Sept. 18, 1951 I. A. BILLIAR 2,568,428

MOLD WITH RISER AND EXOTHERMIC INSERT

Filed Sept 9, 1949 3 Sheets-Sheet 1

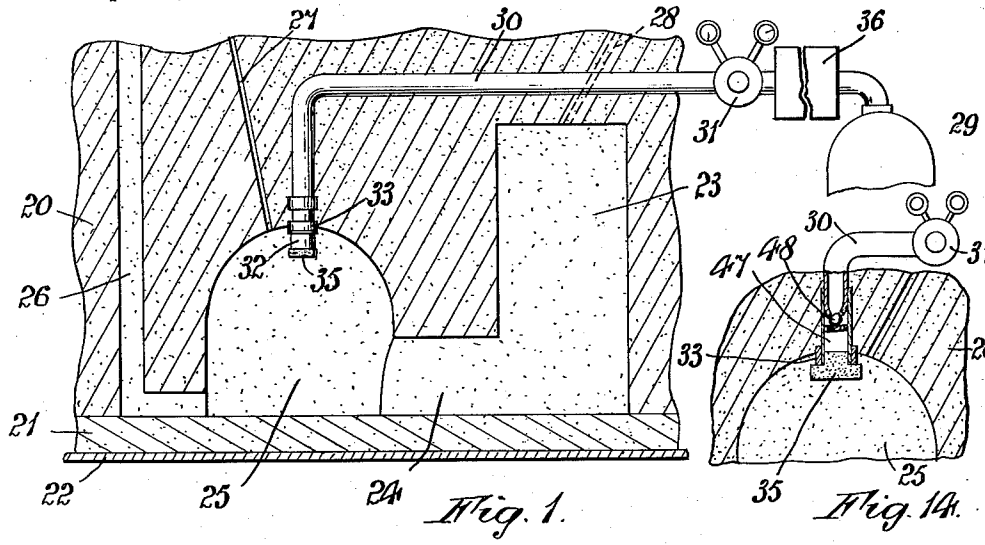


Fig. 1.

Fig. 1A.

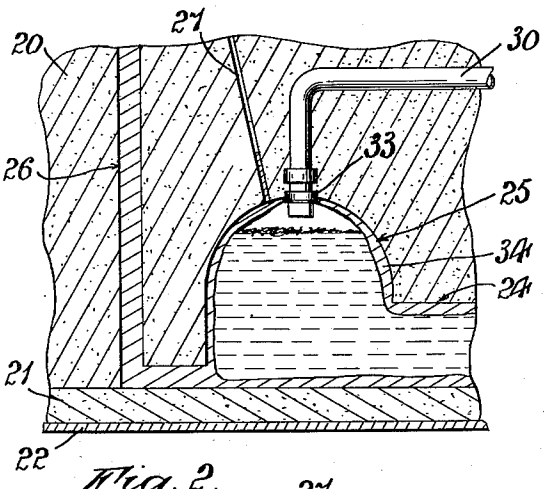


Fig. 2.

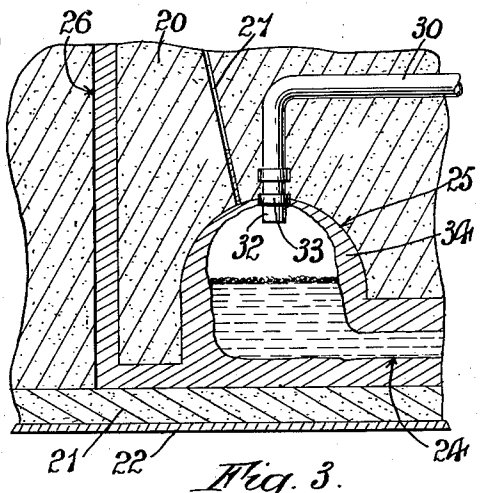


Fig. 3.

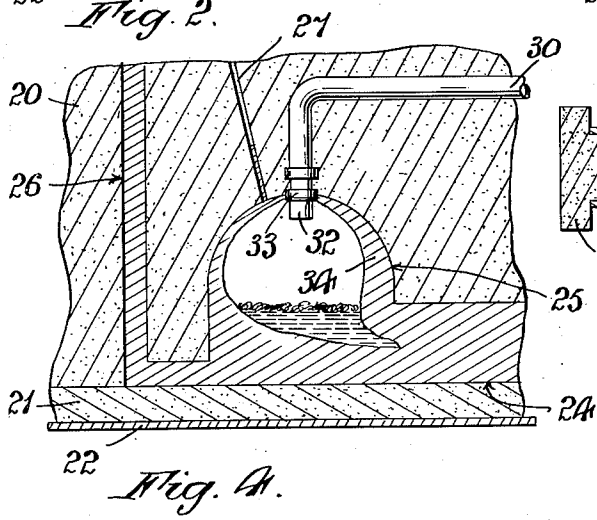


Fig. 4.

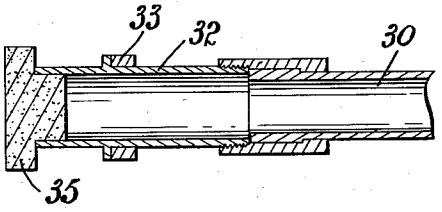


Fig. 5.

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MOLD WITH RISER AND EXOTHERMIC INSERT

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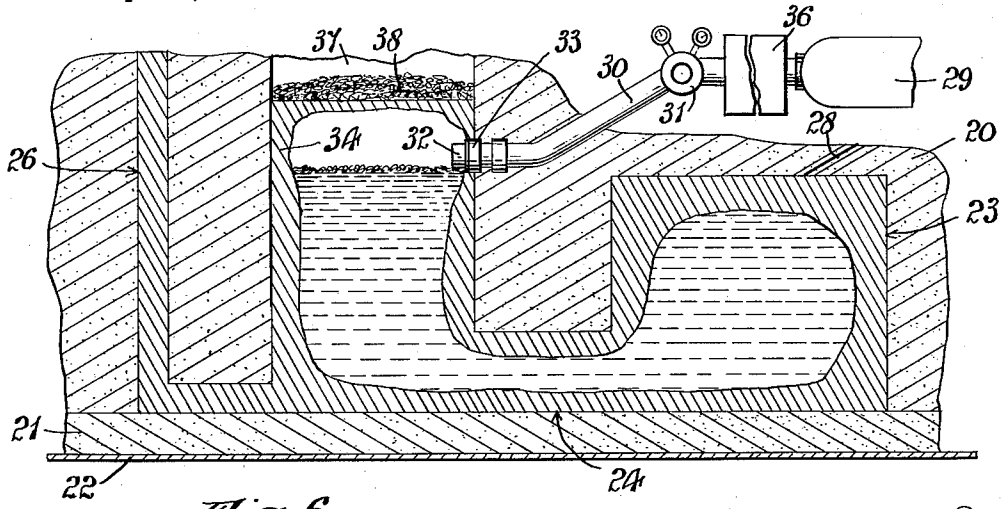


Fig. 6.

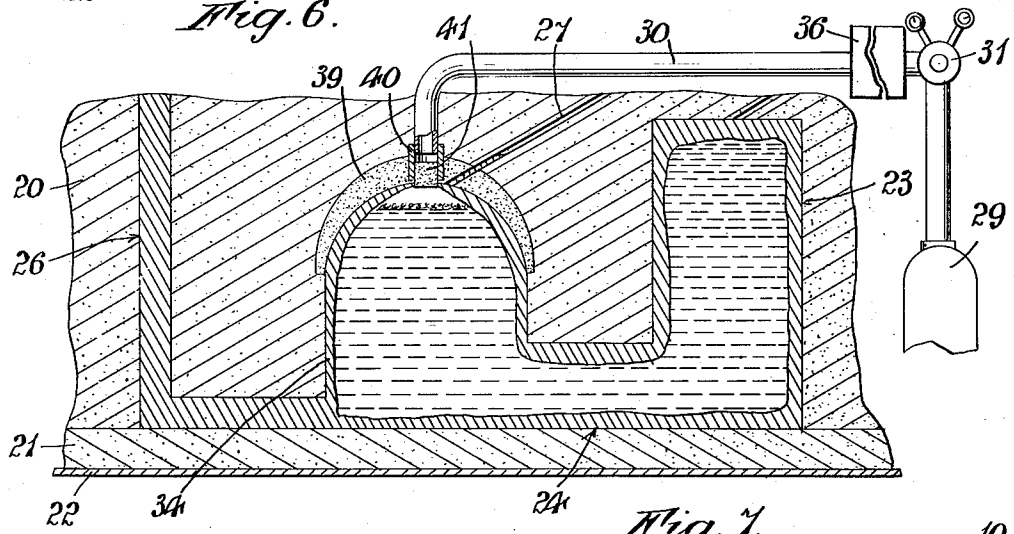


Fig. 7.

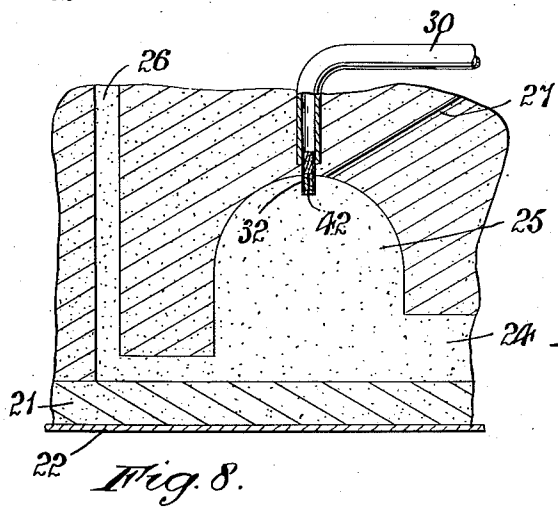


Fig. 8.

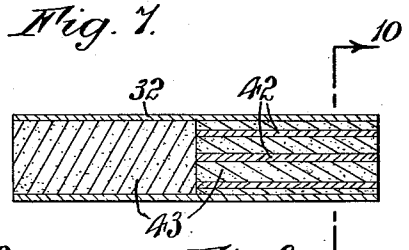


Fig. 9

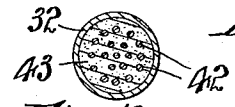


Fig. 10.

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MOLD WITH RISER AND EXOTHERMIC INSERT

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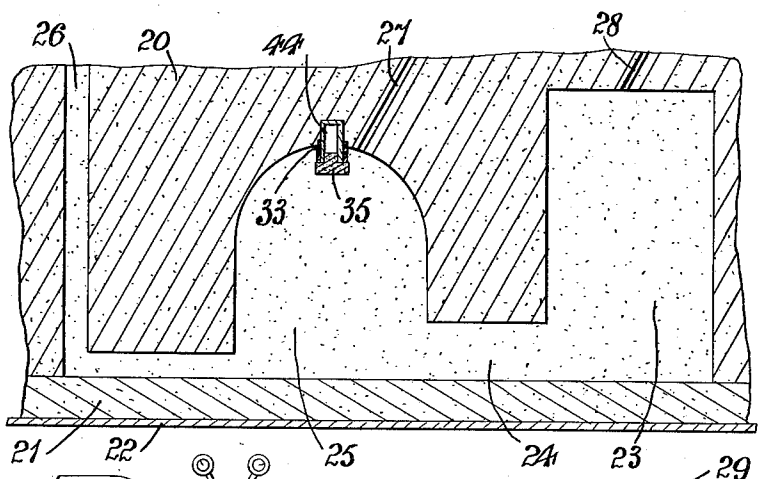


Fig. 11.

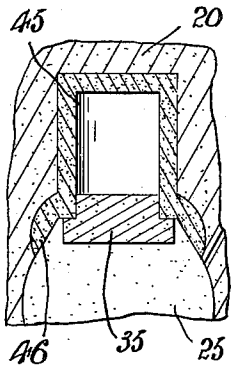


Fig. 13.

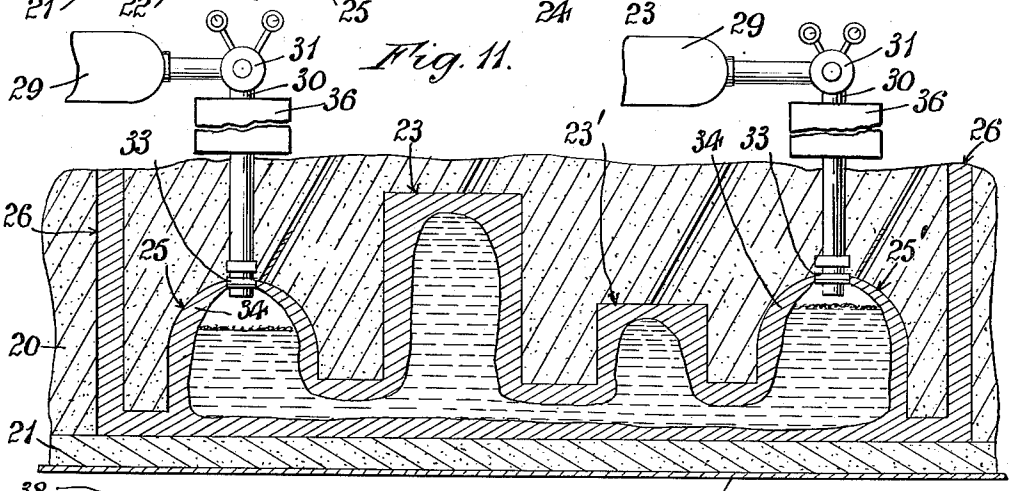


Fig. 15.

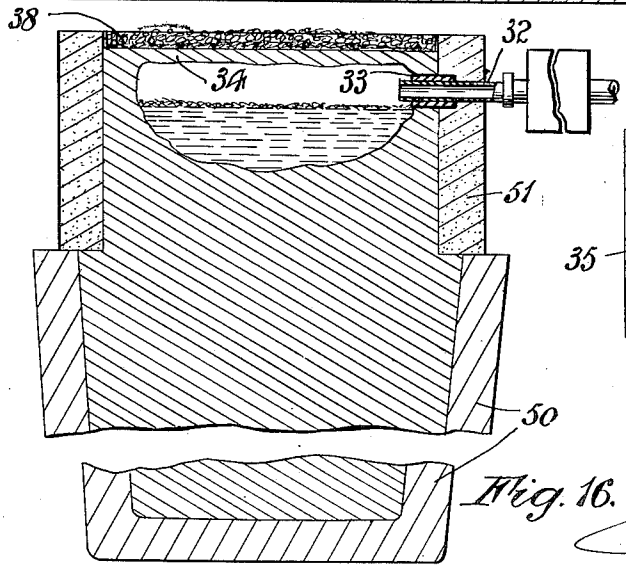


Fig. 16.

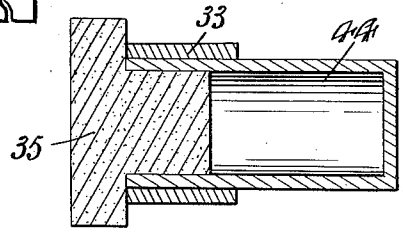


Fig. 12.

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Patented Sept. 18, 1951 2,568,428

UNITED STATES PATENT OFFICE

2,568,428

MOLD WITH RISER AND EXOTHERMIC INSERT

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Application September 9, 1949, Serial No. 114,821

3 Claims. (Cl. 22—134)

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This invention relates to the production of metal castings, more particularly of steel, and to that type of mold wherein a "riser" is provided in communication with the mold cavity with the idea of insuring the feeding of molten metal to said cavity in an adequate and complete manner whereby sound castings may be obtained and the effects of shrinkage of the metal, as it solidifies in the mold cavity, counteracted by progressive feeding of molten metal to the said mold cavity from the reservoir of molten metal in the riser.

While the present invention is more particularly directed to covered or enclosed risers of the type generally known as "blind risers," it is also adapted, as it will appear, to use in connection with open risers in certain cases where the use of such open risers may be more convenient or desirable.

Generally speaking, in the case of blind risers the formation of an initial shell in contact with the walls of the riser has been considered as a detriment inasmuch as it prevented the access of atmospheric air to the molten metal within the shell so that as this metal shrunk, or as it attempted to flow from within the shell to the molten cavity, a vacuum would be formed within the shell resulting in loss of hydrostatic head and consequent reduction in feed efficiency of the riser. To overcome this detriment various means have been suggested from time to time to "break" such a vacuum by providing for the formation of an opening through the aforesaid shell whereby atmospheric air may enter the same.

By my improved system the formation of such a shell within the riser is no longer a detriment, but I actually take advantage of its formation to provide a closed pressure gas system clearly enhancing the production of good castings and even facilitating the production of castings of quality in a relatively cheap and simple manner otherwise not possible with the riser systems such as are in general use.

The mere admission of atmospheric air to relieve any tendency to form a vacuum within the shell of a blind riser fails to meet the requirements of producing sound castings by the riser method, especially where the molten metal in the riser is inherently, or has become in the course of the casting operation, of a sluggish nature. Furthermore, the mere admission of air or gas to the riser, to make up in whole or in part for loss of hydrostatic pressure due to shrinkage or otherwise in the riser, makes no provision for the feeding or forcing of metal into microscopic or macroscopic internal cavities such as may develop during or from shrinkage of the casting or from other conditions within the mold cavity.

It is, therefore, an object of the present invention to provide for a differential in pressure in the riser as related to the mold cavity whereby

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a positive urging of the molten metal from the riser into said mold cavity is secured, whereby such excess of pressure in the riser may be such as to feed metal therefrom into microscopic or macroscopic internal cavities which may develop within the mold cavity or within the casting itself; or whereby such pressure may urge molten metal from the riser to the mold cavity even to replace metal which may escape from the said mold cavity, such as upon rupture of the initially formed shell of the casting for one reason or another.

The invention further aims to provide for the freezing of an initially formed shell of metal in the riser about an air or gas inlet leading to the interior of such shell, and also to provide for such sealing in a manner and by means which will not prevent the ready removal of the inlet pipe or duct from the solidified metal of the riser upon the completion of the molding operation.

To that end it is also an important object of this invention to provide for the connecting of an imperviously walled duct, acting as or leading from a source of gas under pressure, with the shell formed in the riser by the initial freezing of molten metal in such riser contiguous to the walls thereof whereby such gas may be passed through an otherwise permeable mold, such as of sand, without appreciable loss of pressure or escape of gas through the mold material or about the connection between the duct and the formed metallic shell referred to.

An object of the said invention is also to provide a relatively high pressure riser system admitting of a relatively low riser being advantageously operated to efficiently feed a relatively tall casting; and still further to provide an arrangement of high pressure riser system capable of effecting the molding of a tall casting in a manner insuring effective directional solidification uniformly from top to bottom, for the production of more perfect castings of a tall nature than has been generally possible with systems as heretofore used.

A further object of the invention is to provide for the adjustment of feed and/or of pressure of air or gas admitted to the riser, for the purpose of meeting varying casting conditions either resulting from the type of mold or from the type of metal being molded.

The invention also contemplates the use of multiple risers for a common mold, wherein the risers are designed as to capacity each to meet the requirements of the particular part of mold which it is to feed and also contemplates provision of means for varying the gas pressure applied to different risers feeding a common casting, for the purpose of meeting special conditions imposed in each riser; and also, where desired, for producing a surge of metal from one

portion of a casting being molded to another portion thereof to the end that complete filling of all the cavities in the mold may be insured.

An important object of the invention is, further, to provide for delaying the freezing of molten metal within a shell formed in the riser to render more effective the feeding under gas pressure of this molten metal to the mold cavity, such delay in freezing being effected by the latent heat of gas under pressure admitted to the riser, by pre-heating or super-heating such gas before it is admitted to the riser, or by causing the gas to engage in chemical action with a provided substance for the generation of heat before, as or after said gas enters the riser.

The invention also proposes to provide, in certain of its forms, for the formation of a "hot spot" at the point of air or gas admission to the riser to facilitate such admission; and also contemplates that, by the use of a relatively high pressure, the forcing of gas into the riser through sintered or partially fused material about the gas inlet may be effected.

In certain of its modifications the invention further provides, in combination with pressure gas admission to the riser, for the bringing about of a heat-producing chemical action for raising and maintaining the heat of molten metal in the riser for its more effective feeding to the mold chamber, whereby a smaller riser may be utilized than is usual with conventional riser practices with consequent saving in production costs.

In general, the said invention aims to provide a positive means for forcing metal from a reservoir into a mold cavity, using superatmospheric pressure to overcome any lack of pressure which might occur if the ordinary riser fails to function, and contemplates, where thought necessary or desirable, the application of various degrees of pressure within a riser whereby such pressure may be progressively increased as the metal in the riser becomes increasingly sluggish, as during the process of pouring. The invention also contemplates that, where there are several risers on a casting subject to quicker freezing in some risers than in others, differential pressures may be applied to different risers to compensate for the difference in time of freezing between different risers.

Furthermore, the said invention aims to provide, by the variation of pressures in different risers, for the "surging" of molten metal from one part of a mold to another to break up crystal formation in various sections of the mold and so delay undesired premature freezing of the metal in such sections.

In carrying the said invention into effect, I may adopt the novel form of molding apparatus constructed substantially in accordance with one or other of the arrangements illustrated, by way of example, in the accompanying drawing, wherein:

Figure 1 illustrates, more or less schematically and in vertical section, a mold having a blind riser and embodying the present invention whereby a provision is made for the introduction of gas under pressure to the interior of the blind riser in a manner meeting the requirements;

Figure 2 is similar to Figure 1 and shows the riser portion of the mold as it appears shortly after the metal has been poured and a skin has formed by cooling on the walls of the riser, the drawing indicating the initial introduction of gas under pressure within the skin at the upper part of the riser;

Figure 3 is a similar view to Figure 2 showing a further advanced cooling stage of the metal with an increased volume of gas in the riser;

Figure 4 is a similar view to Figure 2 showing the final stage of cooling and the effect of the volumetric expansion and/or additional introduction of gas under pressure to the cavity within the riser shell;

Figure 5 shows in sectional detail a suitable form of capped inlet tube which may be used in connection with the apparatus and system illustrated in the foregoing figures;

Figure 6 shows an embodiment of the invention as applied to an open riser of a mold to produce the results sought for;

Figure 7 shows a modified arrangement wherein a dense impervious material forms the upper part of the wall of a blind riser and illustrates a somewhat modified form of the inlet pipe;

Figure 8 shows a blind riser provided with a further modified form of inlet pipe including means whereby the oxidation of aluminum, or other suitable metal or material, may be availed of to maintain or increase the heat of gas within the blind riser during the pouring operation;

Figure 9 is a detail longitudinal section of the inlet pipe of Figure 8;

Figure 10 is a transverse section of the said pipe, taken on a plane indicated by the line 10—10 in Figure 9;

Figure 11 illustrates a blind riser equipped with a gas reservoir positioned and adapted to provide for the admission of gas under pressure created, at least in part, by the heating of gas within the reservoir by the hot metal in the riser to produce an effect similar to that of the previously illustrated arrangements;

Figure 12 is a detail sectional view of such a reservoir;

Figure 13 shows in section a modified form of such a reservoir composed of a substantially gas-tight dense mold material which may be formed in the mold at the upper end of the blind riser;

Figure 14 shows a combination of such a reservoir as that shown in Figure 11 with means for introducing additional gas thereto under pressure;

Figure 15 illustrates an arrangement, similar to Figure 1, wherein a plurality of blind risers are provided for a single casting, each equipped with separate means for introducing gas thereto under pressure whereby the pressure in different risers may be controlled or varied to suit casting conditions, and whereby, where desirable, a surge of metal from one portion of the mold to another may be effected for the production of more perfect castings; and

Figure 16 illustrates an embodiment of the invention adapted to the use of hot tops, as in the molding of ingots.

Similar characters of reference indicate similar parts in the several figures of the drawings.

Referring first to Figures 1–5, which show a simple mold comprising a cope 20 and drag 21, the latter being supported by the drag plate 22 and the cope and drag being formed of molding sand, according to common practice. This molding sand is usually quite pervious to gas which, in general, is of advantage in enabling the mold cavities to free themselves of air or of gases arising from the molten metal as the metal fills the cavities during the pouring operation.

The illustrated mold is shown as being provided with the mold cavity 23, the lower end of which is connected by a feed gate 24 with the lower end

of a blind riser 25 into which riser the pouring gate 26 opens as shown. 27 and 28 indicate vents from the upper ends of the blind riser 25 and the mold cavity 23 respectively.

All of the foregoing is well known to those familiar with the molding art, and it does not call for further description or explanation herein.

It is also well known that the purpose of the blind riser 25 is to house an excess of molten metal, as a feed for the casting being formed in the mold cavity, to make up for shrinkage which most metals undergo as they solidify and to thus insure a structurally solid and a complete casting of the form defined by the said mold cavity.

It is also well known that, upon the pouring of the molten metal into the riser 25 and into the mold cavity 23, that part of the metal in contact with the walls of the riser and of the mold cavity, as well as with the walls of the connecting feed gate 24 therebetween, will first freeze to form a shell in contact with these walls, said shell being filled with molten metal progressively freezing from the outside to the inside in the course of time and therefore isolating the molten metal within the interior of the shell from the surrounding walls of the mold cavity, riser and their connecting gate.

Consequently, shrinkage of this molten metal as it, in turn, cools within the so-formed shell results in the creation of a vacuum within the riser shell, not only deterring effectual feeding of molten metal to the mold cavity, thus producing an unsound casting in itself, but also preventing full flow and access of molten metal to all areas of the casting, especially as the molten metal becoming cooler tends to thicken and become sluggish in its flow characteristics.

It has been, heretofore, the practice to provide in a mold a gas-permeable or other device designed to provide an opening or vent in the upper portion of the shell formed during the molding operation in the blind riser; or, by mechanically interrupting the formation of such shell at such a point, or by providing a "hot spot" in the mold designed to act as a heat dam at the desired point in the riser. The freezing of the molten metal at that point has been discouraged thereby preventing the localized completion of the shell at the time when contact of the molten metal with the relatively cool walls of the riser caused the shell formation within the riser.

Thus, atmospheric air from the permeable mold material, or from a provided opening through the said material, has been permitted to enter the formed shell to prevent the creation of a vacuum therewithin such as would otherwise interfere with the feeding of the confined molten metal to the mold cavity in the manner contemplated by the use of the riser.

The foregoing arrangements, while serving to minimize the formation of a vacuum in the riser and to that extent enhancing the continued flow of molten metal to the mold cavity, fail to provide for such urging or acceleration of such flow as may be desirable to prevent or overcome any tendency of the forming shell of freezing metal in the mold cavity to buckle or warp, or to provide for such conditions as where a "hot spot" in the surface of the mold cavity results in a weakness in the initial metal shell forming therein resulting in eventual rupture of the shell at this point, thus admitting air from the mold to the mold cavity.

The aforesaid arrangements also are unduly limited as to the relative height of casting which may be efficiently poured with an upward flow of metal from a blind riser of any given height and capacity.

The arrangement of the said Figures 1–5, therefore, is directed toward the admission of air or gas at relatively high pressure (above atmospheric pressure) to the interior of the shell formed within the blind riser, and in a manner affording free access to the interior of the otherwise sealed gas-tight shell, whereby the loss of pressure due to escape of gas through the mold material or otherwise is rendered impossible or reduced to a negligible extent. The said arrangement shows a seal between an impervious walled gas conduit and the riser shell which it penetrates, said seal being formed as such shell results from skin solidification following the charging of the blind riser with molten metal.

This gas-impervious walled passage or duct extending from a reservoir or source 29 of pressure gas (which may be air) is shown at 30, a pressure regulator 31 being interposed in the said duct whereby pressure and flow of gas admitted to the riser 25 may be varied to meet requirements of operation; the said duct 30 being shown, in this example, as provided with an extension tube 32 having a gas-impervious wall projecting into the upper end of the blind riser 25 and provided with an annular sleeve or chill 33 which surrounds the tube 32 at its point of entrance into the riser 25 and also projects, to some extent, into the top of the said riser.

This sleeve 33 performs an important function inasmuch as it acts as a stop for the metal of the shell 34 which forms about it when the contact of the riser wall initiates the contiguous skin solidification or freezing of the molten metal when the riser is first charged, as shown in Figure 2; and this sleeve 33 may be of a material to which the metal of the shell will adhere or weld itself to insure a gas-tight joint at this point. It may be of a fixed or a slip fit on the tube 31 according to desire; or it may be simply an integral part thereof.

The inner end of the tube 32 is shown as being plugged with a cap 35 of graphite, special glass, or other material which may be forced off the end of the tube, or ruptured under gas pressure, to permit such gas under pressure to enter the shell 34 of the riser cavity after such shell has commenced to form and gas is forced through the duct 30 by the subsequent opening of the regulator valve 31 at a determined time following the pouring of the molten metal through the gate 26 into the riser and so to the mold cavity.

The presence of the cap or plug 35 may in itself serve to delay the admission of gas to the riser until after the shell 34 has been fully formed and sealed about the mouth of the tube 32.

It will be observed that, upon this formation of the riser shell 34 about the inner end of the walled duct or passage 30 a very characteristic and distinctive structure results wherein an entirely sealed closed system is formed comprising the said walled duct 30 connected at one end to a source 29 of gas under pressure and at the other end to the shell 34, which shell, however, opens at the bottom end through the shell-lined feed gate 24 to the shell-lined mold cavity 23, thereby completing the total enclosure.

The controlled admission of gas under pressure from the source 29 to the interior of the shell 34, therefore, admits of controlled progressive feeding under pressure of molten metal from

within the said shell 34 through the feed gate 24 to the shell formed within the mold cavity, as clearly indicated in Figures 2, 3 and 4, until the said mold cavity is thoroughly and completely filled with metal, in a manner insuring a well formed casting of sound internal structure, due to the fact that the pressure and flow of the gas may be such as to prevent any collapse or deformity of the initially formed shell within the mold cavity 23 and also because the movement and disposition of the molten metal, even as it may become sluggish through lapse of time and general partial cooling, may be so urged or accelerated in its flow by the gas under pressure as to insure the forcing of the metal into microscopic or macroscopic internal cavities which might otherwise tend to remain within the casting structure.

The gas pressure utilized may, due to the closed nature of the system described, be such as to maintain a relatively high temperature, in part attributed to such compression in the gas on the surface of the molten metal, as to retard the general loss of heat therefrom and thereby tend to maintain the metal in a molten and flow condition for a longer period of time than would otherwise be the case. Means may be even resorted to, such as those hereinafter described, for promoting an elevated heat in the gas admitted to the shell 34 of the riser.

Furthermore, as indicated at 36, any suitable form of pre-heater or super-heater may be interposed in or applied to the system for raising the temperature of the gas to the required degree before it is admitted to the riser shell 33.

An embodiment of the invention as applied to an open riser is shown in Figure 6, wherein 37 indicates such an open riser. In this case, immediately upon filling the said riser 37 with molten metal above the level of the gas inlet tube 32, the surface of the poured metal is covered with a cooling agent, which may be in the nature of a metal or other slab or scrap metal 38, adapted to form the initial upper layer or top portion of the riser shell 34, as will be readily understood, thereby completing the closed pressure gas system which thereafter operates in the manner already described with reference to Figures 1–5.

Figure 7 shows a further modified arrangement, wherein the upper wall and top of the blind riser 34 is formed of a very dense gas-impervious layer of mold material 39 in which is inserted the inlet pipe 40 to which the gas duct 30 is connected, the said pipe 40 being provided with a core 41 which may be pervious to gas under pressure, or which may be similar to the cap 35 referred to in connection with Figures 1–5 as being of graphite, special glass or other material which may be dislodged from the pipe 40 under gas pressure, or ruptured thereby, to permit the gas under pressure to enter the riser after the initial riser shell 34 has been formed. This core 41 may also serve to act as a "hot spot" at the outlet of the pipe to prevent the forming shell 33 from closing up the mouth of the said pipe 40.

Figure 8 shows an arrangement wherein the tube 32 entering the upper end of the riser is charged with material adapted to react with the gas (which may be oxygen) fed to the riser whereby a high degree of heat in such gas, or in the resulting gaseous compound, may be attained for the maintaining of a fluid condition of metal within the initially formed shell for a desirably extended period. For instance, aluminum rods 42 may be imbedded in a gas-pervious core 43 in such position as to be heated by the poured molten metal as the riser is filled so that, when oxygen under pressure is thereafter forced through the porous filling 43 of the said tube 32, this aluminum will be very rapidly oxidized and a correspondingly high temperature gas developed and admitted to the formed shell 34 of the riser, thus transmitting heat to the molten metal in the riser and delaying its freezing. Silicon or other metals or compounds, capable of being rapidly oxidized, will readily suggest themselves as available for use in such a manner.

In Figures 11 and 12 I show another means of producing pressure on the molten metal within a blind riser 25 depending, in this case, on the expansion of confined gas resulting from the heating from such gas by the molten metal in the said riser, a ceramic or other suitable reservoir 44 being shown as imbedded in the mold material at the upper end of the riser 25 and having its open end portion projecting thereinto and surrounded by a metal sleeve or chill 33. The said open end of the reservoir 44 is normally sealed by the cap 35 similar, for instance, to that referred to in connection with the description of Figures 1–5. In this case, the initially formed metallic shell 34 within the riser 25 seals about the mouth of the said reservoir 44 in the manner already described, and gas within the said reservoir is heated both during and upon the freeing of the cap 35 from the open end of the reservoir (as by heat or by pressure, or by both heat and pressure), and the gas so heated expands and exerts pressure on the fluid metal within the formed shell 34, the shell and the reservoir thus combining to form the closed pressure system characteristic of this invention.

Thus, for example, if this reservoir 44 be considered as having an internal length of, say, 6½ inches and a diameter of 1½ inches, enclosing 11 cubic inches of gas under atmospheric pressure such as may be suitable for application to a riser cavity having a capacity of about 15 cubic inches, the raising of the gas temperature within the reservoir by the presence of the molten metal in the riser to, say, 2300° F. would result in an absolute pressure approximating 41 pounds which would be adequate for the purposes.

The capacity of the gas reservoir 44 would naturally be determined to suit the particular riser and molding conditions which it might be required to meet. It is also contemplated that such a reservoir may be initially charged with gas under pressure which pressure would be correspondingly increased by the application of the heat of the molten metal thereto.

Figure 13 shows a modified form of the last described arrangement wherein the air reservoir 45 is of substantially gas-tight, dense mold material formed or inserted in the cope of the mold and having a flange portion 46 forming the upper walled portion of the blind riser 25. With such an arrangement the sleeve or chill 33 may be dispensed with.

Figure 14 illustrates a still further modification of this arrangement wherein provision is made for the admission of gas under pressure to such a reservoir, where thought necessary or desirable, the reservoir in this case being indicated as a tube 47 into the upper end of which the gas duct 30 opens, and 48 indicates a check valve positioned to close the gas inlet to the reservoir when pressure within the said reservoir, due to

the gas-expanding action of the heated metal, exceeds that in the gas duct.

Figure 15 illustrates an arrangement wherein a plurality of risers are utilized in connection with the production of a single casting, and, although in this figure only two risers 25 and 25' are shown as of similar size feeding into connected mold cavities 23 and 23' of different sizes, it will be understood that some castings may have many risers communicating therewith, and these risers may be of various capacities, some large and some small.

As the metal in small risers tend to completely solidify much more quickly than that in large ones, my closed and controlled pressure system is very adaptable thereto as it permits of the application of different gas pressure to different risers. For instance, I may apply a high pressure to small risers and a lower pressure to large ones to take advantage of the fact that a smaller period of time is available during which the metal in the smaller riser is sufficiently liquid to flow into the mold cavities in the required manner.

The form of the mold may be such that greater local pressure is required in one region than another to efficiently fill the same with casting metal, or the spaces through which the metal may have to flow (or the height to which it may be required to be raised) in various parts of the casting may require a greater localized pressure on the molten metal being fed thereto from any particular riser. My system obviously admits of this requirement being met.

Furthermore, in such a casting as that shown in Figure 14 it may be desirable to produce a surge of metal within the casting, and in a direction from one riser to another, to break up any tendency to crystal formation in various sections of the casting and to delay solidification in such sections until a perfect casting structure has been attained; and my invention purposes and provides for the promotion of such surging action by controlled variation of pressure in different risers of a single casting and even of controlled variation of such pressure during the actual process of forming the casting.

To these ends the second riser 25' in Figure 15 is equipped similarly to the riser 25 with a gas duct 30 and pressure regulator 31 together with a sealing collar 33 and heater 36, if desired, as in the case of the riser 25 so that pressure within the second riser 25' may be independently controlled.

While my closed pressure system is primarily intended for use in combination with riser fed casting molds, it lends itself in many respects to the casting of ingots, especially as to the raising or maintenance of temperature of the molten metal being fed as from a hot top downwardly into the ingot mold and the application of pressure within a shell, formed in such a hot top, so as to have more force than is generally available to push feed metal into microscopic or macroscopic internal cavities which may develop in the ingot structure as casting shrinks.

As in the case of the castings already referred to, pools of molten metal may form between solid crystals as the metal in the ingot mold is solidified, such pools being surrounded more or less by these crystals in such manner as to be more or less isolated from the molten feed metal, and by my closed system of applying superatmospheric pressure to the molten metal within the initially formed shell this pressure may be raised to a point which will assist in forcing fresh molten feed metal between the crystals and into the pools referred to for the production of a more perfect casting than would otherwise result. Here again the higher pressure available will insure the more effective flow of sluggish metal into interstices of the casting.

In the said Figure 16, 50 indicates the ingot mold on which is superposed the hot top 51, which may be and is usually of refractory material, through the side wall of which the inlet pipe 32 of the pressure gas duct 30 extends as in the manner of the open riser shown in Figure 6, 33 being the metal sleeve or chill collar for effecting the freezing and sealing of the initially formed metallic shell about the inner end portion of this pipe 32. It will be understood that the said Figure 16 shows the condition existing after gas under pressure has been admitted to the area within the initially formed shell so that the plug or cap 35 (which, as heretofore explained, is initially used to close the inner end of the said pipe 32 to prevent access of molten metal thereto) is not shown, having been disposed of in any of the ways herebefore stated.

In its preferred form the element about which the riser shell freezes is readily detachable from the pressure gas duct so that after the casting is completed for removal, together with its attached gate and riser portions, this element may be discarded with the riser shell. Thus, for instance, the duct 30 may be simply uncoupled from the pipe 31 which may be discarded with the riser shell, or where the chill collar 32 is of a slip-fit arm or otherwise detachable prong, the tube 31 may be simply withdrawn or detached from the said collar 32 either before or after the riser shell 33 has been broken up according to the requirements of the particular construction of the pipe 31 and the collar 32.

My improved closed pressure system, especially as applied to riser fed castings wherein the castings are relatively tall and the risers are gated to the bottom thereof, enables a much taller casting to be effectively molded in this manner, as will be appreciated by those familiar with this art. As the rising metal within the mold cavity is cooled by the mold walls, the molten metal reaching the top of such cavity, as it is filled, becomes somewhat colder than that at the bottom, which is desirable and is known in foundry practice as directional solidification.

However, the molten metal from the riser must be fed upwardly into such solidifying areas, and it will be obvious that a riser feeding into the bottom of a mold cavity with the molten metal suddenly subjected to atmospheric pressure is quite limited as to the extent to which it may feed metal upwardly within the mold cavity. Consequently, it has been a common practice to provide such tall castings with one or more additional risers leading to the uppermost portions of the mold cavity.

My closed pressure system in many cases eliminates the necessity of using such additional or elevated risers on tall castings while also insuring the desirable directional solidification to a highly efficient degree as well as ensuring the breakdown of isolated pools of metal and the forcing of the molten metal into microscopic and macroscopic internal cavities such as commonly developed during casting shrinkage.

Herein, and in the claims, the term "riser" or "blind riser" is intended to include arrangements such as that shown in Figures 6 and 16,

wherein the presence of the cooling agent **38** on the surface of the molten metal acts as the upper wall or top of the riser and insures the formation of the complete shell **34** through which the gas duct **30** leads and to which the said shell is directly or indirectly connected in a gas-tight manner as described.

While I have in these examples illustrated and described the riser as feeding into the lower part of the mold cavity, I do not wish to limit myself in all cases to this arrangement, as it will be apparent that a riser may open into the middle or the upper part of a mold cavity. In fact, several risers may be used, as on complicated castings, at various levels according to convenience.

This invention may be developed within the scope of the following claims without departing from the essential features of the said invention, and is it desired that the specification and drawings be read as being merely illustrative of a practical embodiment of the same and not in a strictly limiting sense.

What I claim is:

1. In combination with a mold having a mold cavity and a riser communicating therewith, an imperviously walled duct passing through said mold and opening into said riser, means supplying gas under pressure through said duct to said riser, and a charge of material interposed in the path of gas passing through said duct to said riser, said material being of a character to react with said gas and thereby raise the temperature of the gaseous charge entering said riser.

2. In combination with a mold having a mold cavity and a riser communicating therewith, an imperviously walled duct passing through said mold and opening into said riser, means supplying an oxygen gas under pressure through said duct to said riser, and a charge of oxidizable material interposed in the path of gas passing through said duct to said riser whereby to raise the temperature of the gaseous charge entering said riser.

3. In combination with a mold having a mold cavity and a riser communicating therewith, an imperviously walled duct passing through said mold and opening into said riser, means supplying gas under pressure through said duct to said riser, a gas pervious core in said duct, and a charge of material carried by said core, said material being of a character to react with said gas and thereby raise the temperature of the gaseous charge entering said riser.

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