Aug. 11, 1953 A. W. LILLIENBERG 2,648,715

FURNACE FOR MOLTEN METAL

Filed June 6, 1950 2 Sheets-Sheet 1

Fig. 1

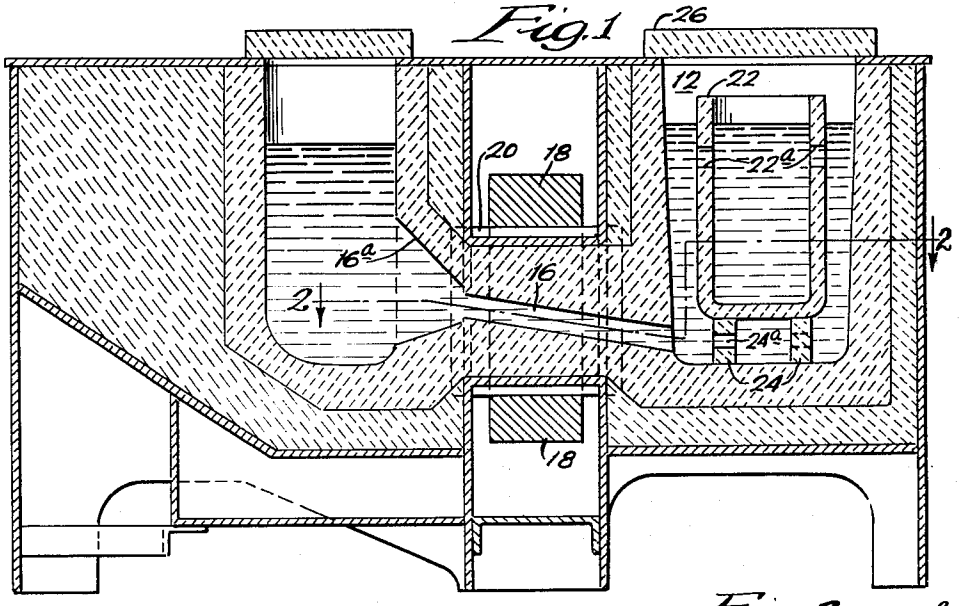


Fig. 2

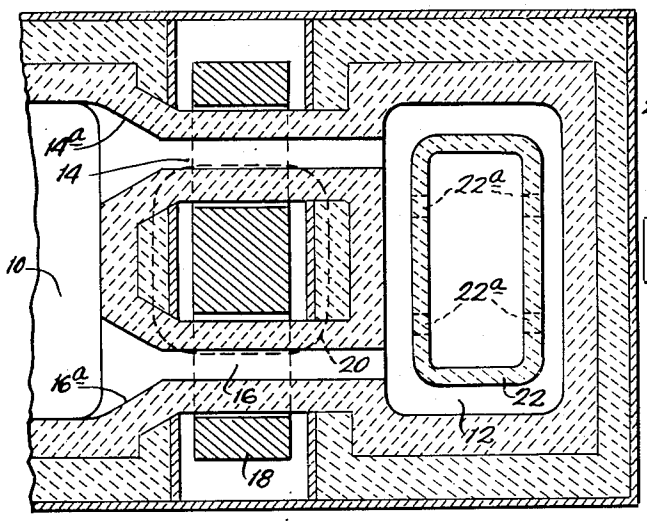


Fig. 3

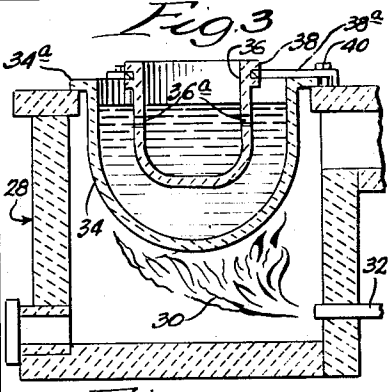
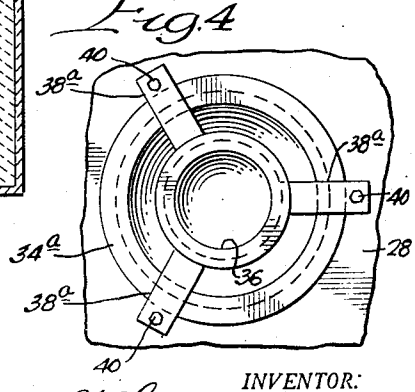


Fig. 4



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Fig. 5

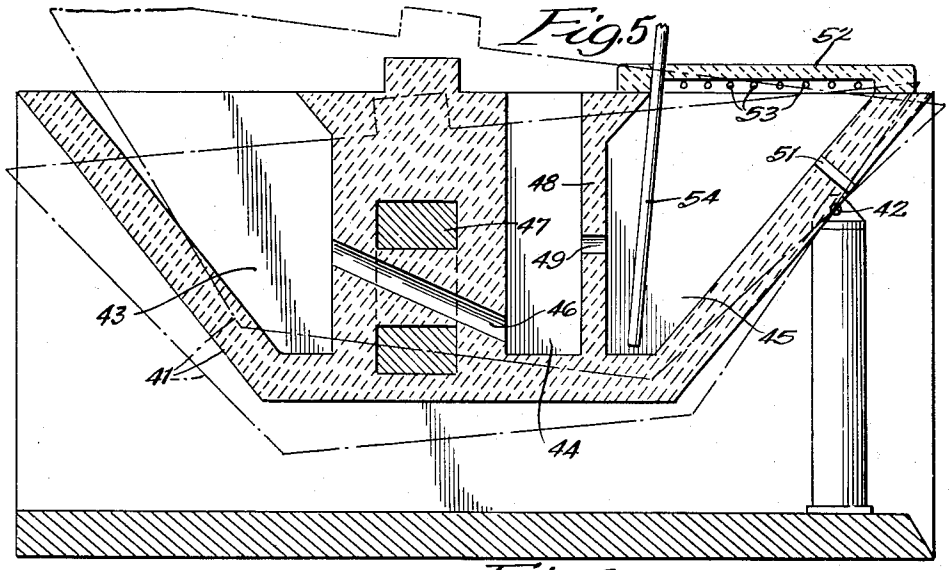
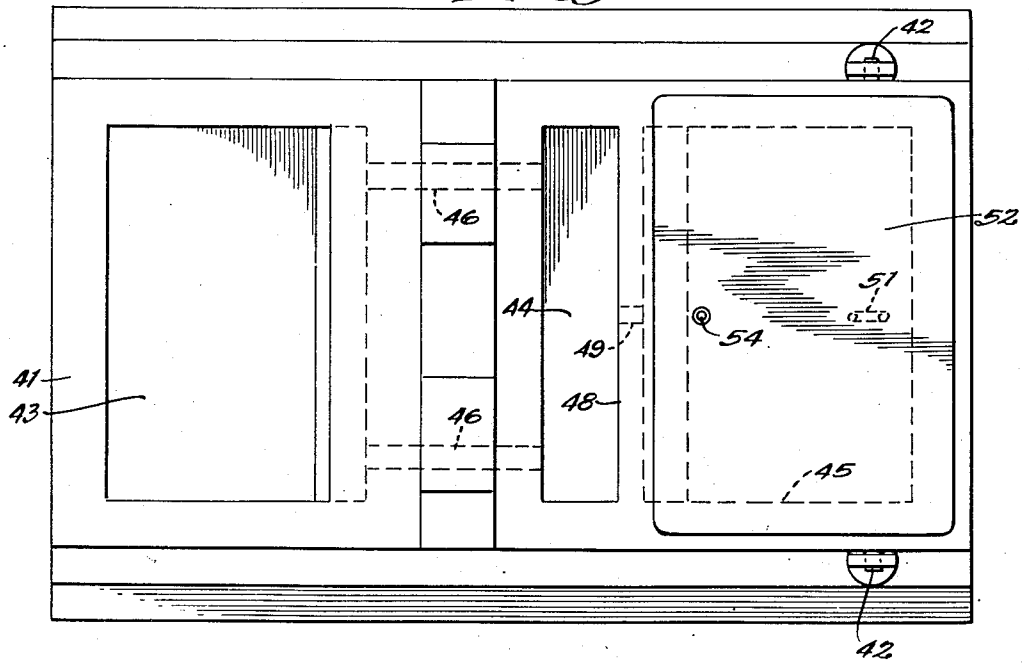


Fig. 6



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2,648,715

FURNACE FOR MOLTEN METAL

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Application June 6, 1950, Serial No. 166,505

9 Claims. (Cl. 13—29)

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This invention relates to an improved furnace for molten metal and specifically for use with molten aluminum alloy or like material to hold the same within predetermined critical temperature limits.

It is desirable in the preparation of metal for die casting and related uses, to hold the metal at a temperature very close to the critical temperature where alloys begin to solidify or otherwise separate. However, this demands extremely accurate temperature control since even a small drop below the critical temperature causes separation of the metal and even a small temperature increase above the critical temperature causes loss of the advantages associated with use of the metal at the critical temperature.

It is often advisable to add cold metal to the furnace during operation, thereby tending to cool the metal in the furnace. This also makes it extremely difficult to prevent the temperature from dropping to the freezing temperature.

When using an induction furnace, heat transfer is accomplished by the circulation of the metal, either in the chamber itself or, in the case of a two chamber furnace, between the chambers. Should the temperature at any point in the path of circulation drop to the melting point, the metal becomes sluggish and fails to flow as desired. This reduces the heat transfer at a time when proper circulation and heating is most needed.

It is, therefore, a general object of the present invention to provide an improved metal holding furnace capable of holding the metal within close temperature limits.

A further object of the present invention is to provide a metal furnace capable of holding temperature very close to the melting point of the metal and at the same time permit charging of cold metal in reasonable amounts without reducing the temperature to the melting point. According to one desirable feature, the furnace can be used for continuous flow with the molten metal being supplied within the desired close temperature limits.

A further object of the present invention is to provide an improved metal holding furnace wherein the metal is held in a quiescent condition in one portion of the mechanism and is agitated in another portion of the mechanism. One advantage of this construction is that the metal can be fluxed in the quiescent zone.

Another object is to provide a furnace in which the metal in the pouring chamber is heated separately from the metal in other parts of the furnace.

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Still another object is to provide a furnace in which the metal in the pouring chamber is blanketed by an inert atmosphere. Preferably an inert gas is bubbled up through the metal to facilitate the fluxing and to assist in removal of slag or foreign particles.

The novel features which I believe to be characteristic of my invention are set forth with particularity in the appended claims. My invention itself, however, both as to its organization and method of operation may best be understood by reference to the following description taken in conjunction with the accompanying drawing, in which:

Figure 1 is a cross-sectional view of a multiple chamber induction furnace constructed in accordance with the principles of the present invention;

Figure 2 is a fragmentary cross-sectional view along axis 2—2 of Figure 1;

Figure 3 is a cross-sectional view of a gas fired furnace constructed in accordance with the principles of the present invention;

Figure 4 is a fragmentary top plan view of the furnace of Figure 3;

Figure 5 is a view similar to Figure 1 of an alternative furnace construction embodying the invention; and

Figure 6 is a top plan view of the furnace of Figure 5.

Referring now to Figures 1 and 2, there is shown an induction furnace having a pair of chambers 10 and 12 for molten metal. These chambers are connected by a pair of spaced channels 14 and 16. A rectangular magnetic core 18 defines a pair of windows to receive the channels 14 and 16. As shown in Figure 2, the center leg of the core is encircled by the energizing coil 20.

When an alternating electromotive force is applied to the coil 20, an alternating flux is created within the core 18. This flux links the closed circuit defined by the channels 14 and 16 and the chambers or reservoirs 10 and 12 to cause current flow therein. The power loss associated with this current flow heats the metal.

In the furnace of Figures 1 and 2, the chamber 10 is the charging or melting chamber and is intended to receive the metal to be melted. The chamber 12 is the holding or ladling chamber and is the chamber from which the melted metal is taken.

The passages 14 and 16 are conically shaped at ends 14a and 16a to cause the fluid level in the chambers 10 and 12 to change when the furnace is energized. This feature of the furnace

construction is described and claimed in my Patent No. 2,540,744, issued February 6, 1951, for Induction Furnace and assigned to the same assignee as the present invention.

In the furnace of Figures 1 and 2, elements (not shown) are provided to energize and de-energize the winding 20 as required to maintain relatively constant metal temperature in the chamber 12. These elements are capable of maintaining the temperature of the metal within a relatively broad temperature band, perhaps 10° F. in width. In one mechanism for this purpose, a temperature sensitive device, such as a thermocouple is positioned to respond to the temperature of the metal in chamber 12 and actuates a relay to shut off power when the metal temperature exceeds an upper limit and actuates the relay to turn on the power when the metal temperature falls below a lower limit.

In accordance with the present invention, the temperature of a predetermined part of the metal in the chamber 12 is maintained constant by substantially isolating it in a separate discharge chamber from which it can be ladled. As shown, this is accomplished by providing a crucible 22 in the chamber 12. Bricks 24, Figure 1, with holes 24*a*, are positioned underneath the crucible 22.

The crucible 22 has one or more restricted openings 22*a* located a few inches below the normal level of the liquid metal in the chamber 12 and above the bottom of the crucible. These openings define a path for limited liquid flow from chamber 12 to the crucible 22 to replenish the liquid metal therein after ladling but are small enough normally to prevent circulation between the crucible and the chamber 12.

The walls of the crucible 22 have a substantial thermal resistance. That is, they are made of material and of thickness such as to produce a substantial temperature difference between the metal in crucible 22 and in chamber 12. This temperature difference arises from the heat losses from the surface of the metal in the crucible and from the walls of the crucible which extend above the molten metal. To create a thermal flow through the crucible to replace these lost heat units, a temperature difference is required, the amount of this difference depending on the thermal resistance of the crucible walls and the quantity of heat lost by the metal in the crucible. In accordance with the present invention these design factors are chosen to give a substantial temperature difference.

I have discovered that with a crucible 22 having walls of ceramic material approximately one inch thick, the temperature difference between the metal in the discharge chamber defined by the crucible and the metal in chamber 12 is sufficient to permit the latter metal to be held at a temperature well above the critical temperature of the metal while at the same time the metal in the crucible 22 is held close to the critical temperature just above the separating temperature where metal is desired to be ladled. Moreover, while the temperature of the metal in chamber 12 varies over a rather broad temperature band, the metal in the crucible is held within a much more narrow temperature range. Consequently, the thermostatic elements may be set to hold a temperature range in the chamber 12 that maintains the metal in crucible 22 close to the critical temperature with assurance that it will not fall below the critical temperature.

In one metal melting furnace constructed similar to the furnace of Figures 1 and 2, the following construction was used and conditions of operation were achieved:

Crucible 22—Graphite of cylindrical shape with inside diameter 10" and 14" depth and a single hole 22*a* 5/8" in diameter 3" below the top of the molten metal and having wall thickness of 1¼".
Chamber 12—16" deep, 18" long and 14" wide.
Chamber 10—16" deep, 18" long and 8" wide.
Power input—29 kw.
Pouring rate—2½ pounds every 75 seconds.
Charging rate—10 pounds every 5 minutes.
Temperature, crucible 22—1148 to 1150° F.
Temperature, chamber 12—1187 to 1197° F.
Temperature, chamber 10—1145 to 1200° F.

From the above data it will be evident that the metal in crucible 22 was held to a 2 degree temperature band whereas the metal in the chamber 12 where the thermostatic control elements were located varied over a 10 degree band.

In addition to maintaining the temperature of the liquid metal within a very narrow temperature range, the crucible 22 defines a space wherein the metal is in a quiescent condition. The metal in the chambers 10 and 12 is agitated by the combined action of the magnetic field and the current flow in the metal and normally circulates violently. This circulation has the advantage of keeping the outer surface of the crucible 22 at a uniform temperature and, in addition, maintains the metal well mixed.

In the quiescent metal in the crucible 22, the impurities have an opportunity to settle out or rise leaving only the pure metal in the body of the crucible.

In operating the furnace fluxing of the metal is preferably performed in the crucible. This keeps the flux away from the chamber walls and the channels thereby keeping them clean for longer periods and confines the flux to the crucible which can easily be cleaned or replaced when necessary.

There is some controversy among those skilled in the art in connection with the advantages of having the metal quiescent or agitated before ladling or pouring. Experience indicates that agitation tends to separate some of the impurities and produce a homogeneous metal. A short period of quiescence is known to be valuable after fluxing, particularly for sand and permanent mold castings. Since the metal passes through both conditions in the furnace of Figures 1 and 2 before it is used, whatever advantages are associated with either condition of the metal are achieved.

Figure 3 shows a gas fired metal holding furnace constructed in accordance with the principles of the present invention. This furnace is defined by a refractory housing 28 in which a gas flame 30 from burner 32 burns. A semi-spherical crucible 34 is supported over flame 30 by the annular rim 34*a* which rests on the top surface of the housing 28. The supply of gas to the burner is controlled by thermostatic elements (not shown) which vary the rate of gas flow as necessary to keep the metal temperature in crucible 34 within a relatively broad temperature band.

In accordance with the present invention a crucible 36 is disposed within outer crucible 34 in spaced relation with the walls thereof. As shown in Figures 3 and 4, this is accomplished by the mounting ring 38 which is received in an annular groove at the upper edge of the crucible 36.

Arms 38a fan out from the ring 38 and are secured to the housing 28 by bolts 40. The crucible 36 has one or more restricted holes 36a located a few inches below the normal level of metal in the chamber 34 and above the bottom of the crucible.

The crucible 36 is made of material having a substantial thermal resistance. This causes the temperature of the metal in the crucible to be substantially lower than the temperature of the metal in the space between crucibles 34 and 36. Moreover, the temperature of the metal in the crucible 36 is held within a relatively small range of values as compared with the range of values of the metal in the space between the crucibles. Thus the thermostatic elements controlling the application of heat to chamber crucible 34 may be set to a temperature to hold the metal in the crucible 36 close to the critical temperature without danger of falling below that temperature.

The structure shown in Figure 3 possesses the great advantage of permitting use of fluxing chemicals without requiring high temperature furnace operation or a waiting period for the furnace to cool after fluxing. Fluxing chemicals requires a metal temperature substantially higher than the most desirable ladling temperature, the exact temperature depending on the alloy being melted. This demands operation of the furnace at this higher temperature while fluxing chemicals are used and thereafter waiting, with the metal in the furnace or in a special ladle, while the metal cools to the desired temperature.

In the apparatus of Figure 3, the metal outside the crucible 36 is above the temperature of the metal in the crucible. This temperature difference can be made sufficient to permit effective fluxing of the metal outside the crucible. At the same time, however, the metal in the crucible is at the desired temperature for use and can be used without delay.

Moreover, since the impurities are fluxed out in the chamber outside the crucible, the metal in the crucible is bright and free of a heavy layer of dross. This simplifies ladling as it renders it unnecessary to skim away the dross before the metal can be ladled.

It will also be observed that heating of the metal in the crucible is also accomplished by the hotter metal surrounding the crucible flowing into the crucible through openings 22a or 36a. The greater the amount of metal ladled from the crucible the greater the effect of this heating source. This tends to counteract the cooling effect of the ladling.

The temperature differential between the metal in the metal holding chamber and the metal in the crucible is determined by the rate of heat loss from the crucible, the thermal resistance of the crucible, and the exposure of the surface of the crucible to the molten metal. In the furnace of the present invention, these values are adjusted to give the requisite differential.

If desired, the amount of heat flow to crucible 22 may be decreased by eccentrically positioning it against a wall of chamber 12, thus reducing exposure of the crucible to the hot metal in the chamber.

The embodiment of the invention shown in Figures 5 and 6 comprises a furnace body 41 pivoted on a horizontal axis 42 for tilting movement from the solid line position shown to either of the dotted line positions shown. The body is formed with three horizontally spaced chambers 43, 44, and 45. The chamber 43 comprises the

melting chamber and is connected to the chamber 44 which forms the holding chamber by a pair of sloping channels 46. A primary coil may be wound on a core arranged around the channels 46 as indicated at 47 to heat the metal in the channels and in the melting and holding chambers in the same manner as described in connection with Figures 1 and 2.

The chambers 44 and 45 are separated by a relatively thin common wall 48 of a material having a relatively low thermo conductivity such as a ceramic material. The chambers are connected by a restricted opening 49 spaced above the chamber bottoms and below the normal liquid level in the chambers. The chamber 45 constitutes a pouring chamber and is formed in its end wall with a pouring opening 51 through which molten metal may be discharged.

The pouring chamber 45 is preferably closed by a cover 52 to prevent access of air to the metal therein. If desired, the cover 52 may carry heating means shown as electric resistance elements 53 which are independently controlled to maintain any desired temperature in the pouring chamber.

Additionally, the metal in the pouring chamber may be agitated by and blanketed with an inert gas such as nitrogen, hydrogen, or the like. As shown, a conduit 54 extends through the cover into the lower part of the chamber 45 and may have inert gas forced therethrough to bubble up through the molten metal in the pouring chamber and to fill the upper part of the chamber below the cover 52 with an inert gas.

In the operation of this construction the metal is inserted in the melting chamber 43 and will be melted by the flow of current therethrough in the channels 46 induced by the primary coil 47. This will heat and agitate the metal in the melting chamber 43 and in the holding chamber 44. Metal from the holding chamber 44 will flow through the restricted opening 49 into the pouring chamber 45. Since the opening 49 is below the normal metal surface and above the bottoms of the chambers, the metal which flows into the pouring chamber will be pure, clean metal. In the pouring chamber the molten metal is agitated by the inert gas and is covered by a blanket of inert gas so that oxidation and slag formation are minimized. It is contemplated that the metal may be fluxed in the pouring chamber so that the flux is kept away from the channels and other furnace parts. Agitation of the metal by the inert gas assists materially in the fluxing.

This furnace construction can be operated for continuous pouring, and for this purpose the furnace body is preferably tilted to the upper dot-dash line position. With the furnace in this position, metal can be continuously changed in the melting chamber 43 and clean metal will continuously flow from the pouring opening 51. Although the changing may produce substantial temperature variations in the melting and holding chambers, the metal in the pouring chamber will remain at a uniform temperature since it is heated only through the wall 48. If the metal in the pouring chamber tends to become too cool, the heating elements 53 may be utilized to increase its temperature to the desired value. To stop the flow, the furnace body may be rocked to the lower dot-dash line position so that the metal in the pouring chamber will be below the pouring opening.

This application is a continuation-in-part of

my application Serial No. 116,084 filed September 16, 1949, and now abandoned.

While several embodiments of the invention have been shown and described in detail herein, it will be understood that they are illustrative only and are not to be taken as a definition of the scope of the invention, reference being had for this purpose to the appended claims.

What is claimed is:

1. A furnace for molten metal comprising horizontally spaced melting and holding chambers to receive molten metal, channels connecting the chambers to conduct metal therebetween, means to establish a time varying magnetic flux linking the channels to heat metal in the channels and chambers to melt the metal, means defining a discharge chamber adjacent to the holding chamber and isolated from the melting chamber, there being a restricted passage between the holding and discharge chambers above the bottoms thereof and below the normal metal level therein, the discharge chamber being remote from the heating means whereby the metal therein will be heated by the heating means only through the metal in the holding chamber.

2. A furnace for molten metal comprising horizontally spaced melting and holding chambers to receive molten metal, channels connecting the chambers to conduct metal therebetween, means to establish a time varying magnetic flux linking the channels to heat metal in the channels and chambers to melt the metal, means defining a pouring chamber adjacent to the holding chamber and isolated from the melting chamber, there being a restricted passage between the holding and pouring chambers above the bottoms thereof and below the normal metal level therein, the pouring chamber having at least one wall in common with the holding chamber and being remote from the heating means whereby it will be heated by the heating means only through the metal in the holding chamber.

3. A furnace for molten metal comprising horizontally spaced melting and holding chambers to receive molten metal, channels connecting the chambers to conduct metal therebetween, means to establish a time varying magnetic flux linking the channels to heat metal in the channels and chambers to melt the metal, means defining a pouring chamber adjacent to the holding chamber and isolated from the melting chamber, there being a restricted passage between the holding and pouring chambers above the bottoms thereof and below the normal metal level therein, the pouring chamber being remote from the heating means whereby it will be heated by the heating means only through the metal in the holding chamber, a cover over the pouring chamber, and additional heating means carried by the cover to supply additional heat to the metal in the pouring chamber.

4. A furnace for molten metal comprising horizontally spaced melting and holding chambers to receive molten metal, channels connecting the chambers to conduct metal therebetween, means to establish a time varying magnetic flux linking the channels to heat metal in the channels and chambers to melt the metal, means defining a pouring chamber adjacent to the holding chamber and isolated from the melting chamber, there being a restricted passage between the holding and pouring chambers above the bottoms thereof and below the normal metal level therein, the pouring chamber being remote from the heating means whereby it will be heated by the heating means only through the metal in the holding chamber, and a conduit opening into the lower part of the pouring chamber below the normal level of the metal therein to discharge an inert gas into the metal.

5. A furnace for molten metal comprising horizontally spaced melting and holding chambers to receive molten metal, channels connecting the chambers to conduct metal therebetween, means to establish a time varying magnetic flux linking the channels to heat metal in the channels and chambers to melt the metal, means defining a pouring chamber adjacent to the holding chamber and isolated from the melting chamber, there being a restricted passage between the holding and pouring chambers above the bottoms thereof and below the normal metal level therein, the pouring chamber being remote from the heating means whereby it will be heated by the heating means only through the metal in the holding chamber, a cover over the pouring chamber, the pouring chamber having an outlet opening in its side wall below the cover, and a conduit opening into the lower part of the pouring chamber below the normal level of the metal therein to discharge an inert gas into the metal.

6. A furnace for molten metal comprising means forming horizontally aligned melting, holding and pouring chambers, the melting and holding chambers being spaced and the holding and pouring chambers having one wall in common, the pouring chamber being wholly isolated from the melting chamber, channels connecting the melting and holding chambers to conduct metal therebetween, means to establish a time varying magnetic flux linking the channels to induce heating currents in the metal in the channels and the melting and holding chambers, and said common wall between the holding and pouring chambers having a restricted opening therein above the bottoms of said chambers and below the normal level of the metal therein.

7. A furnace for molten metal comprising means forming horizontally aligned melting, holding and pouring chambers, the melting and holding chambers being spaced and the holding and pouring chambers having one wall in common, the pouring chamber being wholly isolated from the melting chamber, channels connecting the melting and holding chambers to conduct metal therebetween, means to establish a time varying magnetic flux linking the channels and the melting and holding chambers, said common wall between the holding and pouring chambers having a restricted opening therein above the bottoms of said chambers and below the normal level of the metal therein, a cover for the pouring chamber, and heating means in the cover separately to heat the metal in the pouring chamber.

8. A furnace for molten metal comprising means forming horizontally aligned melting, holding and pouring chambers, the melting and holding chambers being spaced and the holding and pouring chambers having one wall in common, the pouring chamber being wholly isolated from the melting chamber, channels connecting the melting and holding chambers to conduct metal therebetween, means to establish a time varying magnetic flux linking the channels to induce heating currents in the metal in the channels and the melting and holding chambers,

said common wall between the holding and pouring chambers having a restricted opening therein above the bottoms of said chambers and below the normal level of the metal therein, the pouring chamber having a pouring opening in its side wall, a cover for the pouring chamber, and a conduit opening into the lower part of the pouring chamber below the normal metal level therein to discharge an inert gas into the metal.

9. A furnace for molten metal comprising means forming horizontally aligned melting, holding and pouring chambers, the melting and holding chambers being spaced and the holding and pouring chambers having one wall in common, the pouring chamber being wholly isolated from the melting chamber, channels connecting the melting and holding chambers to conduct metal therebetween, means to establish a time varying magnetic flux linking the channels to induce heating currents in the metal in the channels and the melting and holding chambers, said common wall between the holding and pouring chambers having a restricted opening therein above the bottoms of said chambers and below the normal level of the metal therein, the pouring chamber having a pouring opening

in its side wall, a cover for the pouring chamber, heating means in the cover, and a conduit opening into the lower part of the pouring chamber below the normal metal level therein to discharge an inert gas into the metal.

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References Cited in the file of this patent

UNITED STATES PATENTS

Number	Name	Date
308,028	Zimmerman et al.	Nov. 11, 1884
1,238,604	Weaver	Aug. 28, 1917
1,769,223	Isliker	July 1, 1930
2,000,488	Korsmo	May 7, 1935
2,020,101	Brown	Nov. 5 1935
2,040,787	Frost	May 12, 1936
2,102,582	Summey	Dec. 14, 1937
2,472,465	Cornell	June 7, 1949
2,499,541	Tama	Mar. 7, 1950
2,503,621	Lindner et al.	Apr. 11, 1950

FOREIGN PATENTS

Number	Country	Date
578,977	Great Britain	July 18, 1946
882,085	France	Feb. 15, 1943