A furnace vessel comprises a vertically oriented refractory lined cylindrical metal shell and a cover. The interior bottom of the vessel is dished and there are circumferentially spaced orifices through the wall of the vessel at the edge of the dish. A channeled molten metal receiving spout connects with one of the orifices and a pouring spout connects with the other. A riser on the receiving spout permits pouring metal into the vessel even when it is tilted for discharging metal from the pouring spout. The tilting axis of the vessel is on a side thereof, and, if extrapolated, the axis will pass through the tip of the pouring spout in which case the tip will not ascend or descend appreciably when the vessel is tilted. The vessel is adapted for holding, reducing, alloying, degassing, vacuum treatment and introducing additives to molten metal during the interval between melting and utilization of the metal. The argon-oxygen stainless steel refining process can also be carried out in the vessel. Continuous casting machinery is also furnished with molten metal from the vessel. The temperature of the metal in the furnace is maintained by heat radiated from an electrically resistive graphite rod which extends across the interior of the furnace above the metal level.
MOLTEN METAL HOLDING FURNACE SYSTEM

This is a continuation of application Ser. No. 323,733, filed Jan. 5, 1975, now abandoned, which in turn is a division of application Ser. No. 185,633, filed Oct. 1, 1971, now U.S. Pat. No. 3,757,153.

BACKGROUND OF THE INVENTION

In connection with production line casting of iron and steels it is customary to discharge a molten metal heat from a melting furnace into a holding furnace from which molten metal is continually or incrementally delivered to molds. This arrangement permits operating melting furnaces with a high duty cycle since they can begin melting a new charge immediately after a heat is discharged into the holding vessel. Production of castings is also increased because molten metal is available to the molds from the holding furnace except when the melting furnaces fall behind or the holding furnace must be reloaded. Typical known types of holding furnaces are shown and described in the present assignee's U.S. Pat. No. 3,514,519 and in the book N. R. Stansel, Industrial Electric Heating, pp. 367-372, John Wiley and Sons, New York, 1933.

SUMMARY OF THE INVENTION

An object of the present invention is to further improve the rate at which castings can be produced by providing a holding furnace which cooperates with the casting apparatus in such manner that the holding furnace vessel may be refilled with molten metal when the holding furnace is inactive or even when it is tilted for pouring molten metal.

A further object is to provide a holding furnace which employs molten metal for sealing the orifices through which molten metal is received and discharged in which case inert gas may be maintained within the furnace under positive pressure at all times.

A further object is to equip a holding furnace with a resistive heating rod for maintaining the molten metal at the temperature which is desired for casting regardless of the length of the period during which the metal is stored.

Another object is to provide a holding furnace or vessel which has diverse capabilities such as for vacuum treating molten metal, subjecting it to argon-oxygen treatment, superheating metal, maintaining its temperature, completing its reduction, degassing it, alloying it and introducing additives to it so that the melting furnace where some of these steps are now being carried out can be confined to the duty for which it is best adapted; namely, melting.

An important object and feature of the new holding vessel is that it permits melting furnaces such as arc furnaces to be used exclusively for melting and it frees the melting furnace for producing the next melt while the various processes mentioned in the preceding paragraph are being carried on in the holding furnace. An incident to this object is that the workmen, who heretofore have had to stand by until a melt was completely refined in the melting furnace and ready for casting, are now able to complete the refining process and utilize the metal and still have another heat available immediately for refining and utilization. Start-up time of the shop is also shortened since the last heat of the melt shop produced by a previous shift may be stored in the holding vessel and the melt will be ready for utilization by the next shift without waiting for the melting furnace to complete a heat.

In general terms, the new holding furnace is characterized by a vertically oriented cylindrical metal shell which has a lining of refractory material. The metal shell is equipped with a refractory lined cover which effects a gas-tight seal with the shell. Means are provided for maintaining inert gases such as argon and nitrogen inside of the shell at slightly above atmospheric pressure. Means are also provided for introducing reactive gases and solid additives without breaking the seals of the vessel.

There are a pair of orifices extending through the refractory lining and shell of the holding furnace at circumferentially spaced locations. A refractory lined pouring spout is attached to the shell in the vicinity of one of the orifices and the channel of the spout aligns with the orifice. A portion of the pouring spout extends radially from the metal shell and terminates in a tip from which metal is poured. A metal receiving spout is attached to the furnace shell in the vicinity of the other orifice. The receiving spout projects radially and has a portion which is angled upwardly. The end of the receiving spout terminates in a normally vertically oriented riser which serves as a metal receiving inlet. The top of the riser is higher than the expected level of molten metal within the holding furnace even when the furnace is tilted. The tilting axis of the furnace is outside of the shell and on the same side as the two spouts. If the tilting axis is extrapolated, it will extend through the pouring spout tip and through the receiving spout riser. Thus, when the furnace is tilted, the pouring spout tip does not rise nor descend appreciably nor does it execute an arc since it is on the tilting axis. When the furnace is tilted, the top of the riser remains above the molten metal level inside of the furnace in which case molten metal may be poured into the holding furnace even though it is tilted for discharging metal from the pouring spout.

The holding furnace may be positioned for delivering molten metal to the tundish of a continuous casting machine or a mold box or other device which utilizes molten metal continually or periodically. The holding furnace receiving spout may be positioned under one or more tundishes that receive molten metal from individual melting furnaces when the holding furnace is either tilted or upright. Thus, the holding furnace will make molten metal available to individual casting molds or to casting machines on a substantially continuous basis. Means which are responsive to the quantity of metal in a tundish or mold box are used to control the pouring rate of the molten metal so that casting rate will be maximized and uninterrupted.

The furnace is also provided with a graphite rod which extends across its interior and is insulatedly mounted in the furnace shell. Electric current is passed through the rod to heat it. Heat radiated from the rod maintains the temperature of the molten metal and superheats it if desired within the furnace during storage.

How the foregoing general objects and more specific objects are achieved will appear from time to time throughout the course of the ensuing more detailed description of an embodiment of the invention taken in conjunction with the drawings.

DESCRIPTION OF THE DRAWINGS

FIG. 1 is a plan view of one system which incorpo-
rates a holding furnace, a conveyoris casting line, and two melting furnaces;

FIG. 2 is a front elevation view of a holding furnace associated with a conveyoris casting production line;

FIG. 3 is a side elevation view of a holding furnace which is isolated from FIG. 1 and is tilted for pouring molten metal therefrom;

FIG. 4 is a fragmentary transverse sectional view taken on the line 4—4 in FIG. 2, showing some details of the furnace spouts in relation to the riser wall at the periphery of the furnace bottom;

FIG. 5 is a plan view of another embodiment of the holding furnace in conjunction with a plan view of an associated continuous casting machine tundish;

FIG. 6 is a fragmentary right side elevation view of the tundish and mold in the preceding figure, the furnace being omitted and a diagram of the electrohydraulic furnace tilt control system being included; and

FIG. 7 is a side elevation of a holding vessel receiving spout such as the one used on the vessel in FIG. 5;

FIG. 8 is a side elevation of a holding vessel pouring spout such as the one used on the vessel in FIG. 5,

FIGS. 9A and 9B are side views, partly in section, of the heating rod carriage and track assemblies which are associated with opposite sides of the holding furnace, the views being taken looking from the right to left of FIG. 1.

DESCRIPTION OF A PREFERRED EMBODIMENT

FIG. 1 shows a top view of the holding furnace which is generally designated by the numeral 10. It comprises a normally vertically oriented cylindrical metal shell 11 which is lined with a suitable refractory material 12. As can been in FIGS. 2 and 3, the interior bottom 13 of the furnace is also lined with refractory material and is generally dish shaped. At one side of bottom 13 there is a chordal riser wall 4 at the ends of which are circumferentially spaced apart orifices 15 and 16 which penetrate refractory material 12 and shell 11. The purpose of riser wall 14 is to divert molten metal toward orifices 15 and 16 when the back end of the furnace is tilted toward the observer as is the case when the molten metal is being poured from the holding furnace.

The furnace is tiltible through a vertical angle of about 30° so that molten metal may be poured out of orifice 16 and through a pouring spout which is generally designated by the numeral 19. The pouring spout comprises a metal shell 20 which is lined with a refractory material 21. The refractory material may be formed with an open-topped channel 22 in it. Channel 22 is aligned with metal discharge orifice 16 so that when the furnace is tilted molten metal will flow out of orifice 16 and down channel 22. Note that channel 22 has a straight portion which extends radially from furnace shell 11 and that it also has laterally extending portion 23 at the tip 24 of the pouring spout. It is evident in FIG. 2 that the part of pouring spout 19 which is attached to furnace shell 11 is pitched angularly upward so that the slope of channel 22 will constitute a barrier to the discharge of metal when the furnace is not tilted. The tip 24 of the pouring spout, however, is substantially horizontal when the holding furnace is not tilted. Molten metal closes discharge orifice 16 to thereby serve as a vacuum and gas pressure seal when the furnace is either tilted or upright. The design is such that pouring spout tip 24 does not ascend or descend significantly when the furnace is tilted.

The furnace is also equipped with a spout for receiving molten metal. This spout is generally designated 27. The receiving spout comprises a metal shell 28 which is lined with a refractory material 29. This material is formed with a channel 30 that communicates with receiving orifice 15 which penetrates refractory lining 12 and shell 11 as well. Channel 30 communicates with a basin or recess 31 which is larger than the channel so that metal may be poured into the receiving spout easily. Note in FIG. 2 that basin 36 is designated by a riser 32. The part of the receiving spout 33 which is connected to shell 11 extends from the shell at an angle. The top 32' of riser 32 is well above the maximum expected molten metal level in the furnace when the furnace is not tilted and top 34 remains above the molten metal level when the furnace is tilted. Thus, even when the furnace is tilted through its maximum angle for the purpose of discharging metal from pouring spout 19, the top 32' of riser 32 will still be above the molten metal level within the furnace. This permits pouring molten metal into the furnace through receiving spout 27 without breaking vacuum or relieving pressure in the furnace while metal is also being poured out of spout 19. The receiving spout 27 and particularly riser 32 are on the tilting axis of the furnace in which case these elements also execute minimum motion when the furnace is tilted.

Means, which are not shown in the drawings, may be provided for enabling complete drainage of the furnace. Such means may comprise a removable or swingable door hinged or receiving spout 27 in line with a suitable opening so that when the furnace is tilted through a large angle while the pouring spout 19 is blocked off all residue in the furnace will flow out of the door. This door may be located in the outboard side of riser 32 or in the angled part 33 of receiving spout 27.

Because pouring spout 19 and receiving spout 27 are angled upwardly, molten metal will block their channels and orifices 15 and 16 when the furnace is tilted. Of course, during furnace operation, enough molten metal is kept in the furnace to seal off orifices 15 and 16. The pouring spout 19 and receiving spout 27 may also be provided with removable caps, not shown in the FIGS. 1–3 embodiment, although such caps are illustrated in the embodiment shown in FIGS. 5, 7 and 8. The molten metal seals, caps or both contribute toward maintaining the vacuum and gas pressure integrity of the holding vessel 10 and make possible gas treatment and vacuum treatment of its molten contents.

As mentioned earlier, advantages of the cooperation between the melting furnace and the holding furnace 10 as proposed herein are that various metallurgical processes can be conducted in the holding vessel and the melt therein can be maintained in various desired states while the melting furnaces are preparing its next heat. For instance, inert gases such as argon or nitrogen may be introduced into the holding vessel to supplant air and thereby prevent oxidation of the molten contents of holding vessel 10 pending use of the contents. In connection with making stainless steel an argon-oxygen mixture may be bubbled through the melt in vessel 10. As is known, this gas mixture inhibits certain reactions between chromium and other gases and hence, prevents undesirable removal of chromium. Bubbling or
diffusing gases through the melt in vessel 10 is also done for stirring and mixing the melt on some occasions.

One means for admitting gases to the melt or the space above it is to equip vessel 10 with a porous plug device as can be seen particularly well in FIGS. 2 and 3. A porous refractory plug 164 extends through the refractory bottom of vessel 10 and is secured with an apertured flange 165. Flange 165 cooperates with a stationary flange 166. The two flanges are together to form a seal when the vessel 10 is tilted as in FIG. 2 and the flanges are separated when the vessel is tilted as in FIG. 3. The lower stationary flange 166 terminates a gas feed pipe 167 in which there is an annular corrugated member 168 which is similar to a bellows. Member 168 is yielding and resilient and effectuates a better seal between flanges 165 and 166 when the vessel 10 is tilted. Pipe 167 leads to the sources, not shown, of various gases that are used in the vessel 10.

As can be seen particularly well in FIGS. 2 and 3, the furnace is provided with a removable cover 34 which has a refractory lining 35 on its interior. Cover 34, of course, is required to maintain the gas and vacuum tight integrity of vessel 10 and to make the interior of the holding furnace accessible for maintenance and inspection purposes.

As stated earlier, the holding furnace or vessel 10 may also be used to introduce alloying and other additives to the melt after it has been melted separately in a melting furnace and transferred to the vessel. This can be done in a gas or vacuum ambient. The furnace cover 35 supports a double-chamber hopper 170 for introducing additives and alloy materials to vessel 10. As shown in hidden lines in FIG. 2, hopper 170 has an upper gate 171 on which solid alloying materials may be deposited and a lower gate 172 which swings inwardly to drop materials into vessel 10. Materials are first deposited on gate 171 while it is closed. The materials are then dropped onto gate 172 while it is closed. When upper gate 171 is reclosed, lower gate 172 is opened to drop the materials into vessel 10 in which case there is no flow of gases between the atmosphere and the interior of vessel 10 because of gate 171 being closed. Vessel 10 separates from hopper 170 when the vessel is tilted as in FIG. 3. The mechanism for operating the gates 171 and 172 is not shown.

An important aspect of admitting alloying materials through the top of vessel 10 as just described is that the materials may be deposited directly on the top of the melt and on a clean surface because the inert gas or vacuum ambient maintained in the vessel avoids appreciable oxides and slag on the melt surface and much of the little slag which may be present rises in the receiving spout of the vessel.

The pumping system for evacuating vessel 10 is not shown but it will be understood to be severally connected to a laterally extending pipe section 174, shown fragmentarily in FIG. 2, which has an opening 175 through the refractory furnace lining as can be seen in FIGS. 2 and 3.

Nitrogen or other gases may also be introduced into vessel 10 at higher flow rates than are obtainable through porous plug 164 through a pipe 177 which feeds through furnace cover 34 but could be located anywhere above the melt surface inside the vessel. The pipe has mating separable flanges 178 and 179 and a resilient corrugated section 180 to accommodate tilting of vessel 10 and reconnection when the vessel is upright.

The holding furnace will now be described. In FIG. 2, one may see that there is an upright column 36 in front of the furnace. At the top of the column is a steel bearing plate 37 on which a pair of bearing posts 38 and 39 are mounted. Extending from the furnace shell are a pair of clevises 40 and 41 which are engaged with bearing posts 38 and 39, respectively, by means of pins such as 42, as shown in FIG. 3, the centers of which constitute a horizontal pivot axis for the furnace. As explained earlier, this tilting axis extends through riser 32 of receiving spout 27 and particularly the tip 24 of pouring spout 19.

The holding furnace may be tilted through a large vertical angle such as about 30° in order to pour metal from the furnace as can be seen in FIG. 3. The furnace may also be tilted backwardly through a smaller angle to facilitate removal of slag from a rear slag removal door assembly 45 which is of a known construction and need not be described.

The tilting mechanism is at the rear of the furnace. It comprises a pair of hydraulic rams 46 and 47 which are identical in structure so that only one will be described briefly. The hydraulic ram 46 is provided with a base 48 in which there is a pivot pin 40 attached to a stationary piston 50. A cylinder 51 is adapted to telescope on pivotal but axially immovable piston 50 when the volume within cylinder 51 is pressurized with hydraulic fluid.

Cylinder 51 has trunnions such as 52 extending laterally from it. These trunnions extend through a bearing block such as 53 that is fixed to a bracket 54 which is in turn attached to furnace shell 11. Thus, the force generated by extending or telescoping cylinder 51 is transmitted to furnace shell 11 to cause the whole furnace to tilt as illustrated in FIG. 3. Hydraulic pressure can also be relieved from cylinder 51 for back tilting the furnace through a small angle to thereby facilitate slag removal through door 45.

The holding furnace in FIG. 1 is incorporated in a system which permits essentially uninterrupted utilization of molten metal without lowering the level of molten metal within the furnace fall below a level at which the inert gas seals would be broken. Thus, the holding furnace is ideal for use in connection with a conveyored molding line, in which a series of molds such as 57 and 58 are passed under a pouring box 59 in the direction of the arrow 60 in FIG. 1. Pouring box 59 has some of its details omitted but it may be seen to comprise vertically movable arms 61 and 62 that operate valve stems 63 and 64 which cooperate, respectively, with valve seats, not shown, which are in the bottom of pouring box 59. Thus, when lifter arms 61 and 62 are raised, valve stems 63 and 64 are also raised and molten metal can flow from pouring box 59 into molds of the conveyored series 57, 58.

The top and side of pouring box 59 is slotted as indicated by the numeral 64. The tip 24 of pouring spout 19 extends into slot 64. Molten metal is discharged from the end of channel 23 of pouring spout tip 24 through slot 64 and to the interior of pouring box 59. There may be a rather close fit between tip 24 and slot 64 because, as explained earlier, tip 24 is on the furnace tilting axis and does not ascend or descend appreciably.
ciably nor does it execute an arc when the furnace is tilted.

As shown in FIG. 1, the holding furnace 10 may be furnished with molten metal from more than one melting furnace. Each of the melting furnaces are merely symbolized by concentric circles from which a pouring spout extends. The melting furnaces are indicated generally by the reference numerals 68 and 69. These furnaces may be of the electric arc type although their arc electrodes are not represented in the drawings. Electric furnaces 68 and 69 may be conventional in respect to their making available a heat of molten metal periodically. When the metal is ready for pouring from a melting furnace it is tilted and molten metal is discharged from one or the other of the pouring spouts 70 and 71. Positioned in line with the pouring spout of each melting furnace are molten metal conducting troughs 72 and 73. These troughs comprise metal shells that are lined with a refractory material 74 which is formed so as to provide a central channel 75 and an enlarged molten metal receiving basin 76. The tips 77 and 78 of troughs 72 and 73, respectively, are positioned over receiving basin 31 in the riser 32 of receiving spout 27 which is associated with holding furnace 10. Thus, it should be apparent that when either melting furnace 68 or 69 is tilted, molten metal will be delivered from their respective pouring spouts 70 and 71 to the troughs 72 or 73 and into the receiving spout 27 of the holding furnace. Because the tips 77 and 78 of the troughs are over receiving basin 31, and because the basin does not change its position significantly when the holding furnace is tilted, it is possible with the arrangement described to deliver molten metal to the holding furnace receiving spout 27 when the holding furnace is upright or tilted at any angle within its tilting limits. And, as explained earlier, molten metal may be discharged through pouring spout 19 while simultaneously admitting molten metal to the holding furnace through its receiving spout 27.

Holding furnace 10 is also equipped with means for maintaining its charge of molten metal at a desired high temperature. For this purpose an electrically resistive graphite heating rod 80, which is shown in hidden dashed lines in FIG. 1, extends across the interior of the holding furnace at a level which is above the expected high level of the metal charge. Electricity is passed through rod 80 so as to produce heat due to its resistance. This heat is radiated from rod 80 to the molten metal within the furnace. The manner in which the graphite rod 80 is supported will be described shortly hereafter in reference to FIGS. 9A and 9B. For the moment, however, it is sufficient to observe in FIG. 1 that opposite ends of the graphite rod 80 are engaged by normally stationary carriages 81 and 82. Carriage 81 is movable on an I-beam track 83 part of which is attached to a stationary platform 84 and the other part of which is attached to a platform 85 which tilts with holding furnace 10. Platforms 84 and 85 are separated by a joint or small gap 86. The other carriage 82 on the opposite side of the furnace is on an I-beam track 87 which is attached to a platform 88 that is connected with holding furnace 10 and tilts with it. There is also a stationary platform 89 around tilting platform 88 for the convenience of operating and maintenance personnel. The carriages 81 and 82 and their cooperating tracks 83 and 87, respectively, permit retraction of opposite ends of the graphite heating rod 80 for replacement of the rod as required.

FIG. 9A shows some of the details of the carriage 81 and I-beam track 83 assembly for holding graphite rod 80. Track 83 is attached to shelf 11 of holding furnace 10 by means of suitable brackets and bolts which are indicated generally by the reference numeral 92. There is also a gusset 93 which has a cap screw 94 that reacts against furnace shell 11 for leveling track 83.

Graphite rod 80 is tapered at one end 79 to engage tightly in a tapered mating bore in a graphite contact element 95. The end 96 of element 95 is also tapered to engage tightly in a correspondingly tapered bore of an adapter 97 which is preferably of copper or other good heat conducting material. Adapter 97 extends back into a water cooling jacket 98 that is secured with u-bolts 99 to a truck 100.

Furnace shell 11 is provided with a cylindrical radially extending thimble 101 which is closed at its end with an apertured plate 102 as may be seen in FIG. 9A. Spaced away from plate 102 is another apertured plate 103. The apertures of these plates cooperate with sealing rings 105 and 106 which prevent leakage of inert gas from the interior of holding furnace 10. Apertured plates 102 and 103 are pressed toward each other by a clamping device 107. A closed loop of coil spring 108 surrounds sealing rings 105 and presses them radially against cylindrical adapter 97.

Cylindrical adapter 97 serves as an electrical connector from a power source, not shown, to the socketed contact element 95 which holds graphite heating rod 80. Power is brought into the connector assembly through a slotted copper bus bar 109. Jacket 98 is equipped with a cooling water inlet 110 and an outlet such as 111.

Carriage truck 100 runs on track 83 which, in this example, constitutes a beam 90. The truck has two sets of upper wheels 112 and 113 and opposed lower guide wheels such as 114. There are also side cam rollers such as 115 and 116 engaged with opposite edges of I-beam flange 90 so that the truck is constrained to follow the track.

Attached to truck 100 is a clevis 119 that is engaged by a threaded bolt 120 which has a nut 121 and a washer on it. There is a coil spring 122 fitted over bolt 120. The spring 122 is compressed between nut 121 and a floating hinge element 123. Element 123 is provided with a stop foot 124. The end portion 129 of bolt 120 extends freely and slidably through a suitable aperture in hinge element 123. There is a stop nut 130 on the end 129 of bolt 120. Also pivotally connected to hinge element 123 is a link 125 whose opposite end is pivotally connected to a stationary post 126. Link 125 and bolt 120 comprise an over-center toggle linkage.

Thus, when hinge element 123 is pressed downwardly, its pivot goes beyond center and causes truck 100 to be restrained against movement away from furnace shell 11. Because spring 122 is captured between hinge element 123 and nut 121, the spring is in compression when the hinge element is pressed down. By lifting on hinge element 123 by way of a handle 123', the toggle linkage can be broken over center and folded as suggested by its initial broken-line position 127 and its final folded position 128. This, of course, causes truck 100 to retract and withdraw one end of the graphite rod 80 from the interior of the holding furnace for maintenance purposes.
Since the graphite rod 80 when intact is about equal to the width of the holding furnace, it is desirable that an intact rod can be admitted or withdrawn from one end of the furnace. For this reason, the truck which supports the graphite rod on the other side of the furnace as shown in FIG. 9B is adapted to translate a considerable distance along the two piece I-beam carriage track 87, 87′. Most of the construction shown in FIG. 9B is similar to that which is shown in FIG. 9A and described heretofore. Accordingly, like parts will be given the same reference numerals with a prime mark and their construction and purpose will not be described again since this can be inferred from the previous discussion. Only distinctive parts will be given new reference numerals and described.

Truck 100′ has wheels 112′, 113′, and 114′. There are also side cam rollers 115′ and 116′ that cooperate with the track flange 90′ beam 87. There is no toggle mechanism in this case. Rather, truck 100′ is latched in position by a hand pin 131 which engages a suitable socket 132 in the short section of track 87. When latch pin 131 is removed, truck 100′ and the various elements attached to it is free to roll back on the other piece of track 87′ so as to permit withdrawal of graphite rod 80 from the holding furnace. Since the graphite rod 80 may be very hot when it is withdrawn, the top of track 87′ is covered with a layer of refractory material 133. The track also has a joint 134. The section 87 of track to the left of the joint is, of course, attached to furnace shell 11 and tilted with it as suggested by the dashed-dot outline marked 87′. The section track 87′ to the right of gap 134 is, of course, stationary as can be inferred from the fact that it is mounted on a post 135.

Note in FIG. 9B that the end of rod 80 is rounded as indicated by the numeral 117 and that this rounded end bears against a v-shaped socket 118 in graphite contact element 95′. The rounded or ball shaped end 117 a rod 80 cooperates with socket 118 to impart a self-aligning and, hence, strain-relieving characteristic to rod 80.

As shown in the drawings, heating rod 80 extends across the interior of the furnace below the chord of the arc that defines the interior surface of refractory lining 35 in furnace cover 34. It will be appreciated that this arrangement results in avoiding feedback reflections of heat from one area of the cover lining to another which would otherwise result from the heat source rod 80 being between the spherical or arcuate surface of the lid and the chord. It will also be appreciated that the location of rod 80 relative to the cover lining 35 and the spherical shape of the lining results in a major portion of the heat radiated to the cover being reflected back to the surface of the molten metal in the furnace so that heat radiated to the metal is maximized.

In FIG. 5 the holding vessel is shown somewhat modified for cooperation with a continuous casting machine, only a schematized top view of the tundish of the casting machine being shown in this figure. Parts which have been discussed earlier and which are substantially the same will be given the same reference numerals in FIG. 5 but with a prime mark.

The receiving and pouring spouts of the vessel 10′ are shown in modified form in the FIG. 5 embodiment and these spouts are shown isolated in elevation and in somewhat greater detail in FIGS. 7 and 8, respectively. Components of the spouts are given distinctive reference numerals.

The receiving spout in FIGS. 5 and 7 is generally designated with the numeral 193. It comprises an angularly disposed metal shell section 184 connected to another section 185 by flanges 186 and 187. Clamping members 188 hold the flanged sections together and are removable. There is also an upright shell section 189 which has an apertured top flange 190. A domed cover 191 bears on flange 190 and effects a gas and vacuum seal therewith. The cover 191 is mounted on a hinge 192 so that the cover may be swung away to allow pouring melted metal from a ladle or other means, not shown, into holding furnace or vessel 10 and so the cover may assist in maintaining gas pressure or vacuum within the vessel. The shell sections are lined with hollow refractory material.

The pouring spout in FIGS. 5, 6 and 8 is generally designated with the numeral 195. It comprises an angularly upwardly disposed metal shell section 196 connected to a laterally extending section 197 which terminates in a flange 198. A flanged cap 199 is hinged at 200 to flange 198 so that cap 199 may be swung away or removed to enable discharge of molten metal from the pouring spout. The cap 199 is, of course, closed or in place when maintenance of vacuum or pressure in the holding furnace 10′ is desired.

Pouring spout shells 196 and 198 contain a channeled spout 201 of refractory material. The tip or end 202 of the refractory spout extends into cap 199 and tip 202 is thereby exposed and extending beyond flange 198 when the cap is open. This construction facilitates pouring from the vessel 10′. Note that the tip 202 of the pouring spout is in-line with the tilt axis of the vessel in which case the tip will not swing through an arc when the vessel is tilted.

In FIGS. 5 and 6 vessel 10′ is arranged for furnishing molten metal to the tundish 204 of a continuous strand casting machine. Only those elements of the casting machine are shown which are necessary to elucidate another feature of the system which is the matter of maintaining a certain quantity of metal in the tundish 204 at all times during casting by regulating the tilt angle and, hence, the discharge rate of vessel 10′.

As seen in FIGS. 5 and 6, tundish 204 is supported over the mold 205 of a continuous casting machine. A molded strand 206 emerges from the mold. Vessel 10′ is presumably at about the same elevation as the tundish so the vessel may pour directly into the tundish 204. The tundish 204 is on tracks 207, 208 and 209. Small gaps 210 and 211 separate short track sections 208 from adjacent sections 207 and 209. The latter sections are fixedly mounted but section 208 is supported on a load cell 212. There are parallel sets of tracks as can be seen in the drawing. A pair of wheels such as 213 on a common axle of the tundish bear on short track section 208 when the tundish is in position to feed the mold 205 by discharging from its bottom valve hole 214. The weight of the tundish 204 and its molten contents is thereby sensed by the fixedly mounted load cells 212 which are under each of the track sections 208. Loads cells 212 may be of the hydraulic type in which case pressure changes are a function of load changes or they may be of the strain gage type in which case impedence variations are a function of load changes. Load cell 212 may be considered to be of the strain gage type in this example.
In one mode, signals from load cells 212 are delivered to a control unit 151 wherein the signals are processed and used to control a motor 152 which drives a pump 153. A hydraulic output pipe 154 is connected to the hydraulic rams 46 and 47 which tilt the furnace. The return pipe 155 has an electrically controlled valve 156 installed in it. When the valve is open, pressure is relieved from the rams and the furnace tilts back.

The electric control unit for the valve 156 is symbolized by the element 157. Conductors 161 interconnect control unit 151 and the electric valve control 157. When valve 156 is open, hydraulic fluid returns through pipe 158 to a reservoir 159. Pump 153 draws hydraulic fluid from the reservoir 159 by way of a pipe 160. A pair of electric signal feedback conductors 161 also feed into control 151. The feedback signal is derived from conventional tilt position sensors, not shown, but which are installed on the furnace. Feedback is not required in all arrangements of the system.

In the depicted arrangement, the magnitude of the signal from load cells 212 depends on the weight of molten metal in tundish 204 at any instant. If the weight of metal is greater than the set value of control 151, the latter delivers its signal to valve control 157 which causes valve 156 to throttle open and the furnace to tilt back. Conversely, if the metal weight is below the set limit of control 151, the latter responds to the signal from load cells 212 by increasing the output of pump 153 and correspondingly increasing the tilt of the furnace so that more metal will flow from its pouring spout. The feedback signal may be used to vary the response rate of the hydraulic rams as the molten metal weight approaches set limits and this signal may also be used to establish the permissible differential between the maximum and minimum weights of metal that are allowed in the tundish 204.

Thus, it will be seen that a substantially constant rate of molten metal discharge from the furnace can be maintained with this system even though additional molten metal is admitted to the receiving spout 183 of the holding furnace while the furnace is tilted and issuing molten metal from its pouring spout 195.

Those skilled in this art will appreciate that the load cell 212 could be associated with the holding furnace rather than the tundish 204 as described. In such case the weight of the metal in the furnace would govern the signals from the load cell.

In summary, a new holding furnace system has been described. The holding furnace used in the system is on a tilting axis which extends through its receiving and pouring spouts. The receiving spout is so shaped and positioned as to permit introduction of molten metal into the furnace at the same time that molten metal is being discharged from the pouring spout to a molten metal utilizing device. When the furnace is either tilted or upright, molten metal serves to seal the metal receiving and metal discharging orifices so that a slightly pressurized inert gas atmosphere can be maintained within the holding furnace to minimize oxidation and slag formation. Means are provided to control the rate of molten metal discharge from the furnace so that the system can be fully automated. All of the finishing operations for a heat may be conducted in gaseous or vacuum conditions in the holding furnace or vessel.

Several melting furnaces may be used to supply the holding furnace. These are located in proximity with the holding furnace and deliver metal to it by means of individual troughs which have their discharge tips located over the receiving spout of the holding furnace. The holding furnace permits operation of the melting furnaces at a high duty cycle. A resistance heating rod maintains the temperature of the metal within the holding furnace at all times. The system maximizes the duty cycle of molten metal utilizing equipment and improves productivity of a foundry or casting plant.

Although a preferred embodiment of the invention has been described in detail, such description is to be considered illustrative rather than limiting, for the invention may be variously embodied and is to be limited only by interpretation of the claims which follow.

We claim:

1. A holding furnace comprising:
   a. an enclosed refractory lined vessel,
   b. said vessel having spaced apart orifices extending therethrough, and below the normally expected level of molten metal to be contained in said furnace,
   c. molten metal receiving spout means mounted on said vessel in communication with one orifice and a pouring spout means mounted on said vessel is communication with another orifice,
   d. said receiving spout means and said pouring spout means extending upwardly from said orifices so that their receiving and pouring openings are above the normally expected level of molten metal in said vessel,
   e. means supporting said vessel for tilting on an axis,
   f. means operable to tilt said vessel selectively on said axis,
   g. means for receiving a quantity of molten metal from said vessel, said receiving means being movable with respect to said vessel and being arranged to be positioned beneath the pouring spout when said vessel is in a tilted position, and
   h. weight responsive means positioned to be engaged by said receiving means when the latter is beneath said pouring spout, means for initiating the tilting of said vessel to pour molten metal into said receiving means, said responsive means being operative to produce a signal functionally related to said weight, and control means responsive to said signal for controlling said tilt means to terminate said pouring after a preselected quantity of metal has been poured into said receiving means,
   i. the tilting axis of said furnace extending through at least the terminal portions of said receiving spout and said pouring spout whereby molten metal may be admitted to said furnace through said receiving spout when said furnace is tilted for discharge of molten metal into said receiving means and whereby atmospheric air is prevented from entering the interior of said furnace when said furnace is tilted.

2. The invention set forth in claim 1 wherein said receiving means comprises a receptacle mounted on wheels which in turn cooperate with a track for supporting and allowing movement of said receiving means, and wherein said means responsive to the weight of said receiving means comprises load cell means disposed beneath said track.

3. The invention set forth in claim 2 wherein:
   a. said pouring spout includes a generally horizontally disposed channeled tip, and
   b. said tilting axis lies outside the shell of said furnace and extends through said tilted of said pouring spout,
whereby said channeled tip rotates about its own longitudinal axis during furnace tilting but the outlet of said tip remains substantially fixed during such tilting.

4. A holding furnace system comprising:
   a. a furnace having a metal shell, a hollow refractory lined interior and a cover for enclosing the same,
   b. said shell and said refractory lining having spaced apart orifices extending therethrough, and below the normally expected level of molten metal to be contained in said furnace,
   c. molten metal receiving spout means exteriorly mounted on said furnace in communication with one orifice and a pouring spout means exteriorly mounted on said furnace in communication with another orifice,
   d. said receiving spout means and said pouring spout means extending upwardly from said orifices of said furnace so that their metal receiving and pouring openings are above the normally expected level of molten metal in said furnace,
   e. means supporting said furnace for tilting on an axis,
   f. means operable to tilt said furnace selectively on said axis,
   g. a porous plug means extending through said refractory lining of said furnace at a level below that normally occupied by molten metal during normal furnace operation, and
   h. means for conducting gas under pressure to said porous plug means from a source thereof exteriorly of said furnace,
   i. means for evacuating the interior of said furnace, said means including a pipe means passing through the shell and refractory lining thereof and connected exteriorly of said furnace to a vacuum source.

5. A holding furnace system comprising:
   a. a furnace having a metal shell, a hollow refractory lined interior and a cover for enclosing the same,
   b. said shell and said refractory lining having spaced apart orifices extending therethrough, and below the normally expected level of molten metal to be contained in said furnace,
   c. molten metal receiving spout means exteriorly mounted on said furnace in communication with one orifice and a pouring spout means exteriorly mounted on said furnace in communication with another orifice,
   d. said receiving spout means and said pouring spout means extending upwardly from said orifices of said furnace so that their metal receiving and pouring openings are above the normally expected level of molten metal in said furnace,
   e. means supporting said furnace for tilting on an axis,
   f. means operable to tilt said furnace selectively on said axis,
   g. means for evacuating the interior of said furnace, said means including a pipe means passing through the shell and refractory lining thereof and connected exteriorly of said furnace to a vacuum source.

6. A holding furnace comprising:
   an enclosed vessel having an enclosed hollow refractory lining defining a metal containing space,
the molten metal to be contained in said vessel forming a pool defined by the bottom and side walls of said lining,
said first and second orifices and said second molten metal conductor being below the normal molten metal level in said pool when said vessel is in its pouring position so that molten metal is discharged from the other end of said second molten metal conductor, said first molten metal conductor extending upwardly from said first orifice and the other end of said first conductor being above the normal level of molten metal in said pool when the vessel is in said position whereby molten metal may be admitted to said vessel through the other end opening of said first conductor and molten metal is discharged from the other end of said second molten metal conductor without atmospheric air entering said furnace through said pouring or receiving spouts,
an electric resistance heating means disposed in said furnace and between said cover and the expected level of molten metal in said furnace for heating the latter.
11. A holding furnace comprising:
an enclosed refractory lined vessel having a cover, a side wall and a bottom defining a molten metal containing space,
said side wall having first and second spaced apart orifices extending therethrough and opening into said space adjacent said bottom and below the normally expected level of molten metal to be contained in said furnace,
a molten metal receiving spout mounted on said ves-
sel and having a first molten metal channel formed therein and extending away from said vessel and having one end connected to said first orifice and an opening at its opposite end, a pouring spout mounted on said vessel in spaced relation from said receiving spout and having a second molten metal channel formed therein and extending away from said vessel and having one end connected to said second orifice and an opposite end displaced therefrom,
means supporting said vessel for tilting on an axis, said vessel having a molten metal discharging position wherein said first and second orifices in said side wall and said second molten metal channel and the other end thereof are below the expected molten metal level in said vessel whereby molten metal is discharged from said pouring spout and said enclosure is sealed,
the outer end of said first molten metal channel being disposed above the expected level of molten metal in said furnace when said vessel is in its pouring position whereby molten metal may be admitted to said furnace through the outer end opening of said first channel when said furnace is in its pouring position the metal is being discharged from said pouring spout without atmospheric air entering said vessel through said receiving spout.
12. The holding furnace set forth in claim 11 and including an electric resistance heating element extending between the sides of said furnace lining and between the cover and the expected level of molten metal in said vessel.