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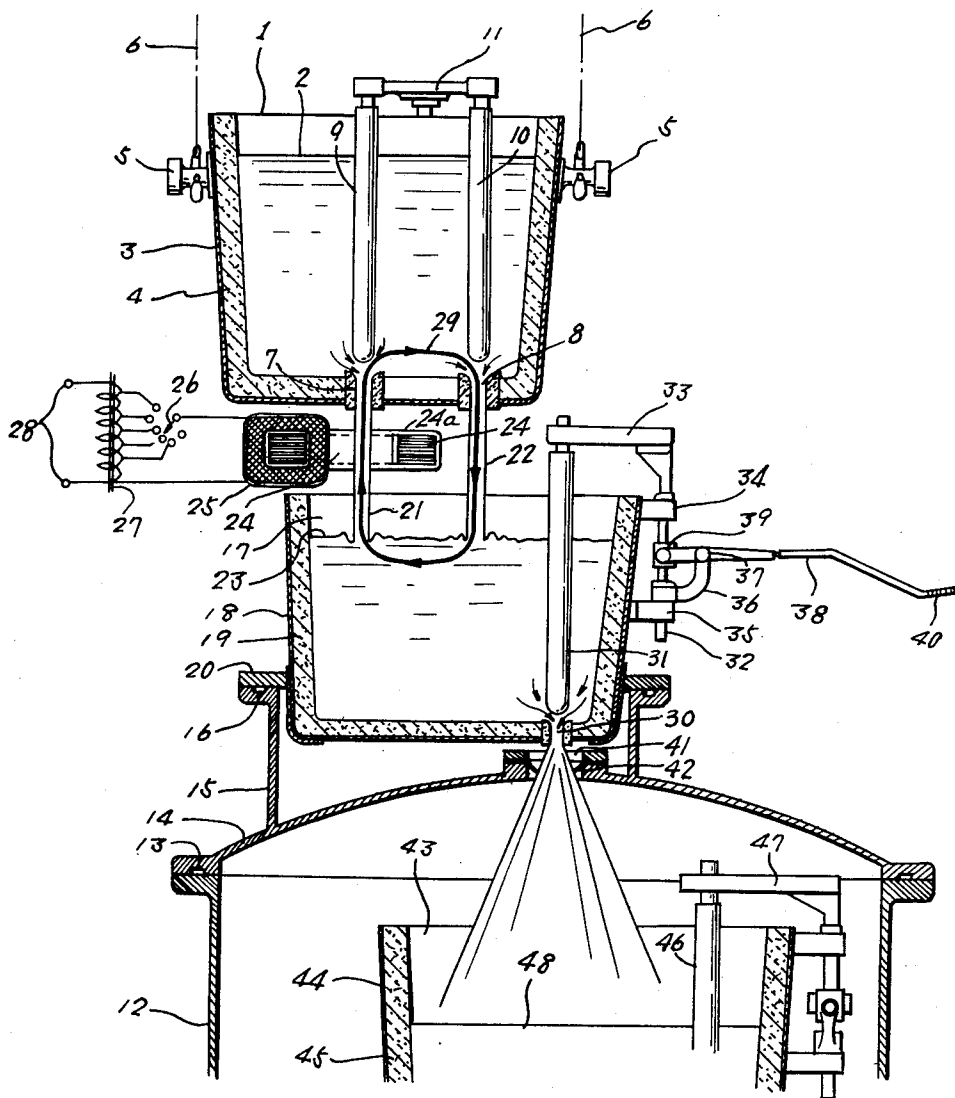
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APPARATUS FOR TREATING MOLTEN METALS

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3 Sheets-Sheet 1

Fig. 1.



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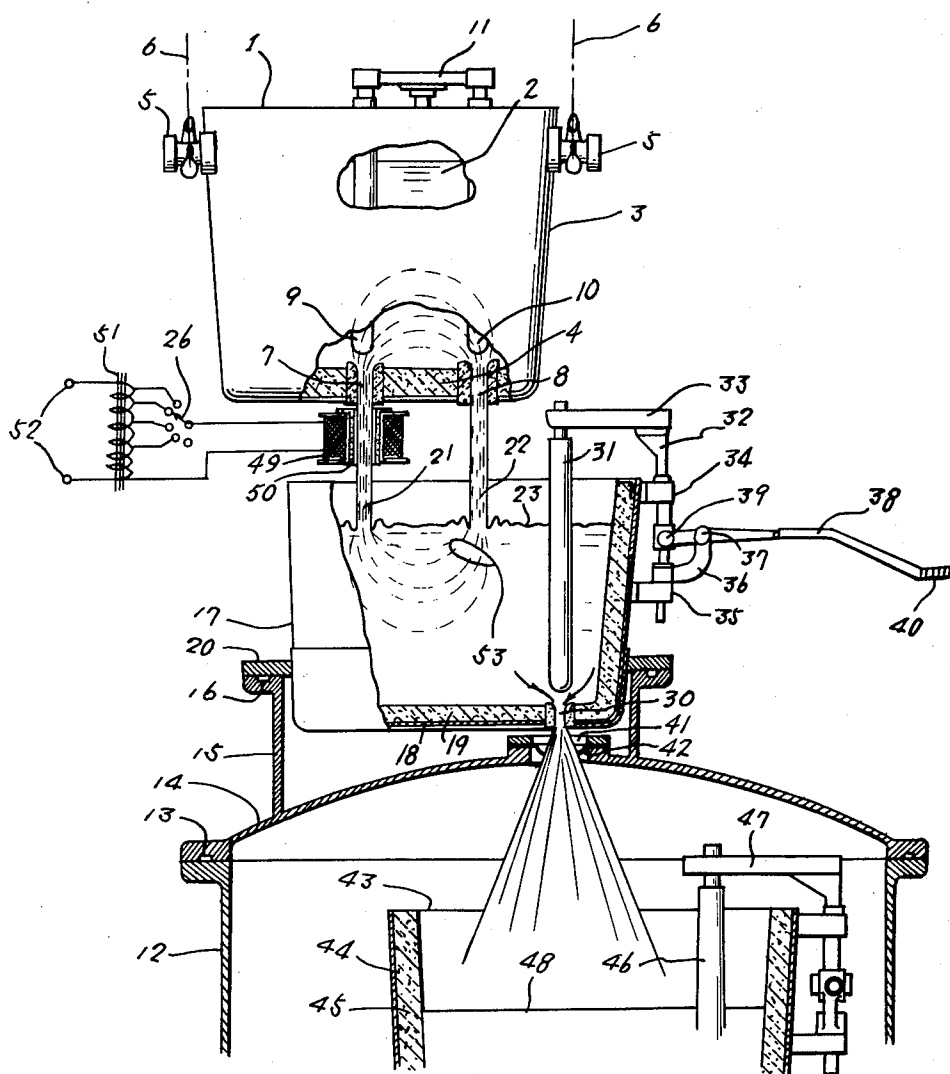
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Fig. 2.



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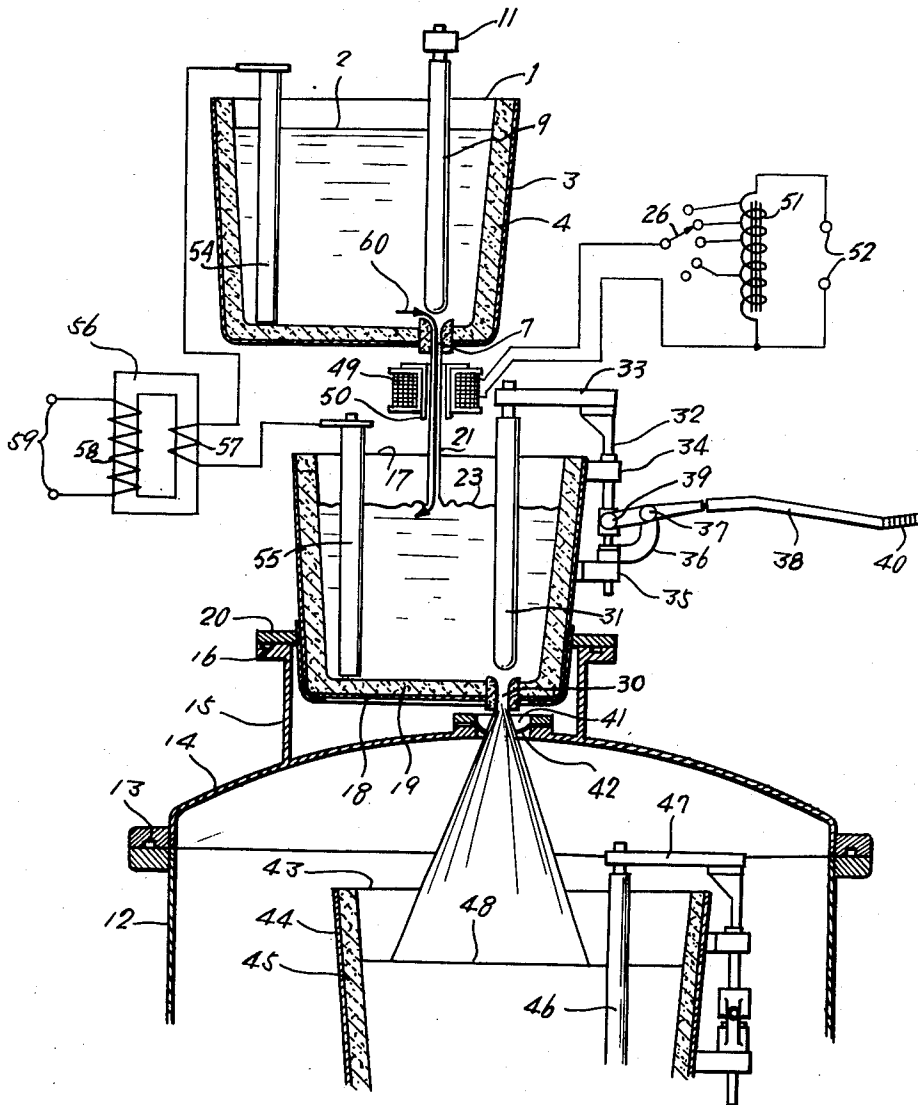
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Fig. 3.



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APPARATUS FOR TREATING MOLTEN METALS
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This invention relates to improvements in treating and degassing molten materials and, more specifically, concerns improved method and apparatus for processing and degassing molten materials such as metals and the like preparatory to utilization of the metals in molds and other similar forming devices.

It is well known that molten metals upon removal from the melting furnace experience a substantial temperature decrease and should such metals be processed for the removal of gases or other treatment prior to introduction into a mold, the loss of temperature can be sufficient to cause serious imperfections in the resultant molded articles. Temperature losses obviously occur by reason of the absorption of heat by the ladles or vessels utilized for the transport of the molten material, adiabatic expansion and thermal radiation. It is also evident that the mold in which the metal may ultimately be introduced will also absorb considerable heat from the metal during the course of pouring and may cause the metal to begin to coagulate or set before all portions of the mold cavity are completely filled. The loss of heat in molten metals is particularly severe in systems wherein metals are subjected to degassing treatments, and in such cases it was found virtually impossible to produce castings without serious imperfections.

One procedure that has been suggested for overcoming heat losses in molten metals has been to increase the temperature of the molten metal in the furnace in order to compensate for the loss of heat resulting when the metal is removed from the furnace and processed prior to introduction into a mold. Increasing the temperature of molten metal in a furnace to offset anticipated heat losses, has not been found to be satisfactory as it may adversely affect the character of the molten metal, will materially shorten the life of the furnace because of increased erosion of the furnace walls, and will greatly increase the cost of the resultant product since additional heat is required not only to raise the temperature of the metal within the furnace but also the furnace itself with the result that radiation losses are drastically increased.

One object of the invention resides in the provision of an improved method and apparatus for treating and degassing molten materials wherein the molten materials are maintained at a temperature that will insure the production of resultant molded articles free from undesirable defects.

Another object of the invention resides in the provision of a novel and improved method and apparatus for heating molten metals after removal from the furnace to avoid further introduction of gases in the molten material and maintain the metal temperature during the degassing process.

Still another object of the invention resides in the provision of a novel and improved method and apparatus for rapidly and effectively reheating molten materials utilizing electrical energy that is converted to heat within the molten metals.

A further object of the invention resides in the provision of economical and efficient reheating apparatus utilizing electrical energy and that is characterized by its compactness, simplicity, and relatively low cost. This is obtained through an improved method of handling the molten material and converting electrical or electromagnetic energy into heat within successive portions of the

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molten material and thus raise its temperature without the direct transfer of heat from an external body which has been found to be expensive, time consuming, and undesirable from the standpoint of re-introduction of gases into the material.

The above and other objects and advantages of this invention will become more evident from the following descriptions and accompanying drawings forming part of this application.

In the drawings:

FIG. 1 is an elevational view in partial section of one form of apparatus in accordance with the invention for treating and degassing molten materials prior to molding, certain elements of the drawings being in diagrammatical form for purposes of simplicity.

FIG. 2 is an elevational view similar to FIG. 1 and illustrating a modified heating means in accordance with the invention.

FIG. 3 is an elevational view of apparatus similar to FIGS. 1 and 2 and illustrating still another form of heating means in accordance with the invention.

Broadly, the invention concerns an improved method and apparatus for degassing materials and particularly conductive molten metals after the metals have been removed from the melting furnace and prior to their introduction into a mold. The presence of gas in the molten material that may have been absorbed by the metal during the initial melting process, or may become incorporated therein upon transfer from the melting furnace to a first ladle or vessel, will result in the formation of pockets in the final molded article which frequently render the molded articles useless for the purposes intended. Moreover, air or gas pockets which may be incorporated in the wall of a molded article may not be detected with the result that the article when subjected to stresses and strains will be more readily subject to fracture. In accordance with the invention, the molten material after transfer to a transporting ladle or vessel is again transferred to a second vessel disposed below the first vessel, the latter having a relatively small orifice in the bottom to permit the molten metal to flow uniformly from the first vessel to the second vessel by means of gravity. This procedure permits trapped gases to escape from the metal though it is also evident that during the course of transfer of the material cooling will result. In accordance with this invention electric or electromagnetic energy is introduced into the stream of metal flowing from one vessel to the other and it has been found that the temperature of the molten material, when it is finally transferred into the second vessel, will have attained a sufficiently high temperature to permit further treatment in a vacuum chamber and subsequent introduction into a mold at a desirable molding or casting temperature.

In the case of magnetic materials it has been found that electromagnetic fields may be induced into the stream or streams of molten metal, as the case may be, and be converted, within the molten metal, into heat. In the case of nonmagnetic materials it has been found that an electric current can be passed directly through the stream of metal flowing from the first vessel to the second and the resistivity of the stream is sufficiently high to cause a direct conversion of electric energy into heat. Thus the invention affords a mode of heating molten materials during the course of transfer from one vessel to another and it may, therefore, be said that portions of the molten material are successively heated so that the temperature of the entire body of material can be rapidly and quickly brought to any desired temperature without the need for expensive and relatively inefficient heating means, or the need for transferring heat from an external body, such as an electric heater, to the metal, which is a laborious and time consuming procedure.

Referring now to the drawings, FIG. 1 illustrates one embodiment of the invention for processing a molten metal having conductive characteristics and electromagnetic means for imparting heat to the metal during the course of the degassing process. In this figure, the numeral 1 denotes a first ladle or vessel containing a molten metal 2 which has been removed from the melting furnace. The vessel or ladle 1 comprises an outer shell 3 and an inner lining 4 of a heat resistant material. The vessel 1 may be supported in any desirable manner as by the utilization of chains 6 attached to ears 5 on the sides of the vessel. In this embodiment of the invention the bottom of the ladle 1 includes a pair of openings or orifices 7 and 8, and these orifices are provided with closure means or valves 9 and 10, the latter being in the form of rod-like elements extending through the molten material and adapted to enter and close the openings 7 and 8. The valve members 9 and 10 are carried by a control mechanism generally denoted by 11, and which mechanism may be operated from a position externally of the vessel 1 for opening and closing the openings 7 and 8.

Below the ladle 1, there is disposed a vacuum tank generally denoted by the numeral 12. This vacuum tank may include a permanently closed bottom portion, not shown, and a removable cover or lid 14 closing the top of the tank 12 and having suitable packing 13 to insure an air-tight seal. The cover 14 of the tank 12 is provided with an upwardly extending ladle supporting structure 15 which, in the instant embodiment of the invention is essentially cylindrical. A ladle 17 having an outer shell 18 of steel or other suitable material includes a surrounding flange 20 that is adapted to engage the upper end of the cylindrical supporting structure 15. The flange 20 is held in sealed relationship with the structure 15 and, if desired, a suitable gasket for packing 16 may be included to insure a perfect seal. The vessel 17, as in the case of the vessel 1, includes a lining 19 of a heat resistant material and has a single opening 30 in the bottom thereof. The opening 30 of the vessel 17 is aligned with a top opening 41 in the cover of the vacuum tank 12 and the opening 41 is further provided with a closure member 42 of a thin foil or other material having a relatively low melting point in comparison with the temperature of the molten metal being treated. One material found satisfactory for this purpose has been aluminum.

The vessel 17 when in position on the vacuum tank 12 is in registration with the openings 7 and 8 in the bottom of the vessel 1 so that when the valve members 9 and 10 of the vessel 1 are lifted, metal will flow through the openings and into the vessel 17, and in so doing will form streams or pillars of molten metal 21 and 22.

As in the case of the ladle 1, the ladle 17 is also provided with an adjustable valve member 31 which can be moved into and out of engagement with the opening 30. The valve member 31 may be controlled in any desired manner and in the present embodiment of the invention it is carried by a transverse member 33 supported by a shaft 32 extending through journals 34 and 35 on the side of the ladle. A lever 38 having an operating handle 40 is pivotally secured to the rod 32 at 39 and is fulcrumed at a point 37 on the bracket 36, the latter slidably engaging the shaft 32 and resting on the lower support 35. In this way, as the handle 40 is depressed, the valve 31 will be lifted to open the orifice 30.

In the course of the process, the metal 2 after transfer to the vessel 17, which metal when in the vessel 17 is denoted by the numeral 23, is then transferred to a vessel or ladle generally denoted by the numeral 43 which is sealed within the vacuum tank 12. The vacuum tank 12 is connected with a suitable pump, not illustrated, in order to maintain the desired negative pressure therein. Ladle 43 is similar to the ladles previously described in that it includes an outer shell 44 having a heat resisting liner 45. This ladle may also be provided with a lower opening similar to that of the ladle 17 and appropriate

valve means 46 and 47 which is substantially identical to the valve means 31 and 33 of the vessel 17.

It was pointed out above that the opening 41 in the top of the vacuum chamber 12 is sealed by a thin diaphragm 42. In this way when the vessel 17 with molten metal therein is positioned as illustrated in FIG. 1, and the valve 31 is open, the hot metal will flow through the opening 30, will melt the diaphragm 42, and diffuse as it flows into the vacuum chamber 12. The ladle 43 is disposed beneath the opening 41 and the diffused molten material will accumulate in this ladle and, at the same time, all gases will be removed from the material.

As previously mentioned, the molten material by the time it is collected within the ladle 43, must have a temperature sufficiently high to insure the production of good castings when the metal is finally introduced into a mold. It has been found that by the utilization of ladles 1 and 17, as previously described, and the transfer of the material through relatively small openings in the bottom of one ladle and into the second ladle, the metal can be heated in the course of such transfer by electrical or electromagnetic means, and thus avoid the accumulation of additional gases within the metal. In FIG. 1 electromagnetic means are utilized to develop heat within the streams of material as it passes through the openings 7 and 8 and is collected in the vessel 17. For this purpose an essentially circular or rectangular core 24 of good permeability is provided and is disposed in essentially a horizontal position between the ladles 1 and 17. The core 24 carries a coil 25 which may be considered the primary of a transformer. The core is also positioned so that the stream of molten material leaving the opening 7 will pass within the opening defined by the core 24 while the stream 22 which emanates from the opening 8 will be positioned outside the core 24. In this way the two streams of molten material which are interconnected at their top ends by the body of molten material 2 and at their lower ends by the body of molten material 23, form in effect a single turn on the transformer comprising the coil 25 and the core 24. This conductive turn or path is indicated by arrows 29. With this arrangement, upon the application of energy to the coil 25, which in this instance includes an auto transformer 27, having terminals 28 to which energy is applied and the contact switch 26 for adjusting the voltage applied to the coil 25, an exceedingly high current is generated in the streams 21 and 22. Since these streams form part of a closed conductive circuit, the high circulating current will be transformed into heat within the streams 21 and 22, and thus raise the temperature of the molten material collected within the ladle 17 to a temperature that will permit it to be degassed by the vacuum means previously described and transferred to the final mold at the desired molding temperature.

After the degassing operation has been completed, the lid 14 of the vacuum chamber 12 may be removed and the ladle 43 then transported by suitable means to the receiving mold for introduction of the metal into the mold.

The embodiment of the invention as illustrated in FIG. 2 is substantially identical to that illustrated in FIG. 1 except that it utilizes modified means for heating the streams 21 and 22. In this case the molten material to be heated must have magnetic characteristics so that it will be influenced by a magnetic field. The generation of the field is effected by a coil 49 having a heat resistant liner 50 extending centrally thereof. The coil and liner 50 are placed in registry with the opening 7 so that the stream 21 will flow through the center of the coil. The coil 49 again may be energized in any suitable manner as, for instance, by means of an adjustable auto transformer 51 having terminals 52 to which alternating current energy is applied and a switch 26 for adjusting the amount of energy fed to the coil 49. The coil 49 produces a strong magnetic field generally denoted by the

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dotted lines 53, which field is concentrated within the streams 21 and 22, and the connecting bodies of molten metal in the ladles 1 and 17.

A still further mode of producing heat directly within the molten metal as it is transferred from ladle 1 to ladle 17 is illustrated in FIG. 3 of the drawings. This figure is substantially identical to the previous figures except that the ladle 1 in this embodiment is provided with a single opening 7 rather than the dual openings 7 and 8. The ladle 1 is also provided with an electrode 54, and the ladle 17 is provided with a second electrode 55. As the metal 2 passes from the ladle 1 into the ladle 17, the stream 21 forms a conducting path between the two bodies of molten material. While a transformer 56, having a primary 58 to which electrical energy is applied and a secondary connected between the electrodes 54 and 55, is utilized to produce a strong current flow through the stream 21, it is evident that direct current may also be utilized for heating purposes. Alternating current, however, is desirable to prevent or minimize electrochemical effects. Inasmuch as this form of the invention as well as the form of the invention shown in FIG. 1 do not rely on electromagnetic properties of the molten material, these heating systems can be utilized with either magnetic or non-magnetic materials. In the case of materials having magnetic properties, the embodiment of the invention as shown in FIG. 2 may be used.

In the course of the foregoing description, the vacuum chamber 12 has been illustrated as containing a third receptacle or ladle 43 for the reception and collection of the finally degassed material. In certain instances, however, it may be desirable to utilize a mold for the reception of the metal within the vacuum chamber 12 in place of the ladle or receptacle 43. In this way the metal, upon leaving the receptacle 17, is transferred directly to the final mold and is degassed just prior to introduction into the mold.

While only certain embodiments of the invention have been illustrated and described, it is apparent that other modifications, alterations, and changes may be made without departing from the true scope and spirit thereof as defined by the appended claims.

What is claimed is:

1. Degassing apparatus for molten metals comprising a relatively large first ladle containing a molten metal to be degassed, said ladle having means for transferring said metal to a second ladle in a continuous stream, a layer of heat insulating material on the inner surface of said first ladle, a first elongated electrode immersed in the metal in said first ladle and extending from the rim thereof, a second ladle receiving molten metal from said first ladle and having a layer of heat insulating material

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lining the inner surface thereof and an opening in the bottom, a second elongated electrode within said second ladle and with a portion thereof extending above the rim of said ladle, electrical means including a source of alternating current connected to said first and second electrodes for passing a relatively large current through said first electrode, the stream of molten material flowing from the first ladle into the second ladle and through said second electrode, said current maintaining the temperature of the molten material during its transfer from said one ladle to the second ladle, and a vacuum chamber having a top opening and a third ladle within said chamber and means on said vacuum chamber connecting the vacuum chamber and second ladle openings for transferring molten metal from said second ladle into said third ladle.

2. Degassing apparatus for molten metals comprising a relatively large first ladle containing a molten metal to be degassed, said ladle having means for transferring said metal to a second ladle in a continuous stream, a layer of heat insulating material on the inner surface of said first ladle, a first elongated electrode immersed in the metal in said first ladle and extending from the surface thereof, a second ladle receiving molten metal from said first ladle and having a layer of heat insulating material lining the inner surface thereof and a bottom opening, a second elongated electrode in said second ladle and extending above the rim thereof, electrical means including a source of alternating current connected to said first and second electrodes for passing a relatively large current through said first electrode, the stream of molten material flowing from the first ladle into the second ladle and through said second electrode, said current maintaining the temperature of the molten material during its transfer from said one ladle to the second ladle, an electromagnetic coil having a central opening therein surrounding the stream of molten material, alternating current means for energizing said coil to produce a strong electromagnetic field about said stream and a vacuum chamber having a top opening and a third ladle within said chamber, and means on said vacuum chamber connecting the vacuum chamber and second ladle openings for transferring molten metal from said second ladle into said third ladle.

References Cited in the file of this patent

UNITED STATES PATENTS

848,422	Wynne	Mar. 26, 1907
2,253,421	De Mare	Aug. 19, 1941
2,893,715	Harders et al.	July 7, 1959

FOREIGN PATENTS

102,406	Sweden	Aug. 26, 1941
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