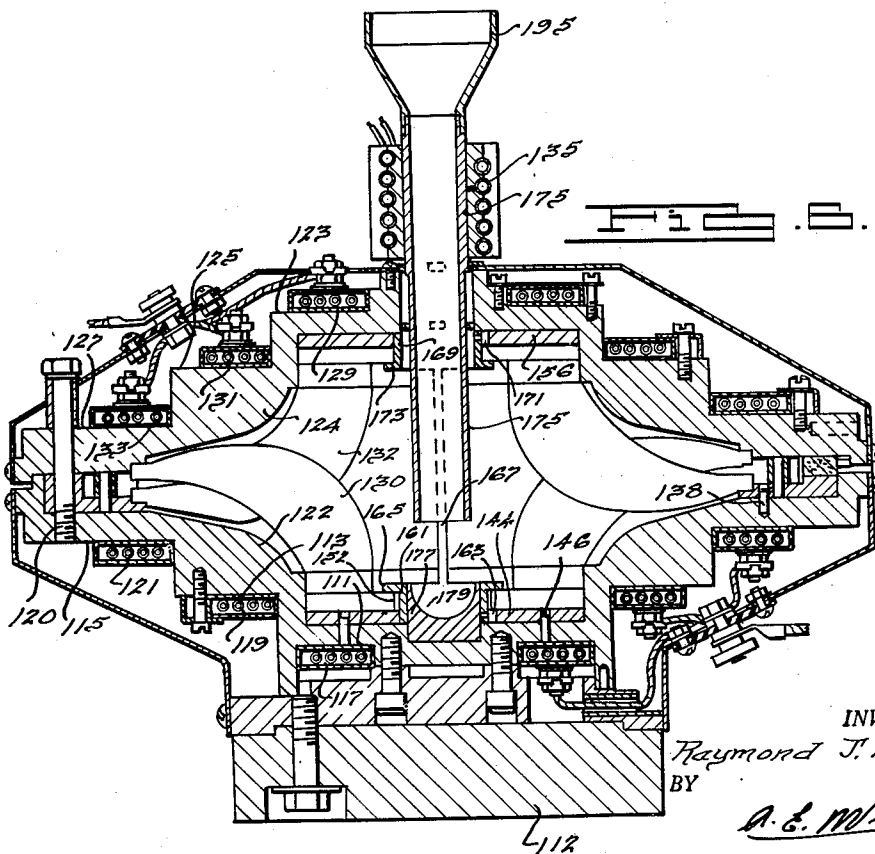
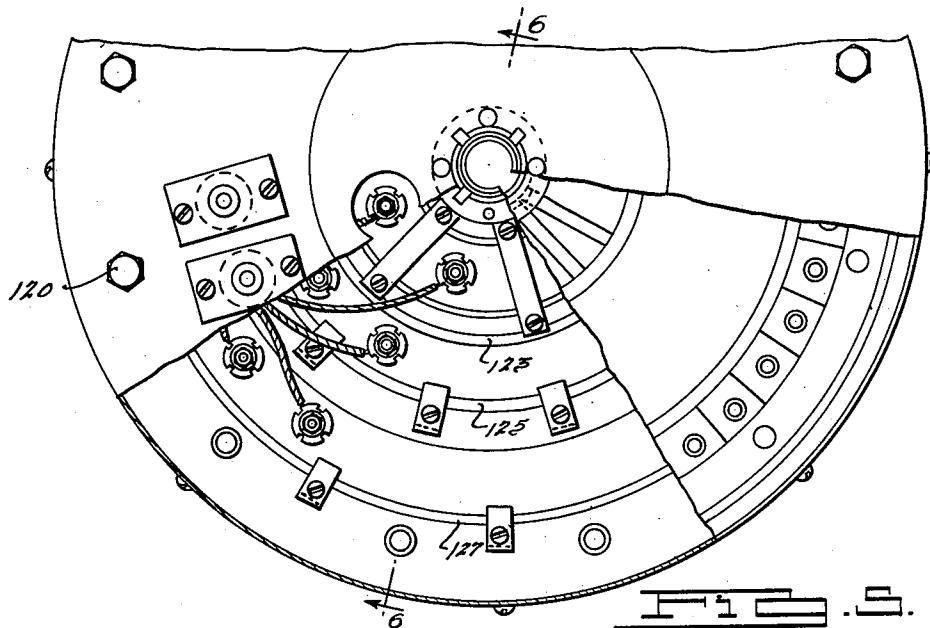
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3 Sheets-Sheet 2



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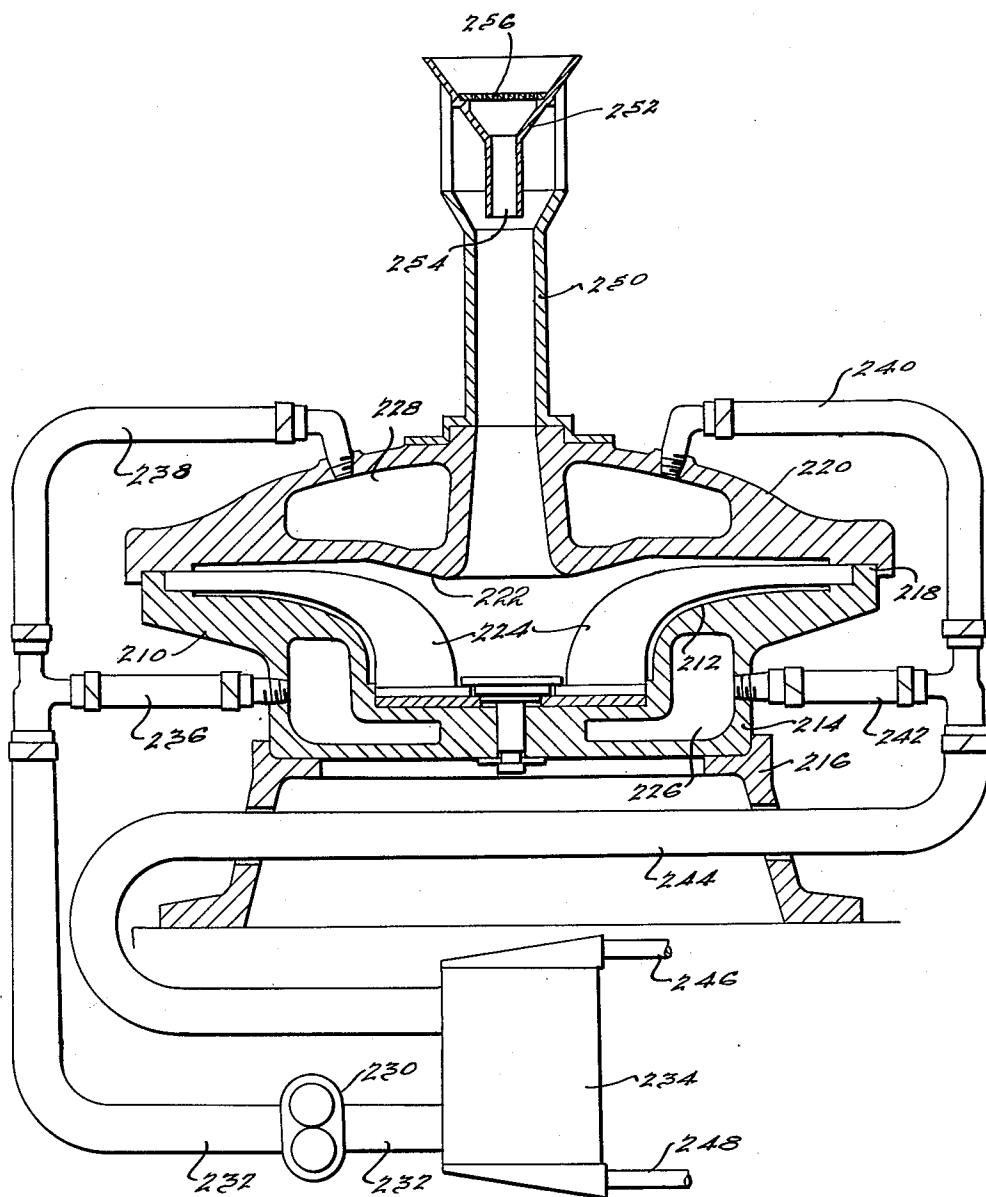
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TEMPERATURE CONTROL MOLD

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This invention relates to the art of casting, and more particularly to the control of the temperature of a mold before, during and after the filling of the casting cavity to insure complete filling of the mold, and to induce progressive solidification of the casting toward the feeder to prevent the formation of shrinkage strains.

Difficulties have heretofore been encountered in the casting of articles having thin sections because of the chilling effect of the mold on the molten material cast into a mold causing it to solidify before the casting cavity was completely filled. Partially formed castings or castings having high shrinkage strains resulted. In an effort to induce complete filling of the mold it has been customary to heat the molten alloy or metal considerably above its normal casting temperature to overcome the chilling effect caused by contact with the surface of the mold. Difficulties have been encountered where this practice has been resorted to because in the casting of certain materials under superheat conditions the physical properties of the material are destroyed, whereupon castings having low physical properties result. I have found that these difficulties can be overcome and castings having very thin sections can advantageously be cast if the mold is heated to such an extent as to prevent a chilling of the molten material until the casting cavity is completely filled.

In the casting of certain materials, such for example as aluminum, it is desirable that the casting be cooled rapidly to effect quick solidification of the molten alloy or metal to provide a smooth textured surface and fine grained metal structure. It has been impossible heretofore to effect rapid solidification of castings having thin sections because of the impossibility of completely filling the casting cavity before the molten material chills to such a point that the cast material will not flow readily to insure complete filling of the casting cavity.

An object of this invention is therefore to provide means for controlling the temperature of molds to insure complete filling of casting cavities having thin walled sections by maintaining the mold in a heated condition until the molten material has completely filled the casting cavity.

A further object of the invention resides in the provision of means for successively heating and cooling a mold to permit complete filling of the casting cavity and to insure rapid solidification of the casting to provide a solid casting of fine grained metal structure having high physical properties and a smooth textured surface.

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Another object is to flow a heat transfer medium over the walls of a mold to impart progressively decreasing heat to the mold as the feeder passage is approached to maintain molten material cast into the mold in the liquid state until the casting cavity is completely filled.

Yet a further object of the invention resides in the provision of fluid passages adjacent a mold to permit successive heating and cooling of the mold from points remote from the feeder toward the feeder to insure complete filling of casting cavities having thin walled sections, and to permit rapid solidification of the cast substance toward the feeder passage to minimize shrinkage strains and provide solid castings having smooth textured surfaces.

Still another object of the invention is to provide a rotatable casting machine having a centrally disposed feeder and a radially extended casting cavity wherein means are provided to successively flow heat transfer mediums over the mold adjacent the outer edges of the casting cavity toward the feeder to first heat the mold to insure complete filling of the casting cavity, and thereafter to chill the mold to effect rapid solidification of the casting.

Another object resides in the formation of molds adapted to receive spaced cores to provide a casting cavity having thin walled sections, and wherein controlled heat transfer means are employed to heat the mold to insure complete filling of the casting cavity, and to chill the mold to effect rapid and progressive solidification of the casting toward the feeder passage.

Other objects and advantages of this invention will be apparent from the following detailed description considered in connection with the accompanying drawings, submitted for purposes of illustration only and not intended to define the scope of the invention, reference being had for that purpose to the subjoined claims.

In the drawings wherein similar reference characters refer to similar parts throughout the several views:

Fig. 1 is a plan view, partly broken away, of a casting machine embodying the present invention.

Fig. 2 is a sectional view taken substantially on the line 2-2 of Fig. 1 looking in the direction of the arrows.

Fig. 3 is a fragmentary sectional view taken substantially on the line 3-3 of Fig. 1, looking in the direction of the arrows.

Fig. 4 is a fragmentary sectional view taken

substantially on the line 4—4 of Fig. 1, looking in the direction of the arrows.

Fig. 5 is a view similar to Fig. 1 showing a modified form of the invention.

Fig. 6 is a sectional view taken substantially on the line 6—6 of Fig. 5, looking in the direction of the arrows.

Fig. 7 is a longitudinal sectional view of a casting machine embodying a still further modified form of the invention.

Before explaining in detail the present invention it is to be understood that the invention is not limited in its application to the details of construction and arrangement of parts illustrated in the accompanying drawings, since the invention is capable of other embodiments and of being practiced or carried out in various ways. Also it is to be understood the phraseology or terminology employed herein is for the purpose of description and not of limitation.

Referring to Figs. 1 to 4 it will be noted that a bottom heat transfer jacket 10 is secured to a rotatable base 12, and is provided with an upwardly extending flange 14 at its periphery. The flange 14 supports a downwardly extending flange 16 carried by an upper heat transfer jacket 18 secured to the bottom heat transfer jacket 10 as by studs 20. Bottom and top mold lining members 22 and 24 are interposed between the bottom and top heat transfer jackets 10 and 18 respectively, and have radially extended portions 26 and 28 adapted to be engaged by the bottom and top heat transfer jackets 10 and 18 inside of the flanges 14 and 16 respectively.

A plurality of removable core members 30 and 32 may be interposed between the bottom and top mold lining members 22 and 24 to contour the space between the mold lining members 22 and 24 in any desired configuration such for example as to form an impeller having passageways to direct the flow of air or other fluid.

The cores 30 and 32 are formed of a moldable substance. Where the article being cast is formed of an alloy such as aluminum, brass or any substance having a pouring temperature of less than approximately 2,000° F., the cores may be formed of plaster or the equivalent. In instances where the article being cast is formed of a substance having a pouring temperature in excess of approximately 2,000° F., such as steel and the higher melting alloys, the cores 30 and 32 are formed of silicon, crastolite or other such suitable substance.

The outer ends of the cores 30 and 32 are bonded to fixtures having spaced apertures to receive pins carried by a core locating ring 34 positioned on the flat outer portion 26 of the bottom mold lining member 22 between the flange 14 and an upwardly extending flange 36 formed on the bottom mold lining member 22. The core locating ring 34 is positioned in a predetermined location relative to the bottom mold lining member 22 by means of a pin 38 carried by the lining member 22 to project into an aperture in the mold locating ring 34.

The inner ends of the cores 30 and 32 are bonded to core locators 40 having rectangular body portions and pins 42 projecting into the core forming substance. A bottom core index plate 44 having radially extended slots is provided to receive the rectangular body portions of the core locators 40. The bottom core index plate 44 is positioned in a predetermined location relative to the bottom mold lining member

22 by means of a pin 46 carried by the index plate 44 and extending into an aperture in the mold lining member 22.

The core locating ring 34 at the outer ends of the cores 30 and 32, and the bottom core index plate 44 at the inner ends of the cores 30 and 32 are accurately located relative to each other by means of their associated locating pins 38 and 46 projecting into apertures in the bottom mold lining member 22.

A spacing tube 48 is provided with a flange 50 to engage the inner ends or toes 52 of the cores 30 to hold the inner ends of the cores in place. The spacing tube 48 is provided with a downwardly extending projection 54 to project into an aperture in the core index plate 44 to locate the tube 48 in a predetermined position relative to the lower core index plate 44 and core locating ring 34.

An upper core index plate 56 having radially extending grooves is provided to receive the rectangular body portions of the upper core locators 40 having pins 42 bonded in the bodies of the cores 32. The spacing tube 48 is provided with an axially extending slot to receive an inwardly extending projection 58 carried by the upper core index plate 56 to accurately locate the upper core index plate 56 with reference to the lower core index plate 44 and the outer core locating ring 34.

It will be noted that the inner and outer ends of the lower and upper cores 30 and 32 are thus accurately located relative to each other to insure uniform spacing of the cores. Core members of suitable configuration can be formed and accurately located at spaced points in mold lining members of suitable contour to insure the formation of articles of virtually any complexity including very thin walled sections. All of the cores of any necessary contours to shape the desired casting cavity may be formed in a single core box to insure identity of contour of the core members.

A pressure ring 59 is positioned on the core locating ring 34 to engage the outer ends 60 of the cores 30 to hold them in place. The top mold lining member 24 has a locating flange 50 to accurately locate the inner edge of the core pressure ring 58.

A heat transfer separator 62 is secured to the bottom heat transfer jacket 10 and is separated therefrom by means of spacers 64 to divide the space between the inner surface of the heat transfer jacket 10 and the outer surface of the mold lining 22. Inlet passages 64 for heat transfer mediums are formed in a housing 66 secured in the rotatable base 12 and communicate with a space 68 between the heat transfer separator 62 and the bottom heat transfer jacket 10. A portion of the heat transfer mediums flow around the ends of the separator 62 into a space 70 between the separator 62 and the outer surface of the mold lining member 22. The heat transfer mediums flow radially inwardly along the outer surface of the mold lining member 22, and escape through outlet openings 72 and passage 74 leading to waste. As illustrated in Fig. 3, a metered portion of the heat transfer mediums flow through aligned passages 76, 78 and 80 formed in the outer edges of the bottom and top coolant jackets 10 and 18 into a coolant space 82 formed between the inner surface of the upper heat transfer jacket 18 and the outer surface of the upper mold lining 24.

The heat transfer mediums flow radially inwardly along the outer surface of the upper mold

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lining member 24 from the passages 80 through the space 82 to outlet passages 84 in fittings 86 inter-connected by conduits 88, passageways 90, conduits 92 and fittings 94 with passages 96 communicating with the passage 74 leading to waste. It will be noted that the outlet passages extend through the outer flanges of the heat transfer housings 10 and 18 in such a manner as not to interfere with rotation of the unit.

Attention is directed to the fact that the heat transfer mediums are introduced into the rotatable housing 66 through a fluid tight gland fitting that allows rotation of the unit without permitting the escape of the heat transfer mediums introduced to successively heat and chill the mold forming members.

It will be apparent that the mold lining members 22 and 24 may be heated and cooled by heat transfer mediums flowing inwardly over the outer surfaces of the mold lining members from their peripheries toward the center.

As illustrated in Fig. 4 vent forming members 98 may be positioned in the core locating ring 34 to permit the escape of entrained air and gases formed as molten alloy or metal is introduced into the mold to fill the casting cavity. The vent forming members 98 may be of any desired form such for example as sintered powdered metal, porcelain or fibrous material. As illustrated in Fig. 1, the vent members 98 are relatively closely spaced to permit the free escape of air and gases from the mold as the casting cavity is filled.

The spacing tube 48 interposed between the bottom and top mold lining members 22 and 24 is provided with a plurality of spaced openings 99 to permit molten alloy or metal to flow radially outwardly to fill the casting cavity formed between the cores 30 and 32 and the inner surfaces of the lower and upper mold lining members 22 and 24 respectively. A sprue tube 97 is positioned in alignment with a centrally disposed opening in the upper heat transfer jacket 18 and the upper mold lining member 24 to permit filling the mold. A pouring funnel 95 is positioned on the sprue 97 to facilitate filling the mold and to increase the hydrostatic pressure on the casting.

The operation is as follows: When the mold is assembled as illustrated in Figs. 1 to 4, a heat transfer medium such for example as steam, hot water, hot oil or other suitable heat carrying medium is circulated through the heat transfer passages and flows radially inwardly through the spaces 70 and 82 over the outer surfaces of the mold lining members 22 and 24 toward the sprue or feeder passages. It will be apparent that the outer edges of the mold lining members 22 and 24 will be subjected to a greater degree of heat than the inner portions, and that the heated fluid flows in the direction opposite to the flow of molten alloy or metal as the casting cavity is filled.

When the mold has been heated to the desired temperature, the casting head is rotated to evenly distribute molten alloy or metal in the casting cavity between the cores and the inner surfaces of the mold lining members by centrifugal diffusion. When the proper speed of rotation has been attained, molten alloy or metal is introduced through the funnel 95, sprue 97 and spacing tube 48, to fill the casting cavity.

The flow of the heated fluid through the passages 70 and 82 maintains the mold lining members 22 and 24 at sufficiently high temperature

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to prevent solidification of the alloy or metal before the casting cavity is completely filled. Castings having very thin walled sections can thus be readily cast because the molten alloy or metal is not subjected to sufficient chilling or cooling action to cause it to coagulate or freeze before the casting cavity is completely filled.

As soon as the casting cavity is completely filled, cooling fluid such as for example cold water, oil or other suitable heat transferring medium is circulated through the transfer system to absorb heat from the upper and lower mold lining members 24 and 22 respectively to effect rapid solidification or freezing of the molten alloy or metal to quench the casting and provide a solid casting having a smooth textured surface and fine grained structure.

Since the heat transfer mediums flow radially inwardly as the molten alloy or metal is distributed radially outwardly in the casting cavity, the outer edges of the mold lining members are successively subjected to greater heating and cooling as heated and cooled fluids are successively distributed through the heat transfer passages. When heated fluid is circulated through the heat transfer system, the outer edges of the mold lining members absorb a greater proportion of heat and as the outer edges of the mold lining members heat up a progressively increasing proportion of the heat is transferred to portions of the mold lining members spaced radially inwardly. The outer edges of the mold lining members and casting cavity are thus maintained at somewhat higher temperatures than portions spaced radially inwardly toward the feeder or sprue. There is therefore less tendency for the molten alloy or metal to coagulate or solidify as the mold is filled until the casting cavity is completely filled. The formation of very thin cast sections is thus insured.

When the casting cavity has been filled and cold fluid is circulated through the transfer system, the outer edges of the mold lining members are first subjected to the cooling effect. As the cooling transfer medium flows inwardly it is progressively heated and therefore absorbs progressively less heat as it flows radially inwardly toward the sprue or feeder. As heat is progressively transferred from the mold lining members and the casting being formed more heat will progressively be absorbed from portions of the mold and casting spaced radially inwardly toward the feeder or sprue. The solidification of the molten alloy or metal will therefore start at the outer periphery of the casting and progress inwardly because during the initial stages the coolant absorbs relatively large quantities of heat near the periphery and therefore cannot absorb as much heat as it flows inwardly. When the periphery has cooled off and has solidified, the proportion of heat transferred to the coolant from points adjacent the periphery diminishes, and more heat is absorbed from portions of the casting spaced progressively closer to the feeder.

It will be noted that a metered quantity of coolant is directed to the heat transfer space 82 through the passageways 76, 78 and 80 illustrated in Fig. 3, and that more coolant is circulated through the heat transfer space 70 around the end of the separator 62. The lower portions of the casting cavity are therefore subjected to more cooling action than the upper portions and will therefore solidify more rapidly than the upper portions.

When a molten substance solidifies, gases are

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forced through the molten substance as the solidification progresses. Since solidification of the casting progresses inwardly from the periphery and from the bottom of the casting cavity toward the top, the gases are driven ahead of the progressive solidification and are forced into the sprue or feeder passage. Solid castings free from gas inclusions and porosity are thus formed.

The embodiment of the invention illustrated in Figs. 5 and 6 is similar in many respects to that illustrated in Figs. 1 to 4. Corresponding parts have therefore been given corresponding reference numerals with the addition of 100.

The lower mold lining member 122 has a plurality of radially spaced steps 111, 113 and 115 to receive heat imparting means such for example as electrical resistance elements or strip heaters 117, 119 and 121. The upper mold lining member 124 also has a plurality of suitably spaced steps 123, 125 and 127 to receive heating elements 129, 131 and 133. A heating element 135 is positioned around the sprue 197 to heat the feeder to prevent chilling of the alloy or metal as it is introduced into the casting cavity.

The heating characteristics of the elements associated with spaced portions of the mold lining members can be varied to permit the application of the desired heat intensity to various portions of the mold to insure maintaining the alloy or metal in the molten condition until the casting cavity is completely filled. Castings of complex configurations having thin walled sections can thus be readily cast.

It will be apparent that any type of heating means may be employed, and that if desired the mold lining members 122 and 124 may be of uniform thickness throughout rather than having a plurality of stepped sections. If desired the mold lining members may be of progressively thinner material as the periphery is approached to insure heating the peripheral portions of the mold to a higher degree than the portions spaced closer to the feeder to maintain a cast molten substance in the fluid state until the casting cavity is completely filled, and to insure progressive solidification from the periphery toward the feeder.

A spacer member extends between the lower and upper core index plates 144 and 156. The spacer member has a lower cylindrical member 161 adapted to project into the lower core index plate 144 and be located with reference thereto by a fin 163. A radially extended flange 165 carried by the member 161 is provided to overlie the toes or inner ends 152 of the cores 130. The spacer member has vertically extending struts 167 supporting an upper cylindrical member 169 projecting into the upper core index plate 156. A fin 171 locates the plate 156 in predetermined angular relation relative to the lower core index plate 144. The upper cylindrical member 169 has a radially extended flange 173 to engage the toes or inner ends of the cores 132.

A pouring spout 175 extends through the upper mold member 124 to a point adjacent the bottom of the casting cavity. A removable insert 177 formed of non-conducting material may be positioned in the lower cylindrical member 161 beneath the pouring spout 175. The insert 177 has a concave reservoir 179 to receive molten alloy or metal from the pouring spout 175 to minimize thermal shock and distribute the alloy or metal to the casting cavity.

Fig. 7 illustrates the invention applied to the static or non-rotating method of casting. A lower mold member 210 having a mold surface 212

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is provided with a downwardly extending base 214 to engage a base or support 216. The lower mold member 210 has an upwardly extending flange 218 to receive and support an upper mold member 220 having a mold surface 222.

A plurality of removable cores 224 may be interposed between the mold surfaces 212 and 222 to cooperate therewith in the formation of a casting cavity of any desired contour or dimensions. The inner and outer ends of the cores 224 may be located and secured in place in the manner disclosed in the embodiments of the invention shown in Figs. 1 to 6 or in any manner constituting the mechanical equivalent thereof.

The lower and upper mold members 210 and 220 may be jacketed to provide heat transfer chambers 226 and 228 whereby heated and cooled fluids may be circulated to heat and cool the surfaces of the mold members and the casting cavity.

A closed circulating system may be provided to heat or cool the casting cavity forming molds. A pump 230 positioned in a conduit 232 may be provided to withdraw fluid from a heat exchanger or radiator 234 having spaced inlet and outlet passages. The conduit 232 supplies heated or cooled fluid to branch conduits 236 and 238 communicating with the chambers 226 and 228 of the lower and upper mold members 210 and 220 respectively. Spaced outlet conduits 240 and 242 are provided to receive fluid after it has circulated through the chambers 226 and 228 and direct it through a return conduit 244 to the heat exchanger or radiator 234.

When it is desired to heat the mold members preparatory to a casting operation, heated fluid is pumped through the circulating system by the pump 230. Heated fluid may be introduced into an upper passageway 246 and cooled fluid removed from a lower passageway 248 of the heat exchanger 234, to impart heat to the medium circulating through the chambers 226 and 228 to heat the mold members.

A feeder passage 250, preferably centrally disposed with reference to the casting cavity may extend above the casting cavity to permit subjecting the casting to hydrostatic pressure. A metering funnel 252 having an outlet 254 centrally disposed with reference to the feeder passage 250 is secured to the top of the feeder passage by spaced struts as illustrated. The metering funnel 252 has a perforated disk 256 to act as a strainer to prevent impurities in the molten alloy or metal from being introduced into the casting cavity.

The perforated disk 256 or the outlet 254 of the metering funnel 252 function to control the rate of filling of the casting cavity, and insure introducing the molten alloy or metal through the center of the feeder passage 250. Entrained air and gases can thus readily escape from the casting cavity between the inflowing alloy or metal and the walls of the feeder passage 250.

When the desired mold temperature has been attained, molten alloy or metal may be introduced into the casting cavity through a sprue 250. When the casting cavity is filled, chilled or cold fluid may be circulated through the heat transfer system to remove heat from the molten material introduced into the casting cavity to effect rapid solidification of the casting.

If desired the pump 230 may be connected to another heat exchanger controlled by suitable valving mechanism to interrupt the flow of heat-

ed fluid from the heat exchanger 234 and direct cooled or cold fluid from the other heat exchanger through the conduit 232 and chambers 226 and 228 to effect rapid solidification of the casting.

In instances where the heat exchanger 234 is used to both heat and cool the fluid, cooled fluid is preferably introduced into the heat exchanger through the lower passageway 248 and heated fluid is withdrawn from the upper passageway 246.

It will be apparent that if desired the heated or cooled fluids may be introduced into the chambers 226 and 228 of the mold members adjacent their peripheries and be discharged adjacent the center or sprue as disclosed in the embodiment illustrated in Figs. 1 to 4 if the desired progressive heating and cooling of the mold to insure complete filling of the casting cavity and to effect progressive solidification of the casting is not attained. Also it will be apparent that the passages 236 and 238 may if desired be of somewhat different sizes to permit controlling the heating and cooling of the lower and upper sections of the mold. For example a greater quantity of fluid may be introduced into the chamber 226 to apply greater heat or cold to the lower portion of the casting cavity to insure complete filling of the casting cavity and progressive solidification of the casting toward the feeder.

It will be understood that in the formation of large castings, fluid circulating passages may extend into the casting cavity to insure obtaining the desired heat transfer characteristics. For example certain or all of the core members employed to cooperate with the mold members to shape the desired casting cavity may be hollowed out to permit the flow of heating or cooling fluid therethrough. Where this expedient is resorted to, the core members may have hollow sections formed of metal or plastic material to direct the flow of heating or cooling fluid and to prevent disintegration of the core when the heating or cooling fluid passes through it. The core forming material such as plaster or other suitable substance having for example a silicon base where castings of high temperature alloy or metals are to be formed bonds to the surface of the hollow liners employed to provide the heat transfer passageways. The fluid flow through the core may be from the periphery inwardly toward the center or feeder passage to insure the desired progressive heating and cooling.

It will be understood that features disclosed in connection with one embodiment of this invention can be used with any of the other embodiments disclosed herein.

I claim:

1. The method of forming castings having smooth textured surfaces and fine grained metal structure comprising heating a mold having a casting cavity by applying progressively decreasing heat to the mold from points remotely spaced from a centrally disposed feeder to points spaced progressively closer to the feeder, introducing a castable substance into the casting cavity through said centrally disposed feeder, and thereafter applying progressively decreasing cooling to the mold from points remotely spaced from the feeder to points spaced progressively closer to the feeder to insure progressive solidification of the cast material from points remotely spaced from the feeder to points spaced progressively closer to the feeder.

2. The method of forming castings having thin walled sections comprising forming spaced mold

members having removable cores cooperating with the mold members to form a casting cavity having a centrally disposed feeder, heating the mold by flowing heated fluid over the external surface of the mold from the periphery and discharging the heated fluid adjacent the centrally disposed feeder, rotating the mold and introducing a castable substance thereto to fill the casting cavity by centrifugal diffusion, and cooling the mold by flowing cooling fluid over the external surface of the mold from the periphery and discharging the cooling fluid adjacent the centrally disposed feeder to effect progressive solidification toward the feeder.

3. A casting machine comprising a rotatable base, a lower heat transfer jacket secured to the rotatable base, an upper heat transfer jacket secured to the lower heat transfer jacket, lower and upper mold lining members interposed between the lower and upper heat transfer jackets and cooperating therewith to form lower and upper heat transfer chambers, means defining fluid inlet and outlet passages in the rotatable base communicating with the space between the lower heat transfer jacket and the lower mold lining member, a separator interposed between the inlet and outlet passages and extending radially outwardly between the heat transfer jacket and the lower mold lining member to induce the heat transfer medium to flow radially inwardly in contact with said mold lining member from its periphery toward the outlet passage, and fluid metering passages in the lower and upper heat transfer jackets interconnecting the peripheries of the lower and upper heat transfer chambers to induce a metered flow of heat transfer medium to flow radially inwardly in contact with the upper mold lining member toward centrally disposed outlet passages communicating with the upper heat transfer chamber.

4. A casting machine comprising a rotatable base, a lower heat transfer jacket secured to the rotatable base, an upper heat transfer jacket secured to the lower heat transfer jacket and having a centrally disposed opening, lower and upper mold lining members interposed between the lower and upper heat transfer jackets and cooperating therewith to form lower and upper heat transfer chambers, means defining fluid inlet and outlet passages in the rotatable base communicating with the space between the lower heat transfer jacket and the lower mold lining member, a separator interposed between the inlet and outlet passages and extending radially outwardly between the heat transfer jacket and the lower mold lining member to induce the heat transfer medium to flow radially inwardly in contact with said mold lining member from its periphery toward the outlet passage, and fluid metering passages in the lower and upper heat transfer jackets interconnecting the peripheries of the lower and upper heat transfer chambers to induce a metered flow of heat transfer medium to flow radially inwardly in contact with the upper mold lining member toward centrally disposed outlet passages communicating with the upper heat transfer chamber, and a centrally disposed feeder sprue aligned with the centrally disposed opening in the upper heat transfer jacket and communicating with the casting cavity.

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