United States Patent

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[33] **Australia**
[31] **27983/67**

[54] **CONTINUOUS DEGASSING OF METALS**
14 Claims, 3 Drawing Figs.

[52] **U.S. Cl.** **266/34,** 75/49, 75/93, 266/39
[51] **Int. Cl.** **C21c 7/00**
[50] **Field of Search** ..... 75/45, 49, 93; 266/34, 34 (A), 34 (V), 39

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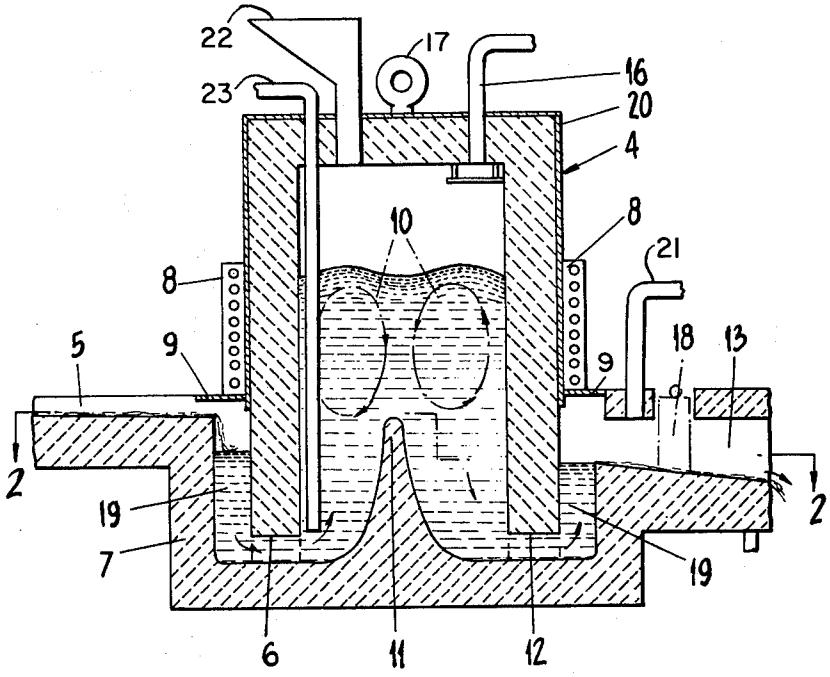
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ABSTRACT: Method for continuously and simultaneously degassing, deoxidizing or desulfurizing of molten metallic material by flowing the material into a removable bell jar-like chamber placed over a dishlike refractory tank bottom while keeping the chamber under reduced pressure and then upwardly over a baffle projecting up into the chamber and electroinductively stirring the upper part of the material in the chamber and flowing it in degassed condition downward and out of the chamber by gravity. The degassing apparatus is a removable bell jar-like chamber placed over a dishlike refractory tank with an upwardly directed baffle to deflect the cross-flow of molten metal, the chamber having an inlet and an outlet aperture on opposite sides of the lower rim and external electroinductive stirring coils around its midportion the roof of the chamber is provided with a vacuum line.



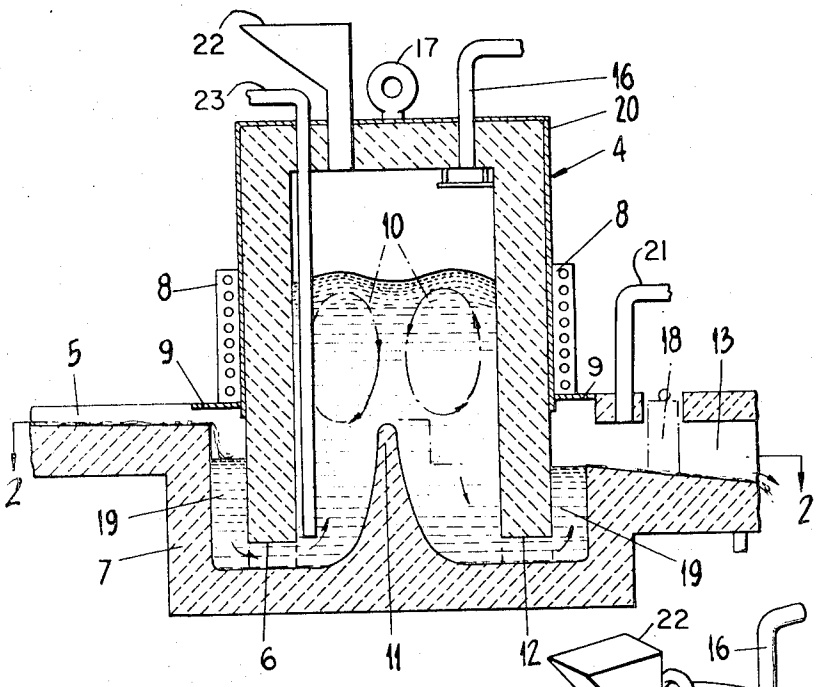


FIG. 1.

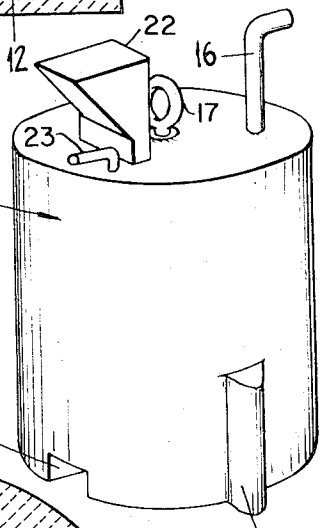
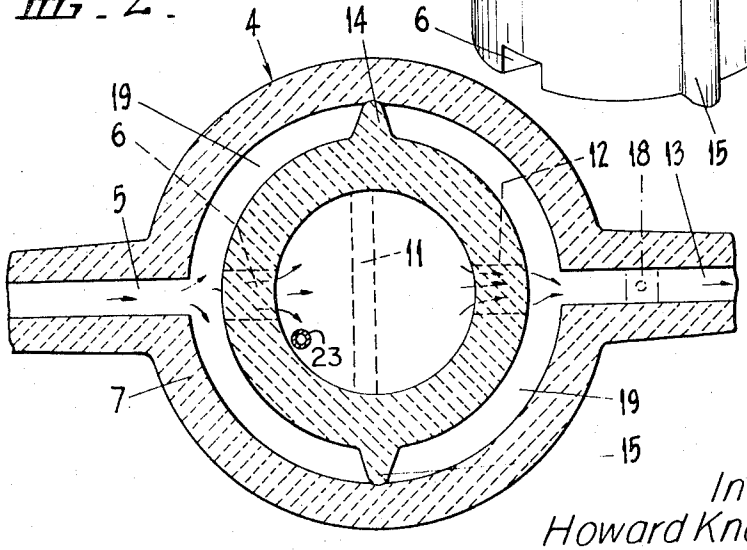


FIG. 3.

FIG. 2.



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CONTINUOUS DEGASSING OF METALS

This invention relates to methods and apparatus for the continuous deoxidation, desulfurization and degassing of metals and alloys.

Various methods have been proposed by which vacuum treatments can be employed to remove occluded gases, such as hydrogen and nitrogen, and also oxygen from low carbon steels and of various occluded gases from aluminum.

Most of the known method of vacuum degassing are batch operations but some methods have recently been proposed for continuous degassing ahead of continuous casting and in which the metal is forced by atmospheric pressure up an inlet barometric leg or pipe into a vacuum chamber where degassing is effected and the metal then leaves the chamber by a somewhat longer outlet barometric leg or pipe.

Efficient continuous degassing can be achieved by these methods but, at the startup of operations, techniques for temporarily closing the entry to the inlet and outlet pipes by heat rupturing discs or other sealing means, are usually necessary. Furthermore, the inlet and outlet pipes are prone to erode or crack during repeated campaigns; additionally, special provision has sometimes to be made, as by tilting mechanisms, in order to empty the vacuum chamber of molten metal at the end of a degassing campaign.

This present invention does not use inlet or outlet pipes and therefore no temporary sealing techniques are necessary. Further, the chamber in which the degassing is effected, according to this invention, can readily be lifted by a crane out of position for repair or maintenance operations. In addition, the controlled release of the vacuum at the end of a campaign allows the molten metal to flow out of the degassing chamber and the only metal which remains in the unit is that contained in the refractory "tank" or vessel into which the degassing chamber is seated during operation. If necessary the tank itself can be made tiltable to discharge into a holding vessel the metal which remains within it after the desulfurization, degassing or deoxidation operation.

Owing to the continuous nature of the process of the invention the size of the equipment required, i.e. the degassing unit itself as well as ancillaries, is much smaller than for conventional batch degassing for the same overall throughput. For instance, for a throughput of some 50 tons steel/per hour the diameter of the bell jarlike degassing chamber may be approximately 5 to 6 feet and the overall height may be approximately 10 feet.

In addition to the continuous removal of occluded gases from metals and alloys generally a particular object of the invention, metallurgically speaking, is the facilitation on a continuous basis of reactions of the type:

$$2\,Cu_2O + Cu_2S \longrightarrow 6\,Cu + SO_2$$

$$2\,PbO + PbS \longrightarrow 3\,Pb + SO_2$$

$$FeO + C \longrightarrow Fe + CO$$

The steel deoxidation reaction not only results in the elimination of oxygen, but the escaping bubbles of carbon monoxide carry out with them a substantial proportion of other occluded gases such as hydrogen. In the case of copper and lead the loss of SO_2 achieves the elimination of both oxygen and sulfur from the metal bath. If desired, the elimination of undesirable components can be facilitated by bubbling into the bath at an appropriate position near the inlet to the degassing chamber a gas which may either be inert with respect to the molten metal or be one which enhances the desired reaction. Thus, the addition of a little air or oxygen-enriched air to the bath will facilitate the elimination of sulfur by reactions of the type:

$$O_2 + Cu_2S \longrightarrow 2\,Cu + SO_2$$

$$O_2 + PbS \longrightarrow Pb + SO_2$$

The metallurgical considerations in respect of deoxidation and degassing of molten steel discussed in applicant's copending Ser. No. 27984/67 also apply to the present invention.

In one general form the invention includes a method of continuous degassing of metals which comprises flowing molten metal continuously through a readily removable bell jarlike degassing chamber under reduced pressure, and subjecting the molten metal to electroinductive stirring as it flows through the degassing chamber.

The molten metal flows through the degassing chamber which is under reduced pressure, and the degassed metal is preferably removed continuously by gravity flow. The tank or vessel is preferably relatively shallow and is refractory lined. The degassing chamber preferably has a substantially flat open bottom and has at its base an inlet opening and an outlet opening more or less diametrically opposite each other and which during operation are below the level of the molten metal in the refractory tank.

Rising from the refractory tank bottom there is preferably a transverse ridge or "wedge" which extends up into the readily removable bell jarlike degassing chamber. This ridge serves to cause the molten metal stream entering the degassing chamber to be diverted upwards into the region stirred by electroinductive influence.

If preferred, the transverse ridge or baffle may form an integral part of the vacuum degassing chamber itself. In this case it would extend transversely across the bottom portion of the readily removable bell jarlike chamber, extending upwards for such distance as will ensure that the ingoing metal is directed upwards into the region stirred electroinductively.

Whilst the degassing chamber is small relative to the tonnage of metal to be treated it is large enough to ensure that the molten metal flowing therethrough has sufficient residence time, while being stirred under vacuum, to undergo the desired degassing, deoxidation or desulfurization reactions.

One advantage of the process of this invention is that the molten metal can be delivered to the tundish of a casting machine at a level only a few inches lower than that of the stream of undegassed metal coming from a smelting, melting or holding furnace. In other words, there is very little loss of head in passing through the degassing unit.

The invention will be better understood by reference to the drawings in which:

FIG. 1 is a diagrammatic sectional elevation of one form of degassing apparatus according to the invention;

FIG. 2 is a diagrammatic sectional plan on line 2–2 of FIG. 1;

FIG. 3 is a semi-isometric view of one form of the bell jarlike degassing chamber, without showing the ancillary induction stirring coils.

The molten metal enters a bell jarlike refractory lined degassing chamber 4 via an appropriate channel or launder 5 leading into a relatively shallow refractory lined container or tank 7. The degassing chamber 4 which is connected to a source of vacuum at 16, rests in the tank 7. When vacuum is applied, molten metal is forced by atmospheric pressure up into the evacuated bell jarlike chamber 4 via an inlet slot or opening 6 therein. Within the chamber 4 the metal is subjected to an appropriate level of vacuum while it is gently stirred by the action of electromagnetic induction from coils 8 surrounding the bell jarlike chamber 4.

The preferred form of induction stirring is of the low frequency polyphase type which ensures efficient stirring over the full depth of the coils surrounding the chamber and without significantly heating the bath. This type of inductive stirring is effective for both ferrous and nonferrous metals. It causes the metal to circulate in the chamber 4 substantially as shown by the arrows 10, and any traces of slag which may be carried into the chamber 4 by entrainment in the molten metal are kept away from the walls of the chamber 4 so that its erosive effect on the refractory lining is minimal. The low frequency polyphase stirring coils 8 can be entirely separate from the vacuum chamber 4 proper, but in this case the metal shell 20 of the chamber 4 in the vicinity of the coils 8 is preferably made of nonmagnetic material such as austenitic stainless steel.

If the stirring coils 8 are separate from the degassing chamber 4, they may be lowered down into position around chamber 4 during the actual vacuum degassing operation and

removed upwardly away from the vacuum chamber 4 when the campaign is completed. Alternatively, the low frequency polyphase stirring coil 8 can, if preferred, be attached more or less permanently to the shell of the vacuum chamber 4.

It is desirable to protect the coils 8 of the induction stirrer from the intense heat radiating from the molten metal in the tank 7 below. This can be done by appropriate heat shields as at 9.

As fully effective electroinductive stirring can take place only in the molten metal in the same general plane as the coils 8 and as, for operational reasons, these coils would not normally be extended right down to the level of the molten metal in tank 7, it is desirable to have within the base of tank 7 a transverse refractory diversion "wedge" 11. This wedge 11 in the base of tank 7 should be appropriately located so as to direct upwards the stream of metal entering through inlet 6 so that it comes under the influence of electroinductive stirring effects higher up in the vacuum chamber 4.

If conventional single-phase induction coils are used to effect both stirring and a degree of heating of the bath, these are preferably embedded in the refractory of the bell jarlike container 4 and not located on the outside of the metal shell 20, otherwise the latter will be subjected to undesirable heating effects.

The degassed, deoxidized or desulfurized metal leaves the vacuum chamber 4 via an outlet slot or opening 12, more or less diametrically opposite to the inlet slot 6, and passes via channel 13 at a slightly lower level than launder 5 to the tundish (not shown) of a continuous casting machine or to a holding vessel or furnace ahead of casting operations. To minimize any pickup of gases by the metal during its passage along channel 13 an inert atmosphere is preferably maintained in this region, the gasses being introduced through tube 21.

In order to prevent the molten metal simply passing around the annulus region 19 of tank 7 it is advantageous to have two transverse extensions, as 14 and 15, on the bottom portion of the refractory of vacuum chamber 4. If these extensions are made to fit fairly snugly (as shown) into recesses in the inside walls of tank 7 and the bell jarlike chamber 4 is well seated down onto the floor of tank 7, the amount of molten metal which will be able to get through the unit without being subjected to vacuum treatment will be negligible.

If additional heat is needed, the top of the degassing chamber 4 may be provided with suitable heating elements (not shown). As an aid to degassing, particulate solid additives (e.g. powdered carbon, ferrosilicon) and/or inert gases, (e.g. argon) may, if desired, be introduced. Solids may be introduced through a sealed charging device 22 preferably mounted on the top of the degassing chamber 4 and inert gases may be introduced through a tube 23 appropriately located at or near the inlet 6.

Vacuum may be applied to the chamber 4 by any conventionally located connecting pipe such as 16 and a lifting "eye" 17 may be provided at the top of the bell jarlike chamber 4 to permit it to be lifted out of position at the end of the campaign.

For startup of degassing operations it may be desirable to fill the tank 7 up to a higher level than the normal operating level of outlet channel 13. This can be effected by an appropriate removable "stopper" as at 18. As soon as effective flow through the degassing-deoxidation chamber 4 is achieved this stopper 18 can be removed and the metal allowed to flow freely through the system. Normally the level of metal in the annulus 19 on the inlet side of 14 and 15 will be a little higher than that of the metal on the outlet side thereof.

I claim:

1. Apparatus for the continuous degassing of metals which comprises a tank, a bell jarlike degassing chamber readily removable from the tank in which the chamber is seated during degassing, a first inlet opening at one side of the tank and a first outlet opening at the opposite side of the tank, a second inlet opening through the lower end of the chamber and a second outlet opening opposite said second inlet opening through the end of the chamber, means for reducing the pressure within the chamber, and means for inductively stirring the molten metal while the molten metal is within the chamber whereby metal entering the apparatus through the first inlet opening flows through the second inlet opening into the chamber, wherein it is stirred and degassed, the degassed metal leaves the chamber through the second outlet opening and leaves the apparatus through the first outlet opening.

2. Apparatus according to claim 1 wherein the means for inductively stirring the molten metal comprises an induction coil located externally of the degassing chamber.

3. Apparatus according to claim 2 wherein the induction coil is located above the tank or vessel.

4. Apparatus according to claim 2 wherein a heat shield is disposed between the induction coil and the molten metal in the tank or vessel.

5. Apparatus according to any one of claim 1 and having a transverse diversion member in the lower part of the degassing chamber which diverts the molten metal upwardly and then downwardly in the degassing chamber.

6. Apparatus according to claim 5 wherein the inductive stirring of the molten metal is substantially effected in the part of the degassing chamber which is above the transverse diversion member.

7. Apparatus according to claim 5 wherein the transverse diversion member is approximately of wedge shape in cross section.

8. Apparatus according to anyone of claim 1 and having an annulus region between the readily removable bell jarlike degassing chamber and the wall of the tank or vessel, the said annulus region being divided into an inlet section and an outlet section by transverse partitions located on opposite sides of the degassing chamber.

9. Apparatus according to claim 8 wherein metal to be degassed flows continuously into the inlet section of the annulus region and from said inlet section through an inlet opening into the degassing chamber, and degassed metal flows continuously from the degassing chamber through an outlet opening into the outlet section of the annulus region.

10. Apparatus according to claim 8 wherein the metal to be degassed flows from an inlet launder or channel into the inlet section of the annulus region, and the degassed metal flows from the outlet section of the annulus region to an outlet launder or channel, the outlet launder or channel being at a lower level than the inlet launder or channel.

11. Apparatus according to claim 8 wherein the metal to be degassed flows from an inlet launder or channel into the inlet section of the annulus region, and the degassed metal flows from the outlet section of the annulus region to an outlet launder or channel, the outlet launder or channel being at a lower level than the inlet launder or channel, and having means for maintaining an inert atmosphere in contact with the degassed metal in the outlet launder or channel.

12. Apparatus according to claim 1 and having means for introducing solid additive materials into the degassing chamber.

13. Apparatus according to claim 1 and having means for introducing additives in gaseous or vapor form into the inlet side of the tank.

14. Apparatus according to claim 1 and having means for maintaining an inert atmosphere in contact with the degassed metal in the outlet launder or channel.