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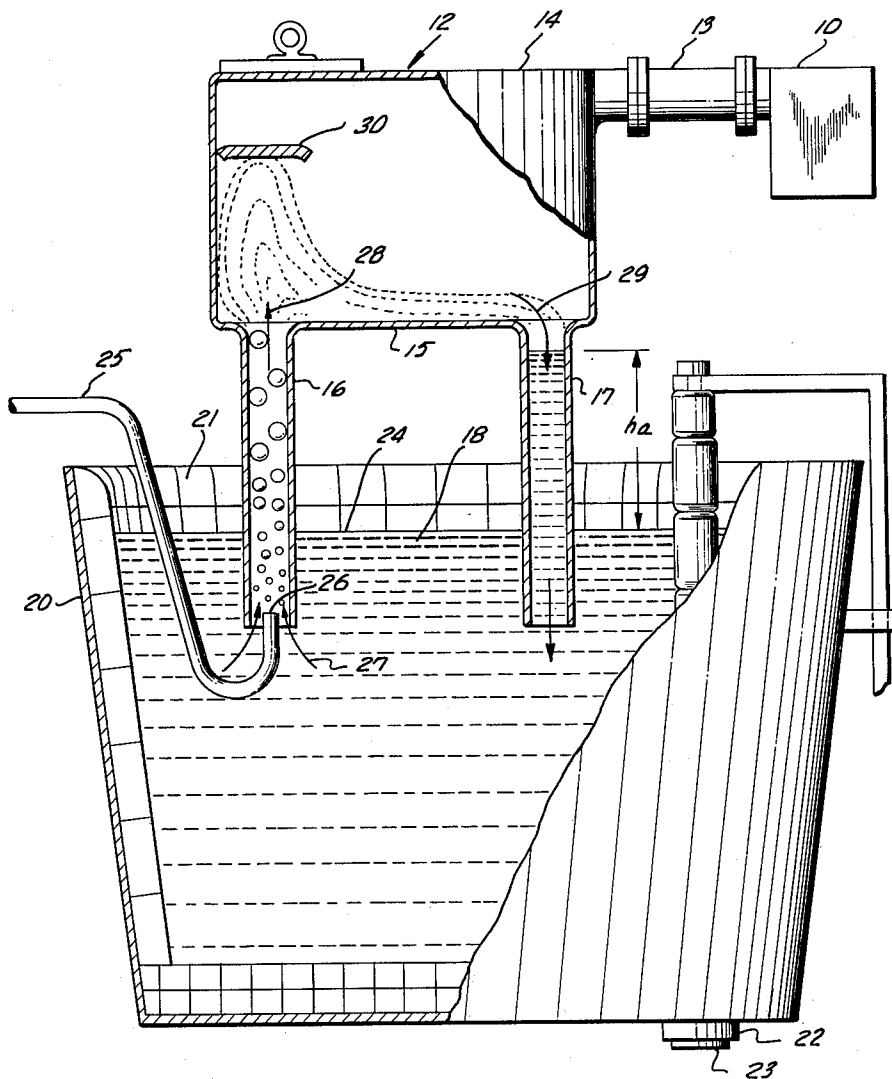
A. LORENZ
APPARATUS FOR CONTINUOUSLY DEGASSING MOLTEN
METALS BY EVACUATION

3,136,834

Filed Dec. 22, 1958

3 Sheets-Sheet 1

Fig. 1.



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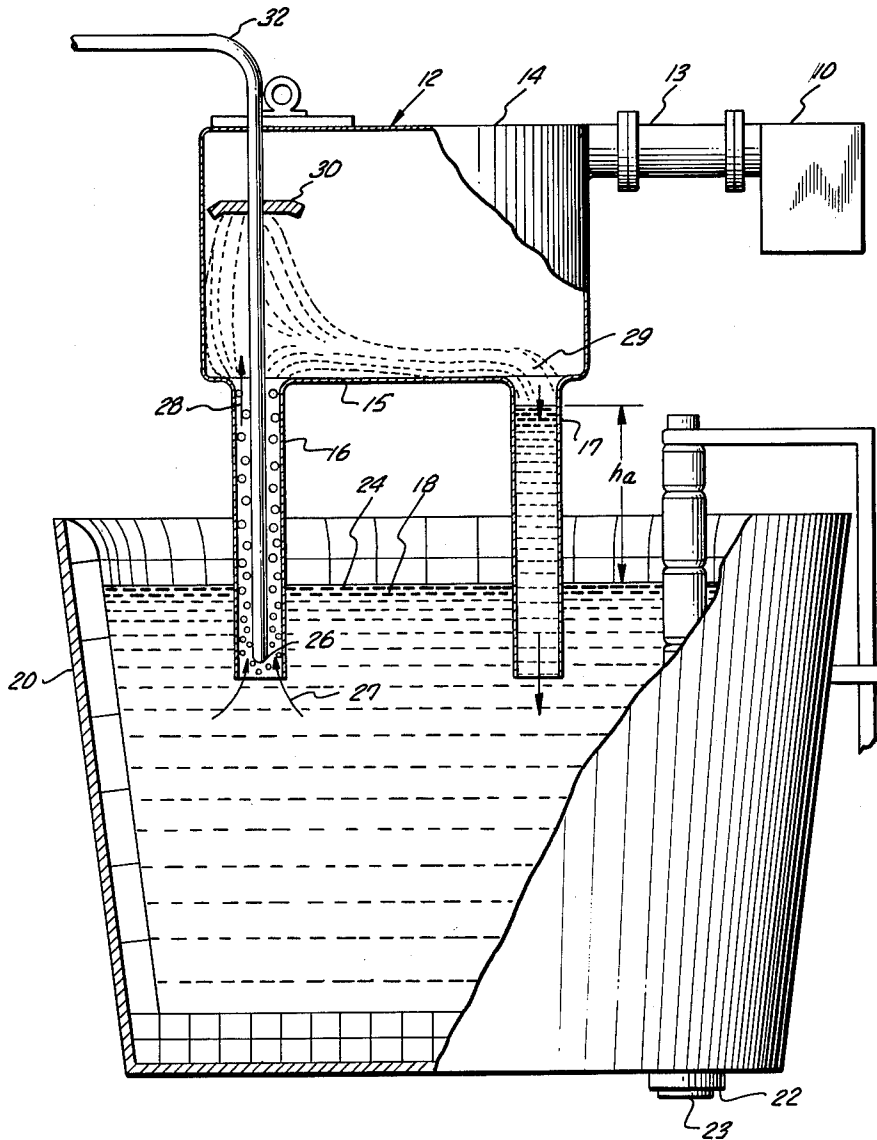
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3 Sheets-Sheet 2

Fig. 2.



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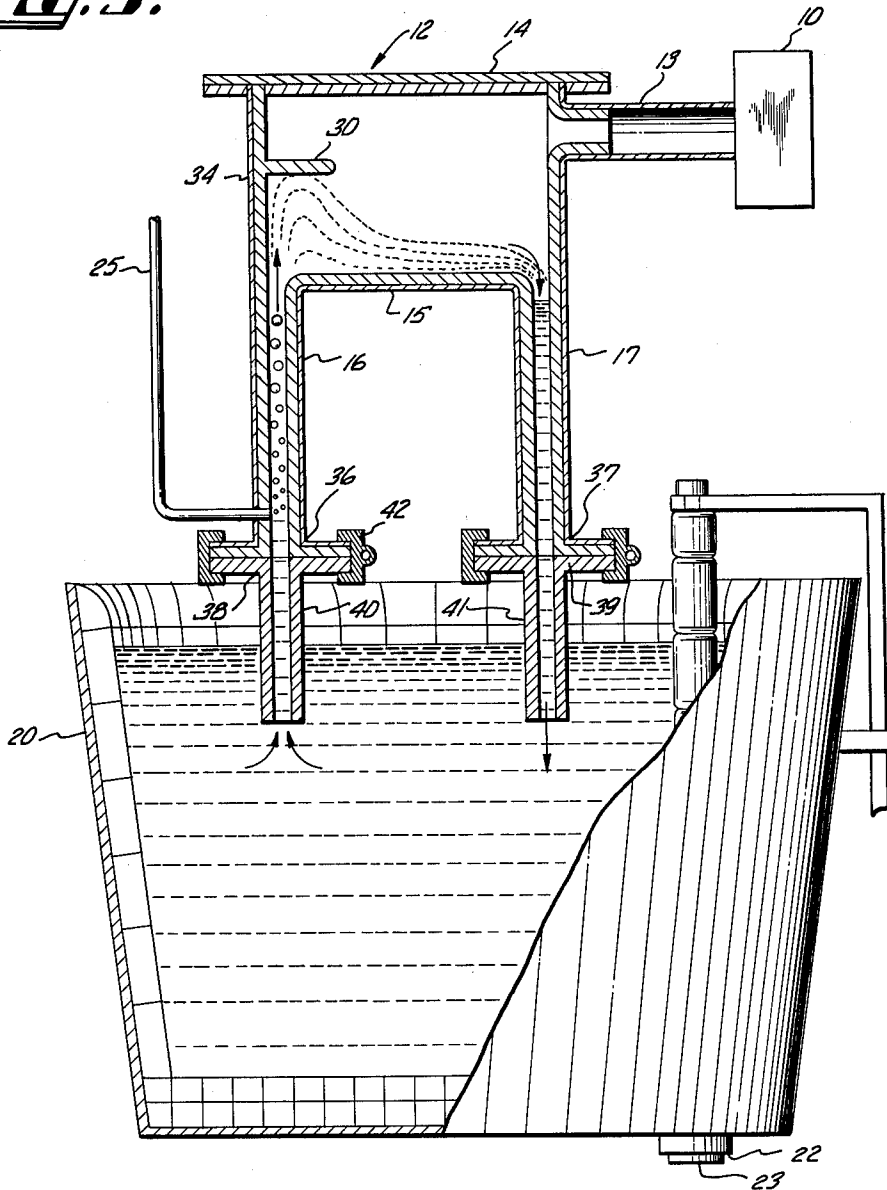
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3 Sheets-Sheet 3

Fig. 3.



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1

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APPARATUS FOR CONTINUOUSLY DEGASSING MOLTEN METALS BY EVACUATION

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The terminal portion of the term of the patent subsequent
to Jan. 30, 1979, has been disclaimed

2 Claims. (Cl. 266—34)

The present invention relates to an apparatus for expelling gases from molten metals and is a continuation-in-part of my co-pending application, Serial No. 676,131, filed August 5, 1957, now Patent No. 2,893,860.

Various methods and apparatus have heretofore been employed for degassing molten metals. For example, molten metal within a crucible has been degassed by subjecting the metal to a vacuum and agitating the molten metal within the crucible by inductive heating means for a sufficient length of time to satisfactorily expel the undesirable gases from the metal. Molten metals, particularly steel, have also been degassed in the past by moving the molten metal through a vacuum chamber by gravity, either by free fall of the metal through the vacuum chamber or by a rise of the barometric level of the molten metal into the vacuum chamber.

All of these prior art methods have many disadvantages which are primarily related to the requirement that great quantities of molten metal must be moved back and forth. Although these disadvantages were fully realized they have so far been regarded as unavoidable since the difficulties of including a degasification process into the mechanical casting operation, as well as the technical difficulties of degassing large quantities of molten metal at high temperatures did not seem to permit any other solution.

Other methods and apparatus for degassing molten metals have been proposed heretofore but for various reasons such methods and apparatus have not been used to any large extent. For example, U.S. Patent No. 1,921,060 to Clyde E. Williams discloses an apparatus for degassing metals in which molten metal is conducted from one container through a vacuum chamber and then to a second container in which the degassed metal collects. This apparatus is difficult to use since the two containers must be lifted and lowered simultaneously and this type of operation is not possible in the average pouring plant. The patent to Williams also discloses an apparatus in which the molten metal is continuously conducted from a single container to a vacuum chamber through the inner pipe of a pair of concentric pipes and back to the container through the outer pipe. In this arrangement the inner pipe sucks that part of the melt out of the container which flows into the container through the outer pipe and is already degassed.

Although the advantages of degassing molten metal by means of a vacuum in the production of metal castings such as castings of rimmed steel have already been realized, it has not so far been possible to satisfactorily degas the metal except by very expensive methods and apparatus.

The above disadvantages of degassing molten metals have been overcome by the present invention which provides an apparatus for continuously degassing molten metals that is simple, inexpensive and efficient. In accordance with the present invention, there is provided an apparatus for continuously degassing molten metals which includes a container such as a crucible adapted to hold a body of molten metal and a vacuum chamber disposed above the container and having a pair of spaced non-concentric conduits in fluid communication therewith and extending downwardly from the chamber with the lower

2

ends of the conduits being adapted to be immersed into the body of molten metal within the container. Means are provided for evacuating the chamber and for continuously circulating the molten metal through the vacuum chamber. Such circulating means may include means for feeding a gaseous material into one of the conduits to cause the molten metal to flow from the container through the one conduit to the vacuum chamber and back through the other conduit into the container, whereby the metal within the container is continuously and efficiently degassed.

The degasification apparatus according to the present invention circulates the molten metal, for example, steel, continuously from its container along one path into an evacuated chamber, and then returns it to the container along another path. The apparatus for thus circulating the molten metal may be of very simple design. For producing the forces required for such circulation the apparatus relies particularly upon the liquid condition and the relatively high density of the molten metal. The new apparatus possesses all the advantages of a continuous process and although it avoids the necessity of moving or agitating large quantities of molten metal as required in the prior noncontinuous methods, it is still capable of degassing such large quantities of metal very efficiently and within a very short time. Since the apparatus of the invention operates continuously and the rate of flow of the molten metal through the vacuum chamber is quite fast, a very large quantity of metal may be efficiently degassed within a short time even though the quantity of molten metal actually passing at any time through the vacuum chamber might be very small. Furthermore, the use of two spaced nonconcentric conduits to conduct the molten metal to and from the vacuum chamber insures a good circulation of the molten metal within the container and prevents the degassed metal flowing into the container through the return conduit from being immediately drawn into the vacuum chamber through the intake conduit. Also the intake and return conduits may be moved to different parts of the body of molten metal in the casting ladle or other vessel so that nearly all parts of the metal will be reached by the apparatus and be passed successively through the vacuum chamber and thus be degassed.

In accordance with another embodiment of the present invention, there is provided an apparatus in which the pipes extending from the vacuum chamber to the body of molten metal are provided at their lower ends with removably mounted highly refractory ceramic end portions that are adapted to be immersed into the molten metal.

The invention is described in greater detail in connection with the accompanying drawings in which:

FIG. 1 is an elevation, partly broken away and partially in section, of one embodiment of the present invention;

FIG. 2 is an elevation, partly broken away and partially in section, of another embodiment of the present invention, and

FIG. 3 is an elevation, partly broken away and partially in section, of a third embodiment of the present invention.

Referring now to the drawings wherein like elements are designated by the same reference characters throughout the several figures and more particularly to FIG. 1, a vacuum pump 10 is connected to a vacuum chamber 12 by a suitable conduit 13. The vacuum chamber 12 is formed by a tank 14 having a bottom 15 to which a pair of spaced nonconcentric pipes or conduits 16 and 17 are connected. The pipes 16 and 17 function as intake and return conduits to the chamber 12 and are partly immersed into a molten metal body 18 within a container

or casting ladle 20. The intake and return conduits 16 and 17 respectively may be spaced any desired distance from each other to insure a good circulation of the molten metal through the vacuum chamber 12 and prevent the degassed metal flowing out of the conduit 17 from being immediately drawn into the intake conduit 16. As shown in FIG. 1, the lower ends of the conduits 16 and 17 that extend into the melt are preferably at the same level and spaced from each other by a distance greater than twice the diameter of one of the conduits.

The ladle 20 includes a lining 21 of refractory material and a tap hole 22 which is adapted to be closed from above by means of a plug 23. The tank 14 and the pipes 16 and 17 may also include a suitable refractory lining (not shown) to protect the surfaces of the tank and the pipes that are exposed to the molten metal.

In operation the tank 14 and the pipes 16 and 17 are lowered so that the lower ends of the pipes 16 and 17 are immersed into the molten metal 18 to a point below the surface 24 thereof. The vacuum chamber 12 is now evacuated whereby the molten metal rises within the pipes 16 and 17 to the normal barometric level h_a as shown.

To start the circulation of the molten metal through the vacuum chamber 12 a material of considerably lower density than the molten metal, preferably a gas or vapor, is injected into the molten metal near the lower end of the intake conduit 16 by means of a gas supply pipe 25. As shown, the pipe 25 is inserted into the molten metal 18 within the ladle 20 so that its lower end 26 is disposed at a point under or within the lower end of the pipe 16. The pipe 25 may be connected to a suitable source of gas or vapor, not shown, and adapted to conduct such gas or vapor into the molten metal within the pipe 16. If an insoluble gas is injected into the molten metal through the pipe 25 the gas bubbles forming within the molten metal will increase in size while rising toward and into the vacuum chamber 12. Such gases will then again easily separate from the molten metal within the vacuum chamber together with the undesired gases originally contained in the metal. By injecting a low density material such as a gas into the molten metal near the end of the pipe 16 the medium density of the molten metal within the pipe 16 is decreased, thereby causing the level of the metal within the pipe 16 to rise to a higher level than the normal barometric level h_a of the degassed metal column in the pipe 17. The injected gas acts as a carrier and conveys the molten metal continuously into the vacuum chamber 12 and produces therein the mentioned difference in levels which in turn results in a continuous circulation of the molten metal from the ladle 20 toward and through the vacuum chamber 12 and back to the ladle.

In order to prevent the molten metal from splashing too far upwardly into the chamber 12, a suitable deflecting plate 30 may be provided within the chamber 12 at a certain height above the mouth of the pipe 16. In the embodiment of the invention as shown in FIG. 1, the pipe 25 through which the conveying gas is supplied to the molten metal in the intake pipe 16 forms an independent element separate from the vacuum tank 14 and the pipes 16 and 17. This pipe 25 is adapted to be removed from the ladle 20 after the flow of molten metal in the direction of arrows 27, 28 and 29 has been started by the added gas, provided the molten metal itself contains sufficient gas to maintain the flow after such start or after the degasification process has been carried out for a certain length of time. When the gas content of the molten metal in the ladle 20 has been diminished to such an extent that the continued automatic circulation without the addition of supplementary gas is interrupted or is diminished to a certain extent, the pipeline 25 may be reinserted into the pipe 16 to start the flow or to assist it by further supply of conveying gas.

FIG. 2 illustrates a modification of the apparatus shown in FIG. 1 in which a gas supply pipe 32 for starting and

assisting the flow of molten metal into the vacuum chamber 12 is secured by a vacuum tight connection to the top of the vacuum tank 14 and extends concentrically through the intake pipe 16, terminating at or near the lower end thereof as shown. The added supplementary or conveying gases may consist of any stable inert gases, for example argon, which are not soluble or are only slightly soluble in the molten metal. However, other gases such as those contained to some extent in the molten metal itself, for example nitrogen and carbon monoxide, may also be used with equal results since they are separated in any event from the molten metal within the vacuum chamber 12.

In certain cases it is also possible to combine the introduction of gas for conveying the molten metal into the vacuum chamber with additional purposes. Thus, for example, if iron or steel is to be degassed, the introduction of oxygen into the molten metal will assist in carrying out the necessary refining process thereof.

The vacuum chamber may also be provided with additional means for effecting or facilitating the separation of the gases from the metal which splashes around in the vacuum chamber in the form of large drops or jets. A simple form of such means may consist of the deflecting plate 30 as shown in FIGS. 1 and 2. However, these separating means within the vacuum chamber may also consist of moving elements, for example, a revolving plate or the like.

The important features of the apparatus of FIGS. 1 and 2 are that two spaced nonconcentric conduits are immersed within the molten metal in a single container and connected to a vacuum chamber so that molten metal is continuously conducted through one of the conduits into the vacuum chamber and back through the other conduit into the container. In this manner substantially all the molten metal within the container is conducted through the vacuum chamber in a relatively short length of time.

While the apparatus disclosed in FIGS. 1 and 2 is very simple, inexpensive and provides a thorough and efficient degassing of the molten metal within a container, the apparatus has several disadvantages. Each of the pipes 16 and 17 in the apparatus of FIGS. 1 and 2 is formed in one continuous piece. To provide the necessary strength and protection against the molten metal the pipes 16 and 17 have been formed with a steel core and a ceramic lining. Thus the ends of the pipes that extend into the melt include a steel core which is heated to a very high temperature by the molten metal. As a result the portions of the pipes 16 and 17 that are immersed into the molten metal are relatively rapidly dissolved or corroded. Also the occurrence of great changes in the temperature to which the ends of the pipes 16 and 17 that are immersed into the molten metal are exposed causes the refractory lining of the pipes to break away from the steel core. To prevent the rapid destruction of the ends of the pipes that are immersed in the metal, such pipes may be cooled by water or the like. However, such cooling also causes a cooling of the melt to occur near the immersed portions of the pipes which may lead to a solidification of the melt in such areas.

It has been discovered that these disadvantages may be overcome by forming the pipes connecting the vacuum chamber and the crucible in two pieces in which the piece that extends into the molten metal is formed of a highly refractory ceramic material. In spite of the fact that this proposal is simple, there has been much opposition in the foundry industry to the use of ceramic materials without any metal supporting core or other reinforcing structure due to widespread and firmly rooted prejudices. The brittleness and fragility of ceramic parts have always appeared to be a serious drawback to the use of such parts in foundry equipment which receives very rough treatment. Therefore, ceramic materials have only previously been used in foundry equipment where the

5

ceramic materials were protected from shock by metal reinforcement, i.e., as refractory linings for casting ladles and other parts.

In accordance with the embodiment of FIG. 3, the pipes for connecting the vacuum chamber to the crucible are provided with removably mounted highly refractory ceramic end portions which extend into the molten metal to prevent rapid deterioration of the pipes and decrease the maintenance cost and time of the degassing apparatus. As shown in FIG. 3, the side portions of the vacuum chamber 12 and the exterior surfaces of the pipes 16 and 17 are reinforced with a metal lining 34 such as steel. The ends of the intake and return pipes 16 and 17 include an annular flanged portion 36 and 37 respectively to which annular flanged portions 38 and 39 of ceramic pipes 40 and 41 are secured by means of conventional ring clamps 42. The pipes 40 and 41 may consist of any highly refractory ceramic material which possesses a great resistance against molten metals. Due to the low heat conductivity of such ceramic materials and their high heat absorption capacity, the pipes 40 and 41 assume the same temperature as the melt and do not conduct this high temperature to the metal parts such as the lining 34 of the vacuum apparatus. The relatively low cost of production of such ceramic parts by molding, coupled with the possibility of exchange after damage, renders the degasification equipment very economical. Numerous experiments have proved that the apparatus of FIG. 3 may be easily and readily maintained to insure that it is ready for immediate operation even in the rough operating conditions of a steel works.

The ceramic pipes 40 and 41 according to the embodiment of FIG. 3 may have any desired length which their

6

structural strength permits. The pipes 40 and 41 may also be constructed with more than one passageway there-through if desired.

What is claimed is:

1. In an apparatus for degassing molten metal by substantially continuous recycling and having as elements a vacuum degassing chamber, a lower positioned container for holding molten metal, a riser conduit for conveying molten metal from said container to said chamber, a discharge conduit for discharging molten metal from said chamber into said container and means for aiding molten metal flow through said riser conduit, the improvement which comprises in combination with said elements the arrangement of said riser and discharge conduits as separate and individual members having their immersion ends in said container in laterally spaced relation and sufficiently remote relative to each other to substantially prevent discharging metal from directly flowing between said immersion ends.

2. In an apparatus in accordance with claim 1 in which said aiding means are means for forcing gas bubbles through said riser conduit.

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